NATURAL FEATURES OF THE
LAKE ANNIE TRACT,
HIGHLANDS COUNTY, FLORIDA

By
James N. Layne

ARCHBOLD BIOLOGICAL STATION
Route 2, Box 180
Lake Placid, Florida 33852

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INTRODUCTION

Lake Annie is a small lake of exceptional geological and ecological interest located in southcentral peninsular Florida. It is the southernmost of a linearly aligned series of lakes extending some 200 miles north along the axis of the peninsula. According to White (1970), these lakes "...comprise the longest smooth line of genetically associated lakes in the United States." Another important geological feature of the lake is the thick bed of sediments that has been deposited in the deeper part of its basin. Lake Annie is the only known lake on the southern coastal plain with a history of continuous sedimentation since the Pleistocene (Watts, 1975). Dating by radioactive isotopes has revealed the age of the oldest sediment layers thus far sampled to be 44,000 ± years (David Frey, personal communication). Studies of fossil pollen at different levels in sediment cores from the lake bottom enabled Watts (1975) to reconstruct the vegetational history of the region from 37,000 ± years ago to the present. In addition, exoskeletal remains from such cores have provided further insight into the evolutionary and zoogeographic history of certain invertebrate animal groups.

J. Belle (1978) has also pointed out that Lake Annie and other aquatic habitats of Highlands County are of particular significance from the standpoint of their odonate (dragonfly) fauna because they lie between the subtropical southern part and more temperate northern part of the peninsula.

Among the lake's interesting limnological features is the development of stable thermal stratification at certain times of the year (Eckblad et al., 1974; McDiffett, 1978), a relatively rare phenomenon in Florida lakes. It is
also remarkable for its pristine water quality, being one of the purest and least modified by human influence of any body of water in southern Florida. Factors contributing to the exceptional water quality of the lake include 1) its position at the head of the drainage system, 2) a small drainage basin with little surface flow into the lake, and 3) absence of development around the lake. As a result of this unusual combination of factors, Lake Annie is not only of basic scientific importance in that it represents what was probably the primitive condition of all the lakes of the southern ridge area but also provides a valuable baseline for monitoring trends in the quality of other surface waters in the region.

The lake contains a diverse assemblage of organisms, including several rare forms and species with very limited geographic ranges. An example of the latter is an undescribed species of chydomid cladoceran (a type of small crustacean) known only from Lake Annie (David Frey, personal communication).

The lands surrounding the lake are also of considerable ecological interest and significance. The major vegetative type represented is scrub, one of the most unique habitats of Florida. In many parts of the state scrub has already been eliminated or is rapidly being destroyed by development. An impressive number of endemic plant and animal species, many of which are listed on federal or state rare and endangered species lists, are associated with this habitat type. Among the rare and endangered species that are thus far known to have established populations in the Lake Annie tract are the Florida scrub jay, Florida mouse, gopher tortoise, eastern indigo snake, Florida scrub lizard, and the scrub St. John's wort. Bald eagles are occasionally seen at the lake and have nested less than two miles away.
In addition to its outstanding environmental and scientific values, Lake Annie is an uncommonly beautiful lake, with its clear waters, stretches of white sand bottom, smoothly-curved shoreline bordered by tall pines, and natural setting. A high wooded bluff along the north shore affords especially attractive vistas of the lake and surrounding native landscape.

This report summarizes available knowledge of the geological, physical, and biological features of the lake and surrounding land area, which are here jointly referred to as the Lake Annie Tract. The major sources of information on the Lake Annie Tract are studies made by visiting investigators and staff members at the Archbold Biological Station. Reports by the following workers have been particularly helpful: Belle (1978), Eckblad et al. (1974), Fitzpatrick and Moskovits (1979), Linzey and Linzey (1975, 1976), McDiffett (1977a, 1977b, 1978, 1979), Nester (1976), Watts (1975), and Werner et al. (1978).

Acknowledgments. Permission for visiting scientists and personnel of the Archbold Biological Station to conduct research on the Lake Annie Tract was generously given by the owner of the property, Consolidated-Tomoka Land Company. Mr. J. F. Holsonback, Vice President and Treasurer of the company, has been particularly cooperative in allowing access to the property for scientific studies.

LOCATION AND BOUNDARIES

Lake Annie is located in the southern part of Highlands County, approximately 6 miles south of the town of Lake Placid (lat. 27 12 35, long. 081 20 57) (Fig. 1). It lies immediately to the south of State Route 70 and west of the
Figure 1. Location of Lake Annie Tract (stippled area) and adjoining Archbold Biological Station (hatched area). Inset map shows general geographic location of the site.
Seaboard Coast Line track. Parts of the lake are contained in sections 31 and 32, T37S, R30E and sections 5 and 6, T38S, R30E (Childs Quadrangle, USGS). The Lake Annie Tract is considered to be the parcel of land that includes the lake and is bounded by State Route 70 on the north, the northern boundary of the Archbold Biological Station on the south, the Seaboard Coast Line right-of-way on the east, and the half section line running north and south of sections 31 (T37S, R30E) and 6 (T38S, R30E) on the west (Fig. 2). The tract lies mainly in section 6, but also includes small portions of sections 5, 31, and 32. It consists of approximately 240 acres, of which about 90 are water and 150, land.

HISTORY

The region around Lake Annie was inhabited by Caloosa Indians in pre-Columbian and pre-Seminole times (Park DeVane, personal communication). Pottery of the Belle Glade Plain type of the Okeechobee-Kissimmee area representing a period somewhere between the first and seventeenth centuries A.D. has been found in a midden at Henscratch, a few miles north of Lake Annie (Bishop, 1956). Food remains collected from the same midden indicated that the Indians hunted and collected shellfish in the region. Marine shells were also present, suggesting trade with the coasts. Park DeVane (personal communication) and his sons, Thomas and Howard, collected an arrowhead and pottery fragments of the Glades type along the shore of Lake Annie in April 1961. The arrowhead was of the type of flint that outcrops in the Hillsborough County, Florida area.

The region was later occupied by the Seminole Indians, who were attracted to the clear lakes and sand hills by the abundance of fish and game. They
Figure 2. Lake Annie Tract (stippled). Boundary of Archbold Biological Station indicated by heavy dashed line.
referred to a site, probably on the west side of Lake Placid several miles north of Lake Annie, as "Okee-he-thi", which means Good Water (Devane, 1978). Following the end of the Second Seminole War in 1842, a large section of southern Florida, including the Lake Annie Tract, was established as a reserve for the Seminoles. However, white squatters soon began to encroach on these lands, and by the 1850's a number of settlers had moved into the Lake Placid area (Devane, 1978). The Seminoles continued to inhabit the region until the beginning of the Third Seminole War in 1856, when they moved south into the Everglades. After the Civil War, in the 1870's and 1880's, some of the Seminoles returned to the region in the vicinity of Lake Istokpoga and Fisheating Creek. About 1908, under pressure from the white settlers, Congress removed the lands from the reservation and opened them to homestead (Devane, 1978).

In 1881, a group headed by Henry Disston, who had made his reputation as a saw manufacturer, arranged to purchase 4 million acres of so-called swamp and submerged lands from the state at 25 cents an acre. The lands involved in the transaction extended from the Kissimmee and Caloosahatchee basins to the coast and included most of the Lake Annie Tract. Disston planned a large-scale drainage program, but the scheme failed and he died in 1896. Around 1900, Consolidated Land Company headed by Walter F. Coachman acquired part of the Lake Annie Tract and other lands in the region from the heavily-mortgaged Disston estate (Devane, 1978). In 1923, Consolidated Land Company obtained the patent on the lands in sections 31 and 32 bordering the north side of the lake and a small portion of section 6 on the southeast side of the lake from the U. S. Government. The Consolidated Land Company became Consolidated Naval Stores in 1931 and Consolidated-Tomoka Land Company in 1967.
The first surveys of the Lake Annie Tract were made by John Jackson in 1859 and J. W. Childs in 1870. Childs named the lake in honor of his wife (DeVane, 1978). These early surveys did not correctly show the boundaries of the lake. The true meander line of the lake was established by a resurvey in 1920 by A. W. Brown, who included a general description of the lake in his field notes.

There is no record of any early settler living around Lake Annie, although there was a road camp on the lake in 1922 during the construction of a graded road, the Dixie Highway, to Arcadia (DeVane, 1978). A stretch of this old road still exists on the property. Prior to the improvement of the road, the stretch in the vicinity of Lake Annie was deep sand. According to Park DeVane (personal communication), Thomas Edison, Henry Ford, and Harvey Firestone got stuck there about 1918 or 1919 while on a trip from Ft. Myers scouting for goldenrod, which Edison was interested in as a potential source of rubber. When the local filling station operator arrived to dig them out, he found them sitting hot and exhausted on the shore of Lake Annie.

The only man-made structure on the lake is the remains of an old dock built in the 1930's by John Roebling, who had purchased a 1,000-acre tract southeast of the lake for an estate. This property, now part of the Archbold Biological Station, was known locally as "Red Hill." According to James Perviss, a long-time resident in the area, Roebling also constructed a small wooden bathhouse near the dock, and one of his employees may have lived there for a while.

PHYSIOGRAPHIC RELATIONSHIPS

Lake Annie lies in the Intra Ridge Valley of the Lake Wales Ridge (Fig. 3). The latter is the most conspicuous topographic feature of peninsular Florida.
Figure 3. Physiographic regions of southcentral peninsular Florida. Arrow indicates location of Lake Annie. (Source: White, 1970).
It is a long, narrow projection extending southward in the center of the peninsula from the more extensive uplands of northern Florida. The Ridge has a gently rolling relief, with elevations ranging from 40 to over 200 feet in the general vicinity of Lake Annie. The toe of the Ridge lies at about 100 feet above mean sea level, the approximate elevation of the Pleistocene Wicomico Sea. The eastern scarp of the Ridge is relatively straight and steep, whereas the western margin is more irregular and slopes off more gradually. The southern end curves westward, as does that of the Florida peninsula itself. The southern portion of the Lake Wales Ridge in the general region of Lake Annie is bounded by three major physiographic regions: the Caloosahatchee Incline, DeSoto Plain, and Okeechobee Plain (White, 1970).

The Caloosahatchee Incline borders the eastern and southern end of the Ridge south of Lake Istokpoga. It slopes gently downward from the toe of the Ridge at an elevation of 50-60 feet to 30-55 feet. For a distance of about 10 miles south of Lake Istokpoga, the Caloosahatchee Incline is about 1 1/2 to 2 miles wide but beyond this point broadens to a width of 5 to 6 miles.

The Okeechobee Plain lies to the east of the Caloosahatchee Incline. It slopes gently southward from an elevation of 30-40 feet at its northern boundary to 20 feet at the north shore of Lake Okeechobee.

The DeSoto Plain abuts the Lake Wales Ridge on the west. Like the Okeechobee Plain, the DeSoto Plain is a very flat expanse of land slightly inclined to the south. Its elevations range from 75-85 feet at its northern border where it meets the Polk Upland to 60 feet at its southern juncture with the Caloosahatchee Incline. According to White (1970), the Caloosahatchee Incline and DeSoto Plain, both characterized by level, featureless topography, are remnants of a well-preserved relict submarine shoal formed in the lee of the Ridge at times of higher sea level.
Davis (1943) recognized somewhat different physiographic divisions in the southern Lake Wales Ridge region. In addition to the Highlands Ridge (= Lake Wales Ridge), these included the Istokpoga-Indian Prairie Basin, Eastern Flatlands, and Western Flatlands. The Western Flatlands region corresponds to the DeSoto Plain. The Istokpoga-Indian Prairie Basin includes the Caloosahatchee Incline and western portion of the Okeechobee Plain, while the remainder of the Okeechobee Plain corresponds to the Eastern Flatlands region.

Reflecting their topographic features and elevations, the physiographic regions vary in their soils and natural vegetation. The Lake Wales Ridge is characterized by generally deep, well-drained sandy soils supporting scrub-type vegetation, whereas the soils of the Caloosahatchee Incline and DeSoto and Okeechobee plains are less well drained; and the predominant vegetation types include pine flatwoods, wet and dry prairies, live oak-cabbage palm hammocks, marshes, and bayheads.

As noted earlier, the Intra Ridge Valley of the Lake Wales Ridge is occupied by a series of lakes, of which Lake Annie is the most southerly, forming a smooth line some 200 miles in length. These lakes were formed by solution of underlying limestone and collapse of the overlying materials and tend to have outlines that are circular or composed of smooth intersecting arcs, which are characteristic of sink-hole formations. The linear arrangement of these lakes suggests that their formation was controlled by some common factor. White (1970) concluded that the lakes are first generation sinks formed subsequent to the sea level transgression that produced the relict beach ridges associated with the Lake Wales Ridge. He suggested two ways by which a common linear orientation could have been imposed during the formation of the lakes. The simplest explanation is that linearly arranged relict beach ridges controlled drainage into adjacent swales and facilitated solution of underlying limestone in these lower areas, thus producing
the linearly aligned series of lakes. The alternative hypothesis involves topographic inversion. It supposes that the early limestone landscape had a varied topography of sinks and valleys produced by differential erosion and that during a later higher stand of sea level sediments deposited on the submerged limestone filled in the low spots and were graded flat on top. Thus, the sediments would be thin over the buried limestone "uplands" and thick in the former "valleys". A subsequent lowering of the water table through uplift or drop in sea level would have increased solution in the underlying limestone. As solution effects would be more pronounced in the buried uplands because of their thinner layer of sediments, these areas would become valleys, while the previous topographic lows, now protected by a thicker layer of sediment, would become the uplands. White does not elaborate on the process by which lineation of the original limestone valleys and uplands, which would seem to be a prerequisite of the topographic inversion hypothesis, was achieved.

The Intra Ridge Valley is about 2 miles wide in the vicinity of Lake Annie and continues southward for several more miles. South of Lake Annie the valley is characterized by numerous shallow depressions, many of which are more or less circular in outline, that may become temporary ponds during wet weather. These depressions appear to be the result of both sediment deposition patterns when the area was covered by a shallow sea during the Okefenokee Sea level stage and subsequent solution of underlying limestone and sinking of the overburden following lowering of the water table when the sea retreated. A small permanent pond in one of these depressions about 4 miles south of Lake Annie represents a deeper sink hole that seems obviously related to the Intra Ridge Valley lake system.
The lakes in the southern end of the Lake Wales Ridge are part of the Lake Okeechobee-Everglades drainage basin. Those from Lake Jackson at Sebring south to Lake Annie drain into Lake Istokpoga through Josephine Creek. Lakes Annie, Placid, June-in-Winter, and Francis, known locally as the West Chain of Lakes, drain north through Jack Creek, a tributary of Josephine Creek (Fig. 4). Historically, Lake Istokpoga was connected to the Kissimmee River by Istokpoga Creek, and also during times of high rainfall water overflowed the southern end of the lake and moved by sheet flow to Lake Okeechobee. Drainage from Lake Istokpoga is now controlled. Some of the flow is to the Kissimmee River via the Istokpoga Canal, but the major path of the drainage is through the C41A canal, which branches southeast of the lake into the Harney Pond and Slough Ditch canals. The Slough Ditch Canal drains into the lower Kissimmee River, while the Harney Pond Canal empties directly into Lake Okeechobee.

GEOLOGY

The Lake Wales Ridge appears to be a residual highland comprised of marine sands, clays, marls, and sandy limestones of the Hawthorn formation resting on limestone and capped by a layer of fluvial sediments, the Citronelle formation, that once covered a more extensive area and which originated from streams flowing out of the old continental land mass to the north at times of higher sea level. The surface of the ridge is almost everywhere covered with a mantle of sand of varying thickness derived from wind and wave action during higher stands of the sea in the Pliocene and Pleistocene. The Lake Annie tract is located in one of the major sand dune zones that are located along the Lake Wales Ridge (White, 1958).
A geologic cross section extending east to west through Lake Annie given by Bishop (1956) shows a thin layer of sand in the valley and a much thicker mantle on the higher ground to the east and west. The Hawthorn (Citronelle) formation extends to the Suwannee limestone of Oligocene age at a depth of about 450 feet. Below approximately 550 feet, limestones of Eocene age begin. These include the Ocala, Moodys Branch, Avon Park, and Lake City series. In a well about 3 miles south of Lake Annie, limestone occurs from a depth of 680 feet to the bottom of the well at 1550 feet (Bishop, 1956). Kohout and Meyer (1959) indicated that the basin of Lake Annie lies mostly in white, white-gray, and cream sand beds, barely reaching the underlying tan-gray and cream clay beds. Below this level are three more beds of sand and clay extending to a depth of about 90 feet. These are followed by six additional strata of clays, with a bed of dark green clay forming a floor over the limestone, which lies at a depth of about 500 feet.

LAKE MORPHOMETRY, BOTTOM TYPE, AND DRAINAGE PATTERN

Lake Annie is egg-shaped with its longest axis oriented northeast-southwest (Fig. 5). The larger end of the lake lies to the southwest and the smaller end to the northeast.

The surface area is approximately 90 acres. Specific values given by various sources include 0.13 square miles (82.3 acres) (Bishop, 1967); 86 acres (Fla. Board of Conservation, 1969); 86.8 acres (Eckblad et al., 1974); and 90.2 acres (present study). The Fla. Board of Conservation (1969) value was determined by planimetry from the topographic quadrangle map, whereas the last two values were obtained by planimetry of different aerial photographs.
Figure 5. Lake Annie and surrounding area.
of 1:4800 scale. The variations are probably due to measurement errors, errors in map scales, and variation in the lake stage at times the photographs or maps were made. Other morphometric parameters for the lake given by Eckblad et al. (1974) are: maximum length, 2800 feet, length of shoreline, 7660 feet; mean depth, 29.9 feet; maximum depth, 68 feet; and volume, 113,400,000 cubic feet. These workers also prepared a bottom contour map at 6-foot intervals (Fig. 6). The lake has a relatively uniform, cone-shaped deep basin in the southwestern end and a shallow bay in the northeastern end. The greatest depth recorded was in the approximate center of the western basin.

The shoreline development (ratio of perimeter of the lake to the circumference of a circle with the same area) is 1.11 (Eckblad et al., 1974). This value indicates a fairly regular shoreline, as a value of 1 is given by a perfectly circular outline and the higher the value above 1, the more irregular the outline. Eckblad et al. (1974) also calculated a development volume index for the lake of 1.32, which indicates a rather u-shaped basin; a value of 1 indicating a cone-shaped basin. They noted that a volume index for only the deeper western basin, excluding the shallow bay at the east end, would probably yield a value below 1, which was typical of the deeper solution lakes studied by Shannon and Brezonik (1972) in north and central Florida.

As is true of the other lakes in the Intra Ridge Valley, the level of Lake Annie reflects the level of the water table (Kohout and Meyer, 1959) and will thus vary with the ground water level. Ground water levels in the vicinity of Lake Annie may fluctuate as much as 4 1/2 feet depending upon rainfall, with maximum height of the water table occurring in September-October and minimum, July-August (Kohout and Meyer, 1959). The Childs Quadrangle gives the elevation of the lake as 111 feet above mean sea level. Based on the landward termination
Figure 6. Bottom contours (upper) and vertical profile (lower) of Lake Annie basin. (Source: Eckblad et al., 1974).
of a well-developed zone of beach stratification, Bishop (1967) determined the high water line to be 111.3 feet. During a 13-year record (October 1951-September 1964) of lake levels, the surface stood at or above the high water line 18 percent of the time, with a range of levels during this period from about 110.3 to 115.2 feet. For about 70 percent of the time, the surface was between 111 and 112 feet. Because of its upstream location and generally undeveloped basin, Lake Annie has a more stable water level than many of the lakes downstream which have been variously modified by water control structures and are affected by pumping for residential or agricultural water supplies.

Evidence from studies of the sediments indicate that during its geological history Lake Annie has experienced drastic fluctuations in water level. According to Watts (1975), during the period from about 13,010 to 4,715 years before present (B.P.) Lake Annie was reduced to a small, shallow pond with an abundance of aquatic and wetland vegetation. Other Florida lakes were dry at this time.

Bishop (1967) presented a tentative classification of lake shorelines in Florida in which eight classes were recognized. The shoreline of Lake Annie is considered to represent the Class 2 type - consequent shoreline (Fig. 7). This type of shoreline is probably characteristic of youthful lakes or younger parts of older shorelines and is typical of sink-hole lakes found at higher elevations in the state. Such lakes are formed by the collapse of the land surface into cavities in the underlying limestone caused by solution. The lakes may grow by further subsidence or collapse of sections of the shoreline or divides between originally separate lakes. Typical features of consequent shorelines are: 1) continuation of the slope of the upland into the lake without any marked evidence of wave action on the soil, 2) absence or scarcity of aquatic trees, 3) little or no muck between high and low water levels, and 4) upland vegetation line at or near the mean high water line.
Figure 7. Stages in the formation of a lake with consequent shoreline. (Source: Bishop, 1967).
The bottom of Lake Annie varies from sand to organic sediments. There are extensive areas of white sand along the shore, and Werner et al. (1978) found little organic matter on the sandy bottom down to a depth of about 13 feet. However, the bottom at the mouths of the two influent ditches is covered with a layer of muck, which gives off hydrogen sulfide when disturbed. Eckblad et al. (1974) reported the organic content of the substrate at depths of 2 to 40 feet to range from 1.02 to 4.93 percent, with the maximum value occurring at 40 feet. H. E. Wright and R. W. Combs obtained an 11-meter (36 ft.) sediment core in water 18.5 meters (61 ft.) deep (Watts, 1975). Watts (personal communication) indicated that there were still additional sediment layers below the bottom of the core. The sediment was relatively homogeneous fine brown algal mud with sand grains of increasing frequency toward the base of the core (Watts, 1975). Another core from slightly shallower water had sand lenses with an abundance of seeds and other coarse plant material at a depth of 25.4 to 27.2 meters (83.3-89.2 ft.) below the present lake surface (Watts, 1975). Frey (personal communication) pointed out that the steep conical shape of the basin is conducive to accumulation of sediments.

The banks are well-defined, ranging from about 1 to 3 feet in height. They are generally steeper on the northern and western sides than along the eastern and southern parts of the shoreline. A number of stumps and dead stubs occur along the edge of the lake. Some of the stumps are out in the water 5 to 6 feet from shore and some dead stubs have toppled into the lake as a result of erosion of the banks. Evidence of erosion appears most pronounced along the northern shore.

A shoreline profile on the northeast shore studied by Bishop (1967) showed a layer of light gray, thinly stratified, well-sorted quartz sand with mean grain
size of 0.437 millimeter overlying dark gray, poorly-sorted, very carbonaceous quartz sand with mean grain size of 0.371 millimeter up to an elevation of 111.3 feet. Upland plants such as slash pine (Pinus elliottii) and saw palmetto (Serenoa repens) extended down to 111.6 feet elevation.

Lake Annie has a drainage basin of 5.7 square miles (Fla. Board of Conservation, 1969). Most of the water that enters the lake is through ground water flow, mainly from the south and west (Kohout and Meyer, 1959). The lake has no natural surface streams flowing into it. However, two shallow ditches dug about 1930 drain into the lake on the south and southeast sides. The south ditch originates on the Archbold Station property and is about 2,200 feet long from its junction with the ditch along the west side of the railroad track to its mouth. The ditch entering the southeast side of the lake also originates on Archbold property and is connected to a canal system on agricultural and industrial lands between the railroad and State Route 17. It is approximately 700 feet long from the outlet of the culvert under the track to the point where it enters the lake. Flow of water in these ditches is intermittent. The lake has an uncontrolled natural outlet along the north shore (Fig. 8). The stream passes through a culvert under State Route 70 about 200 feet from the lake and enters Lake Placid about 1 mile to the north. The remains of the old dock built by John Roebling are located just west of the outlet.

PHYSICAL AND CHEMICAL CHARACTERISTICS

The major sources of data on the physico-chemical features of Lake Annie are the reports of McDuffett (1977a, 1977b, 1978), who studied the lake from September 1976 to July 1977, and Eckblad et al. (1974), who investigated the
Figure 8. Upper: Lake Annie outlet viewed from lake. Lower: Outlet looking toward lake (south) from highway.
lake from 11-22 January 1974. Additional information is contained in U. S. Geological Survey water-data reports for Florida and in an analysis of historical water-quality data by Goolsby et al. (1976). Information on a number of physical and chemical parameters of Lake Annie is summarized in Table 1. Data for two of the lakes, Placid and Francis, downstream of Lake Annie are also included for comparison.

Temperature

Lake Annie is the only one of the three lakes known to develop stable thermal stratification. In McDuffett's (1978) study the lake was thermally stratified from March through October and well-mixed the remainder of the year. In midsummer the maximum temperature differential between the epilimnion and hypolimnion was 14°C, and the thermocline was located at a depth of about 6 to 8 feet. Eckblad et al. (1974) found the lake to be thermally stratified on two dates in January 1974. The thermocline was located at a depth of approximately 15 feet. According to McDuffett (1978), the occurrence of stable thermal stratification in Lake Annie, a relatively uncommon condition in Florida lakes, is facilitated by the lake's small surface area, considerable depth, and protection from the mixing action of wind by a well-vegetated shoreline.

Clarity

Lake Annie is by far the clearest of the three lakes compared in Table 1. During the period of McDuffett's (1978) study, transparency was higher in May-June and October-November and lower from late fall to early spring (November-April). In addition to the values in Table 1, Eckblad et al. (1974) obtained a
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<td></td>
</tr>
<tr>
<td>Dissolved inorganic phosphorus (ug/l)</td>
<td>Mean 1.0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Range 0-2.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total dissolved phosphorus (ug/l)</td>
<td>Mean 3.7</td>
<td>3.9</td>
<td>7.0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Range 0-10.0</td>
<td>0-14.0</td>
<td>0-16.0</td>
<td></td>
</tr>
<tr>
<td>Total phosphorus (ug/l)</td>
<td>Mean 7.5</td>
<td>20.0</td>
<td>49.0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Range 7.0-8.0</td>
<td>13-22</td>
<td>41-56</td>
<td></td>
</tr>
</tbody>
</table>
Table 1. concluded

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Lake Annie</th>
<th>Lake Placid</th>
<th>Lake Francis</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bicarbonate (HCO₃) (mg/l)</td>
<td>2</td>
<td>7</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td>Carbonate (CO₃) (mg/l)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Dissolved silica (SiO₂) (mg/l)</td>
<td>0.4</td>
<td>0.2</td>
<td>9.5</td>
<td>3</td>
</tr>
<tr>
<td>Dissolved chloride (mg/l)</td>
<td>6.5</td>
<td>11</td>
<td>16</td>
<td>3</td>
</tr>
<tr>
<td>Dissolved calcium (mg/l)</td>
<td>1.1</td>
<td>2.3</td>
<td>5.7</td>
<td>3</td>
</tr>
<tr>
<td>Dissolved magnesium (mg/l)</td>
<td>0.5</td>
<td>1.9</td>
<td>5.9</td>
<td>3</td>
</tr>
<tr>
<td>Dissolved sodium (mg/l)</td>
<td>3.8</td>
<td>6.6</td>
<td>9.4</td>
<td>3</td>
</tr>
<tr>
<td>Dissolved potassium (mg/l)</td>
<td>0.4</td>
<td>1.1</td>
<td>2.7</td>
<td>3</td>
</tr>
<tr>
<td>Dissolved sulfate (SO₄) (mg/l)</td>
<td>3.1</td>
<td>7.8</td>
<td>19</td>
<td>3</td>
</tr>
<tr>
<td>Dissolved fluoride (mg/l)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Dissolved strontium (µg/l)</td>
<td>70</td>
<td>80</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>Dissolved solids (residue at 180°C) (mg/l)</td>
<td>22</td>
<td>42</td>
<td>84</td>
<td>3</td>
</tr>
<tr>
<td>Dissolved solids (sum of constituents) (mg/l)</td>
<td>17</td>
<td>34</td>
<td>65</td>
<td>3</td>
</tr>
</tbody>
</table>

*Sources:

2. McDuffett (1977b): Values based on approximately monthly samples between September 1976 and July 1977 except for dissolved inorganic P and total P which are based on two determinations.
Secchi disc depth of approximately 14 feet in January 1974, and the U. S. Geological Survey (1978) reported values of more than 12.2 feet, 19.0 feet, and 22.0 feet, respectively, in January, May, and August 1977.

\[ \text{pH} \]

Lake Annie has significantly softer water than other lakes in the southern Ridge section, perhaps as a consequence of the presence of a relatively large amount of decomposing plant material and a very low buffer capacity (McDiffett, 1977b). Seasonal variation in pH was evident in McDiffett's (1977b) measurements, with higher values occurring from September through March and lower values from April through June. The tendency toward lower pH during the warmer time of year perhaps reflected an increased rate of decomposition during this period.

\[ \text{Dissolved Oxygen} \]

All lakes in Table 1 have mean oxygen concentrations near saturation. As expected, dissolved oxygen exhibits an inverse correlation with water temperature, reaching a maximum in January and February (McDiffett, 1977b). However, Lake Annie had lower oxygen concentrations than Placid and Francis during the period September 1976 through February 1977, perhaps because of less effective mixing by wind action. According to McDiffett (1977b), Lake Annie shows anaerobic conditions in the hypolimnion soon after stratification develops.

\[ \text{Conductivity} \]

Specific conductance, which provides an approximation of concentration of dissolved solids in water, of Lake Annie is very low. Values of specific conductance recorded for Lake Annie in addition to those in Table 1 include: approxi-
mately 25 micromhos per centimeter (umhos/cm) in January 1974 (Eckblad et al., 1974); 29, 65, and 40 umhos/cm in January, May, and August 1977, respectively (U. S. Geol. Surv., 1978); and a mean of 32 umhos/cm (S.D., 2) (Goolsby et al., 1976). In the latter study, Lake Annie had the lowest mean and least variable conductance of 50 sampling stations in lakes, rivers, and canals in the Lake Okeechobee-South Florida drainage system and Upper St. Johns and Indian river area. Mean conductance values for the other sampling stations included in this study ranged from about 75 to 1,430 umhos/cm.

Nutrients

Lake Annie is characterized by relatively low concentrations of nutrients. Compared with lakes Placid and Francis, it has somewhat higher levels of ammonia nitrogen and nitrate nitrogen and lower concentrations of total phosphorus (McDiffett, 1977b). Total organic nitrogen values for Lake Annie were much lower and less variable than those of Lake Placid and Lake Francis, based on three samples in different seasons in 1977 (U. S. Geol. Surv. 1978). McDiffett's (1977b) study showed a clear-cut seasonal cycle in nitrate nitrogen concentration in all three lakes, with the maximum level during January-February and considerably lower concentrations in the remaining parts of the year. He suggested that the winter peaks of nitrate nitrogen might reflect nitrification of ammonia nitrogen produced during fall and winter through decomposition of macrophytic vegetation. However, no corresponding decrease of ammonia nitrogen was seen during this period as would be expected on the basis of this hypothesis.

Other Chemical Constituents

As in the case of nitrogen and phosphorus, Lake Annie has relatively low concentrations of other chemical constituents (Table 1). This is reflected in
its low specific conductance values. In comparison with Lake Placid and Lake Francis, Lake Annie has concentrations of dissolved chemical constituents averaging half or less than Lake Placid, which in turn has values that are usually markedly lower than Lake Francis. Only in the case of dissolved silica does the concentration in Lake Annie exceed that of Lake Placid and approximate that of Lake Francis.

PRIMARY PRODUCTIVITY

McDiffett (1977b, 1978) estimated primary productivity in lakes Annie, Placid, and Francis by determinations of radioactive carbon ($^{14}$C) uptake by plankton samples and chlorophyll$_a$ concentration using acetone extraction of plankton and fluorometric analysis. The dominant phytoplankton in Lake Annie and Placid were green algae (Chlorophyta) and in Lake Francis, blue-green algae (Cyanophyta).

Average productivity in Lake Annie was 207.6 mgC/m$^2$/day compared with 117.3 and 562.1 in lakes Placid and Francis, respectively (Table 2). Considering the lower concentration of nutrients in Lake Annie, this finding of higher average productivity in Annie compared with Lake Placid is of particular interest. Although the basis for the greater productivity in Lake Annie than in Placid is not clear, McDiffett (1977b) concluded that it was not simply due to a larger photic zone in Annie that would result in higher integrated productivity values per unit area. The chlorophyll$_a$ concentrations show the expected sequence, i.e., Annie $<$ Placid $<$ Francis.

Peak productivities were recorded in all lakes in July, which in Lake Placid and Annie is probably due to increased solar radiation (McDiffett, 1977b).
Table 2. Daily and annual primary productivity estimates for lakes Annie, Placid, and Francis. (Source: McDiffett, 1978)

<table>
<thead>
<tr>
<th>Lake</th>
<th>Mean Primary Productivity (mgC/m²/day)</th>
<th>Mean Chlorophyll a Concentration (mg/m³)</th>
<th>Estimated Annual Planktonic Primary Production (gC/m²/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annie</td>
<td>207.6</td>
<td>2.9</td>
<td>75.8</td>
</tr>
<tr>
<td>Placid</td>
<td>117.3</td>
<td>6.4</td>
<td>42.8</td>
</tr>
<tr>
<td>Francis</td>
<td>562.1</td>
<td>17.5</td>
<td>205.0</td>
</tr>
</tbody>
</table>
Lake Annie and Lake Placid showed little seasonal variation in chlorophyll a concentration, whereas Lake Francis, which had higher concentrations at all times, showed a decline during late fall and winter and an increase in spring and summer (McDiffett, 1978). All three lakes exhibited an inhibition of carbon fixation at the surface, the effect being least in Annie. In keeping with its greater clarity and light penetration, Lake Annie exhibited production to a depth of about 10 meters (33 ft.), as compared to about 7 meters (23 ft.) in Lake Placid and 5 meters (16.4 ft.) in Lake Francis. Light extinction values (n/m) given by McDiffett (1978) were as follows: Lake Annie, 0.42; Lake Placid, 0.75; Lake Francis, 1.17.

Based on calculations by McDiffett (1978), estimated annual plankton productivity (75.8g C/m²/yr) in Lake Annie is about 77 percent greater than in Lake Placid and only about 37 percent of that of Lake Francis (Table 2).

Measurements of total phytoplankton cells and total organic carbon given by the U. S. Geological Survey (1978) for lakes Annie, Placid, and Francis in January, May, and August 1977 are shown in Table 3. In contrast to McDiffett's (1977b, 1978) results, these data indicate higher productivity in Lake Placid than Lake Annie.

TROPHIC STATUS

Based on its level of primary productivity, light transmission, and dominant phytoplankton, Lake Annie appears to be oligotrophic; it is mesotrophic in relation to its chlorophyll a characteristics (McDiffett, 1978).

<table>
<thead>
<tr>
<th>Lake</th>
<th>Month</th>
<th>Total Phytoplankton Cells (cells/ml)</th>
<th>Total Organic Carbon (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annie</td>
<td>Jan.</td>
<td>2,000</td>
<td>26.0</td>
</tr>
<tr>
<td></td>
<td>May</td>
<td>58,000</td>
<td>7.0</td>
</tr>
<tr>
<td></td>
<td>Aug.</td>
<td>2,300</td>
<td>0</td>
</tr>
<tr>
<td>Placid</td>
<td>Jan.</td>
<td>9,900</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>May</td>
<td>77,000</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>Aug.</td>
<td>170,000</td>
<td>13.0</td>
</tr>
<tr>
<td>Francis</td>
<td>Jan.</td>
<td>30,000</td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td>May</td>
<td>250,000</td>
<td>9.0</td>
</tr>
<tr>
<td></td>
<td>Aug.</td>
<td>180,000</td>
<td>8.0</td>
</tr>
</tbody>
</table>
RESPONSE TO NUTRIENT ENRICHMENT

McDiffett (1977b; 1978) reported on nutrient enrichment experiments on lakes Annie, Placid, and Francis. Four times in different seasons during 1976-77 measurements were made on the effect on productivity (carbon fixation) of phytoplankton and concentration of chlorophyllₐ in samples of surface water of each lake by enrichment with different amounts and combinations of phosphorus, nitrogen, and secondary sewage effluent. Variation in the relative magnitude of response to enrichment was seen among the lakes, the order being Francis > Annie > Placid. Lake Annie showed response to all combinations of nitrogen and phosphorus, but not to phosphorus alone. Maximum increased productivity was to doubled concentration of nitrogen and phosphorus, whereas in the other two lakes maximum response was to sewage enrichment. The reason for this was not clear. However, in some individual experiments (McDiffett, 1977a) Lake Annie did exhibit maximum response to sewage enrichment. Lake Annie agreed with the other two lakes in showing maximum response of chlorophyllₐ concentration to sewage enrichment.

BIOTA

Plankton


Three genera of zooplankton were recorded in Eckblad's study: Diaptomus, Bosmina, Cyclops, in addition to immature Nauplii forms, predominantly of
Diaptomus and Cyclops. No phytoplankton were detected in Lake Annie, whereas several phytoplankton genera were recorded in Lake June-in-Winter during the same period. Mean numbers of zooplankters at the four stations at depths of 3, 6.5, 35.5, and 40 feet ranged from 1.09 to 5.3 individuals/l, with no obvious correlation between numbers and depth. In order of overall abundance in all samples, the genera ranked as follows: Bosmina (5.52/l), Nauplii (3.58/l), Diaptomus, (2.32/l), and Cyclops (1.29/l). McDuffett (1979) listed 26 species of phytoplankton and 15 species of zooplankton (Appendix 1).

In addition to the taxa noted above, Frey (1978) recorded the occurrence of a new species, E. microdontus, of the highly distinctive genus Eurycerus (Cladocera Chydoridae) in Lake Annie and other lakes of the southern ridge section. He also is presently describing two new species of the genus Chydorus (Cladocera, Chydoridae) from the lake (personal communication). One of these apparently occurs only in Lake Annie, where it is known to have existed for 7,000 years.

The numbers of total Cladocera taxa and of chydorids alone recorded by Frey (1979) in four samples from littoral areas of the lake in March 1979 ranged from 7 to 9 and 7 to 8, respectively.

Benthos

Eckblad et al. (1974) obtained random bottom samples at depths ranging from 2 to 40 feet with an Ekman grab. Diatoms were the most abundant group found. Fourteen genera were recorded in addition to one unidentified form (Appendix 2). Tabellaria was the most abundant genus, and Cymbella was the only other genus that occurred with consistently high frequency in samples. There was no obvious correlation between depth and abundance or number of
genera. Other benthic organisms collected included Cryptomonas, Menidium, Trinema, Hartmanella, Nematoda, Hydracarina, Paramecium, Dileptus, Rotifera, and Euglena. These forms were rare and too few were collected to determine population levels.

McDiffett (1979) recorded eight benthic species in two phyla, Annelida and Arthropoda (Appendix 3).

Aquatic Plants

Emergent aquatic plants are limited to a relatively narrow zone averaging 17.7 meters (59 ft.) wide and extending to a depth of about 1.5 meters (5 ft.) (Werner et al., 1978). Views of the emergent zone are shown in Figure 9. The principal emergent species are maidencane (Panicum hemitomon) and umbrella grass (Fuirena scirpoidea). The emergent vegetation zone has patches of denser growth separated by areas of sparse or no emergent plants. Water lilies (Nymphaea odorata) and spatterdock (Nuphar advena) are frequent, particularly in coves. Thick masses of sphagnum moss occur in some areas, and water fern (Azolla) is locally abundant along the edge. A thick stand of primrose willow (Ludwigia peruviana) occurs at the mouth of the southeast ditch, and a dense mass of swamp fern (Blechnum serrulatum) obscures the outlet of the south ditch. The submersed vegetation zone has an average width of 13 meters (43 ft.) and consists largely of bladderwort (Utricularia) with lesser amounts of eel grass (Vallisneria) and club rush (Eleocharis) (Werner et al. 1978). Average percentage cover of macrophytes of the submersed zone was 99.7 percent between 1.5 and 3 meters (5-10 ft.); 50 percent at 3.5 meters (11.5 ft.); and nearly zero at 4 meters (13.1 ft.) (Werner et al., 1978). Eckblad et al. (1974) give additional notes on aquatic vegetation at various sampling stations around the lake.
Figure 9. Upper: Emergent vegetation zone on north side of lake at site of old Roebling dock. Lower: Emergent vegetation along north side of lake looking west.
Macroinvertebrates. Eckblad et al. (1974) sampled macroinvertebrates from living and decaying emergent and submergent vegetation at ten sites around the lake. They recorded 31 kinds of invertebrates representing four phyla (Appendix 4). The majority of the organisms were insects. The amphipod *Hyallela azteca* was the most abundant single species in the samples. Macroinvertebrates were more numerous at stations with decaying organic matter substrate than at stations with clear sandy bottoms.

Twenty-seven species of damselflies and dragonflies (Odonata) have been recorded from the lake by Belle (1978), Needham (1947), and Paulson (1966) (Appendix 5). One of the species, *Idiaptaphe cubensis*, collected by Belle had previously been known only from the extreme southern tip of the state.

Aquatic Vertebrates

All vertebrates known from the Lake Annie tract are listed in Appendices 6, 7, 8, and 9. Forty-four species associated with aquatic habitats have been recorded.

**Fishes.** Nester (1976) listed 19 species (one, spotted bass, *Micropterus punctulatus*, presumably in error) of fishes of ten families from Lake Annie (Appendix 6). Species of the family Centrarchidae and order Cyprinodontiformes predominate, comprising 68 percent of the total. Werner et al. (1978) confirmed the presence of 18 species and obtained quantitative data on species abundances and habitat distribution in the littoral zone by means of underwater censuses. Starhead topminnow and mosquitofish were the most abundant species in the emergent vegetation, and bluegill and brook silverside were the most numerous species in the submerged aquatic vegetation zone. In terms of biomass, however, the three dominant species in the entire littoral zone were the
bluegill, largemouth bass, and lake chubsucker. These species comprised 90 percent of the total biomass of the fishes regularly censused. All three species were most abundant in the submersed zone, but showed differences in their relative abundance in relation to depth. Overall abundance of bluegills increased with depth from 2 to 3.5 meters (6.6-11.5 ft.); whereas largemouth bass were most abundant at 2 meters (6.6 ft.), at the edge of the emergent zone. The lake chubsucker, which was found almost entirely in the submerged vegetation, showed no obvious depth preference within this zone.

With regard to trophic relationships, the fish fauna of Lake Annie was characterized by predominance of generalized feeders (bluegill and largemouth bass), with 8 percent of the biomass of coexisting species being represented by plankton feeders (golden shiner, brook silverside). This was in contrast to another lake studied, Lake Sirena, in which plankton feeders comprised less than 1 percent of the biomass while benthic feeders accounted for 25 percent of the community biomass. The differences appear to reflect structure of available habitats, fluctuations in water level, and differences in the pattern of productivity of the two lakes. Lake Sirena had a moderately rich benthic fauna, whereas Lake Annie appears to have a relatively sparse benthic fauna. Plankton-feeding fishes are typically intimately associated with macrovegetation. In Lake Annie the width of the vegetation zones allowed the small plankton feeders to be vertically segregated from other species in the upper layers (1-2 meters) of water in the submersed vegetation zone, whereas in Lake Sirena vegetation did not extend deep enough to permit such segregation of the small planktivores from the larger predatory species. Also, water level fluctuations are more pronounced in Lake Sirena than in Lake Annie.
Thus, a fall in water level in Lake Sirena coupled with the narrow vegetation zone, could force the small planktivores into more open water or a narrower vegetation zone, resulting in increased predation on them by larger carnivorous fishes.

Werner et al. (1978) compared Lake Annie with Michigan lakes of generally similar size, morphometry, and habitat structure and found that despite great differences in available species "pools" (more than three times the number of species available in Michigan) the fish community structures were comparable.

**Amphibians and Reptiles.** Linzey et al. (1975, 1976) listed three species of amphibians from the lake during surveys of the vertebrates of the lake and surrounding area in March 1975 and 1976. These included the southern cricket frog, southern leopard frog (tadpoles and adults), and pig frog. The bullfrog (*Rana catesbeiana*) was also heard calling (personal communication). They also observed three aquatic reptiles: the American alligator, peninsular cooter, and banded water snake.

**Birds.** Although waterfowl, wading birds, and other bird species primarily dependent upon aquatic habitats are not abundant on Lake Annie, a number of such species have been recorded. Linzey et al. (1976) listed anhinga, great blue heron, little blue heron, green heron, wood stork, mallard (presumably introduced), osprey, American coot, and belted kingfisher. Workers at the Archbold Biological Station have also observed double-crested cormorant, snowy egret, Louisiana heron, white ibis, mottled duck, wood duck, red-breasted merganser, bald eagle, spotted sandpiper, and solitary sandpiper on or around the lake.

**Mammals.** The only aquatic mammal definitely recorded from Lake Annie is the river otter (personal observations). This species is probably relatively frequent in the lake. Local fishermen have also reported mink (*Mustela vison*) in the lake,
but this appears to be very unlikely. Denser stands of maidencane in shallow parts of the lake offer potential, although not optimal, habitat for the round-tailed muskrat (*Neofiber alleni*).

FEATURES OF THE LAND SURROUNDING THE LAKE

Topography

The approximately 150-acre land area of the Lake Annie Tract is gently rolling with elevations ranging from between 130-135 feet along the southern boundary to below 115 feet around the lake (Fig. 10). Elevations along the south edge of the tract are generally 125 feet or more. About half the remaining area to the north is between 120 and 125 feet and the remainder between 120 and 115 feet. A high ridge with a crest of 125 feet or more borders the north shore of the lake west of the outlet, and less well-defined knolls and ridges with maximum elevations between 120 and 125 feet lie to the west and southeast of the lake. The lowest areas around the lake are at the outlet and at the northeast and northwest corners.

Soils

The physical land conditions map of the area (Florida Agr. Exper. Sta., Sheet 17) shows three soil types represented on the Lake Annie Tract. Soils of the St. Lucie series are found throughout the tract with the exception of the outlet and a small area of several acres in the low ground off the northeast corner of the lake. St. Lucie soils are excessively well-drained, very light, fine sands. The effective depth for plant root growth is 60 inches or more. The permeability of the upper layers is 50 or more inches per hour and
Figure 10. Topography of the Lake Annie Tract. Contour intervals in feet.
remains very high throughout the effective depth. The pH is moderately acidic (5.0-6.5), and very little organic matter is present.

Soils of the Myakka series occur in the area of the outlet. These are moderately deep (effective depth 20-30 inches), very light, fine sand soils with an underlying organic hardpan with sand below. Permeability in the upper sand layer is very rapid (10-20 inches/hr) and moderate (0.8-2.5 inches/hr) in the hardpan zone. The organic matter is low, and the pH strongly acidic (4.0-4.9). Under natural conditions these soils are moderately wet.

The low area off the northeast corner of the lake contains soil of the Placid series. These are deep (effective depth 36-60 inches), very light, strongly acidic (pH 4.0-4.9) fine sand, soils. They have high organic content and the underlying material is sand or sandy clay. Permeability is rapid (5-10 inches/hr). These soils are normally very wet under natural conditions.

Present Vegetation

I surveyed and mapped the vegetation of the Lake Annie Tract during the period 14 December 1978 - 8 January 1979. In addition, numerous plant specimens from the area collected from 1941 to the present are contained in the herbarium of the Archbold Biological Station.

Eight major vegetation types can be recognized on the site (Fig.11). These are described below, and their acreage and relative extent are given in Table 4.

Mixed Scrub. This is the most widespread vegetative association in the Lake Annie Tract, occurring on St. Lucie soils (Fig. 12, Upper). It is a xeric shrub-dominated association with an overstory of clumped or scattered south Florida slash pines (Pinus elliotti var. densa) or sand pines (Pinus clausa). Typical
Figure 11. General vegetation map of the Lake Annie Tract.
Table 4. Acreage and percentage of total land area of major vegetation types of the Lake Annie Tract.

<table>
<thead>
<tr>
<th>Vegetation Type</th>
<th>Acres</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed scrub</td>
<td>118.2</td>
<td>78</td>
</tr>
<tr>
<td>Flatwoods</td>
<td>15.0</td>
<td>10</td>
</tr>
<tr>
<td>Bayhead</td>
<td>2.6</td>
<td>2</td>
</tr>
<tr>
<td>Swamp thicket</td>
<td>8.0</td>
<td>5</td>
</tr>
<tr>
<td>Palmetto thicket</td>
<td>3.3</td>
<td>2</td>
</tr>
<tr>
<td>Live oak thicket</td>
<td>0.2</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Seasonal ponds</td>
<td>1.1</td>
<td>1</td>
</tr>
<tr>
<td>Ruderal</td>
<td>2.8</td>
<td>2</td>
</tr>
</tbody>
</table>
Figure 12. Upper: Mixed scrub vegetation south of lake. Lake visible in distance. Lower: Stand of sand pines in mixed scrub.
shrubs or small trees include myrtle oak (Quercus myrtifolia), Chapman's oak (Q. chapmannii), scrub oak (Q. inopina), scrub live oak (Q. geminata), rusty lyonia (Lyonia ferruginea), rosemary (Ceratiola ericoides), fetterbush (Lyonia lucida), scrub hickory (Carya floridana), and silk bay (Persea humilis). Tarflower (Befaria racemosa), prickly pear cactus (Opuntia compressa), saw palmetto (Serenoa repens), and scrub palmetto (Sabal etonia) are also frequent.

The mixed scrub association is far from uniform, exhibiting considerable site variation reflecting differences in elevation (and probably soil moisture), soil characteristics, fire history, and other factors. It is basically an intermixture of two vegetative types: sand pine scrub and scrubby flatwoods. Sand pine scrub is characterized by an overstory of sand pine and such shrubs as myrtle oak, scrub live oak, Chapman's oak, and rusty lyonia. Scrubby flatwoods contain many of the same shrub layer species as sand pine scrub but have slash pine, rather than sand pine, as the typical pine overstory species. The scrub oak (Quercus inopina) also is abundant in scrubby flatwoods and is one of the most characteristic species of this association in the southern Lake Wales Ridge region.

When they occur in juxtaposition, sand pine scrub and scrubby flatwoods often remain relatively clearly delimited. However, on the Lake Annie Tract, the two associations are extensively intermixed and, although typical areas of both types can be found, there is so much intergradation between them that any boundary drawn would be quite arbitrary. Thus, no attempt is made to distinguish between sand pine scrub and scrubby flatwoods on the vegetation map, although major concentrations of sand pines are indicated. The rather complete blending of typical scrub and scrubby flatwoods elements on the tract
is probably due to infrequent burning which has allowed sand pine to invade sites where it would normally be killed back by fire.

In general, sand pines and other typical sand pine scrub elements are found on the highest, driest elevations such as ridge crests or knolls. Where the sand pines form dense stands (Fig. 12, Lower), the principal understory species is palmetto, with shrubs coming in more abundantly in the more open areas peripheral to the stand. In elevated sites where pines are widely spaced or absent and much bare sand is present, rosemary attains greatest abundance. In some cases such sites are vegetated almost exclusively with rosemary. The height and density of the shrub layer of the mixed scrub shows considerable site variation, the shrubs being low and fairly widely spaced in some areas and taller and denser in others. The densest area of mixed scrub is on the ridge along the north shore of the lake. Species composition is also variable. Fetterbush, saw palmetto, and live oak tend to increase in lower areas, whereas scrub hickory is most frequent in more elevated situations.

**Flatwoods.** Typical flatwoods occupy lower, more poorly drained sites than mixed scrub (Fig. 13, Upper). They are characterized by relatively dense stands of slash pine with an understory ranging from nearly pure palmetto, to a mixture of palmetto and shrubs such as fetterbush and gallberry (*Ilex glabra*), to scattered palmetto and shrubs with a dense ground cover of wire grass (*Aristida stricta*). Palmetto-wire grass flatwoods occur in drier sites.

Flatwoods are mainly found around seasonal ponds and bordering the south ditch.

**Bayhead.** This association is restricted to low areas of muck soil at the northeast corner of the lake (Fig. 13, Lower). It is comprised of a dense tree
Figure 13. Upper: Flatwoods along south ditch at south boundary of tract. Lower: Bayhead vegetation along east side of lake.
layer of red bay (Persea borbonia), sweetbay (Magnolia virginiana), and an understory of elderberry (Sambucus simpsonii), royal fern (Osmunda regalis), greenbriar (Smilax), and other species.

Swamp Thicket. This association has many characteristics of bayhead vegetation but is dominated by dense shrubs and small trees rather than larger trees (Fig. 14). Waxmyrtle, dahoon holly (Ilex cassine), red bay, sweetbay, elderberry, fetterbush, and gallberry, are common woody species. Wild orange (Citrus) and guava (Psidium guajava) also occur infrequently. A single red maple (Acer rubrum) and two laurel oaks (Quercus hemisphaerica) were observed in the swamp thicket at the mouth of the south ditch. Slash pines and palmettos occur in drier areas. The understory consists of a dense mass of young shrubs and woody sprouts, swamp fern (Blechnum serrulatum), royal fern, muscadine grape (Vitis rotundifolia), saw palmetto, and other rank vegetation forming an almost impenetrable tangle.

Swamp thicket vegetation borders the lake (Fig. 14, Upper). Along most of the shoreline it forms a narrow zone about 5 to 10 feet wide. There is a rather abrupt transition to mixed scrub which borders the swamp thicket zone around most of the lake. The transition is marked by denser palmetto and live oak. The swamp thicket zone expands at the mouths of the influent ditches and borders the outlet stream. The lake is ringed with a rather uniformly-spaced line of mature slash pines growing at about the inner margin of the swamp thicket zone. The relatively close spacing of the pines along the edge of the lake contrasts with their generally more irregular and widely spaced distribution in the mixed scrub uplands beyond.

Palmetto Thicket. This association consists of dense stands of saw palmettos, often with occasional to frequent shrubs such as wax myrtle,
Figure 14. Upper: Swamp thicket vegetation bordering margin of lake on west side. Lower: Swamp thicket on northeast side of lake.
groundsel bush (*Baccharis halimifolia*), gallberry, and fetterbush, and vines (muscadine grape, greenbriar). *Sabal etonia* may occur with saw palmetto in palmetto thickets but is usually in the drier edge. The most extensive area of this habitat type is located on the east side of the lake. Seasonal ponds (see below) typically have a well-developed zone of palmetto thicket around them, but most of these are too limited in area to be mapped separately.

**Live Oak Thicket.** These are dense stands of live oaks ranging from low shrubs to small trees. Live oak thickets frequently occur around seasonal ponds just outside the palmetto zone. Only the more extensive areas of this association are mapped in Figure 11.

**Seasonal Ponds.** These are depressions that may become filled with water during wet periods (Fig. 15, Upper). Because of differences in elevation and soil, they vary considerably in wetness. Some probably contain water for part of each year, whereas some probably do not hold water except in unusually wet years. Seasonal ponds often have circular or oval outlines and are usually partly or entirely surrounded by a zone of dense palmetto thicket. Live oak thickets are often found along the outer edge of the palmetto zone. Six seasonal ponds occur on the Lake Annie Tract. One of these, in the low area off the northwest corner of the lake, is relatively deep, with a muck center and drier shelf. Abundant red root (*Lachnanthes caroliniana*) and sphagnum and scattered marsh fern (*Thelypteris normalis*) are found in the muck area, while the drier shoulder is covered with a dense growth of the grass *Panicum abscessum*. There is also a cluster of small (4 feet high) sweetbay and several small wax myrtles growing in the pond, indicating an early successional trend to bayhead association.
Figure 15. Upper: Seasonal pond with dense grass cover. Palmetto thicket zone visible in left foreground. Lower: Ruderal area along old road bed at northeast corner of tract.
The other seasonal ponds on the site are drier and are characterized by a thick growth of \textit{Panicum abscissum} throughout with some scattered St. John's wort (\textit{Hypericum edisonianum}). The seasonal pond shown in Figure 15 (Upper) is an example of this type.

\textbf{Ruderal.} Predominantly open sandy areas with grasses such as sandspur (\textit{Cenchrus}), centipede (\textit{Eremochloa ophiuroides}), natal (\textit{Rhynchelytrum repens}), and brome sedge (\textit{Andropogon}); prickly pear; and various weedy forbs occur along the abandoned roadbed between the lake and present highway and on sandy spoil banks along the southeast ditch (Fig. 15, Lower).

\textbf{Historic Changes in Vegetation}

Field notes of surveyors provide some indication of the nature of the vegetation of the Lake Annie Tract in earlier years. The first surveyor in the region, John Jackson in 1895, noted the presence of "oak scrub" and "bay gall" (= bayhead) in the vicinity of the lake. In 1870, J. W. Childs described the lands to the south of the lake as "light sand ridges" with "...small, scattering pine timber." A. N. Kimmel in 1917 reported that the area was generally covered with "...scattering yellow [slash] pine timber and palmetto." In 1920, A. N. Brown noted the vegetation was "flatwoods in character."

In 1922, Consolidated Land Company employed Mr. J. P. Little, a civil engineer and timber cruiser, to survey their lands (DeVane, 1978). He produced a series of maps of individual sections showing such details as bodies of water, roads, railroads, gulleys, and general vegetation types together with information on size classes and board feet of pine timber. Little's maps of the Lake Annie Tract, made available through the generosity of Mr. Park DeVane, show all of the land as "scrubby" except for a bayhead on the east side of the lake just
west of State Route 17 (an old branch of the Dixie Highway). His notes
described the scrubby area as having scattering short, small timber, although
he stated that a considerable amount was large enough to be cupped for resin
collection. An aerial photograph dated March 1933 shows the entire area
south of the lake covered by scattered, relatively evenly-spaced pines.

DeVane (1978) noted that in 1928 a sawmill owned by the Sherman Lumber
Company was moved to Hicoria and lumbering of the pines in the region began.
Another mill was located on the southeast side of Lake Placid along State
Road 8 (now 17). Prior to lumbering (between about 1922 and 1933) naval stores
and turpentine operations were conducted by Consolidated Land Company. Based
on photographs in the Archbold Biological Station files the area around Lake
Annie was probably logged between 1933 and 1935. Part of the bayhead lying
east of the lake was destroyed with the construction of the railroad, which was
completed in that area in 1916. A major portion of the bayhead remaining
between the railroad and State Route 17 was purchased by Winston Kelsey in 1945
and gradually cleared during the following years. Ditches were dug and the soil
used to build up the remaining land area, as much as 16 inches in some places.
The ditches range from about 3-4 to over 6 feet in depth and connect into the
southeast ditch extending north from the Archbold Biological Station property.

The remainder of the lands around the lake have remained undisturbed since
logging, except for periodic fires. Large numbers of trees were killed by some
of these fires. Beginning about 1933, the area was included in the state fire
protection project and the personnel of the Roebling Red Hill estate also
actively fought fires in the region. Nevertheless, the area was still occa-
sionally burned. A particularly severe fire, which killed many trees, swept
through the area in about 1935 or 1936 (James Perviss, personal communication). The area to the west and southwest of the lake was burned again in February 1939. Based on the sparse historical information available, the present condition of most of the vegetation of the Lake Annie Tract is generally similar to that when the first white men began to settle the region. However, the shrub layer may be denser and higher as a result of less frequent burning in recent times. Comparison with an aerial photograph from 1944 also indicates that pines have increased in density, particularly along the south ditch, since that time.

Late Quaternary Vegetation

Study of pollen from the sediments of Lake Annie have extended knowledge of the vegetation of the region back to 37,000 ± years before present (B.P.) (Watts, 1975). The pollen data indicate that from about 37,000 to 13,010 B.P. the area was much drier than now and that the predominant vegetation consisted of such xeric-adapted species as rosemary, jointweed (Polygonella spp.), and spike moss (Selaginella arenicola) on high, dry dunes. There may also have been some stands of oak scrub or dry woodland, coexisting with prairie-like vegetation in which composites, particularly ragweed (Ambrosia), were well-represented. However, soil moisture was probably too low to permit extensive development of oak scrub. It is of interest to note that those species such as rosemary, Polygonella spp., and spike moss, which were presumably widespread and abundant in the region during this period, are presently mainly restricted to the driest sandy knolls and ridges.

From about 13,010 to 4,715 B.P., dry dune species tend to drop out, and the species composition of the pollen suggests the vegetation consisted of sclerophyllous oak woodland or scrub and prairie rich in composites. There is no modern counterpart of such vegetation in Florida.
After about 5,000 B.P. the modern vegetation of oak scrub on the well-drained sandy areas and pine forests, bayheads and cypress swamps in lower areas was developed. Pine pollen becomes abundant, with oak gradually decreasing after 4,715 B.P. Pollens of such species as wax myrtle, cypress (Taxodium), holly (Ilex), loblolly bay (Gordonia lasianthus), and saw palmetto are also well represented. This assemblage suggests a forest dominated by pines along with cypress swamps and bayheads. The presence of pollen of oak and spores of spike moss document the occurrence of oak scrub in the vicinity of the lake. From about 2,630 B.P., cypress and pine pollen increase, while oak declines, indicating an expansion of cypress swamps in the area during this period. In this connection, it is of interest to note that cypress does not presently occur around Lake Annie or nearby lakes.

The vegetative reconstruction made possible by the sediment record of Lake Annie has contributed greatly to knowledge of Pleistocene and Holocene climates at low latitudes.

Terrestrial Vertebrates

In addition to the aquatic vertebrates listed earlier, 96 species of terrestrial vertebrates have been recorded from the Lake Annie Tract by Linzey et al. (1975, 1976) and personnel of the Archbold Biological Station. This list includes 10 species of reptiles (Appendix 7), 67 species of birds (Appendix 8), and 19 species of mammals (Appendix 9). The species of vertebrates presently known to occur on the Lake Annie Tract is based on limited field work, and more intensive surveys would undoubtedly reveal many additional species. Some indication of the potential number of vertebrate species that may be found as residents, migrants, or as casual transients on the
area is given by the check-lists compiled for the Archbold Biological Station located immediately to the south and containing similar habitats (with the exception of the lake). A total of 276 vertebrate species, exclusive of fishes, has been observed on the Archbold property. This number includes 20 amphibians, 40 reptiles, 178 birds, and 38 mammals. Thus, the known species of vertebrates, excluding fishes, of the Lake Annie Tract is only about one-third of the number that may potentially occur.

**Amphibians and Reptiles.** Amphibians and reptiles characteristic of the predominant habitat of the tract, mixed scrub association, include the oak toad, gopher frog, Florida scrub lizard, six-lined racerunner, black racer, coachwhip, and gopher tortoise. Other common amphibians and reptiles of this and other habitats of the tract are the pine woods tree frog, common toad, green anole, ground skink, and southeastern five-lined skink. One adult indigo snake has been observed, and the species is probably fairly common in the area.

**Birds.** Typical birds of the mixed scrub vegetation include the Florida scrub jay, rufous-sided towhee, brown thrasher, and white-eyed vireo, present year round, and the palm warbler, myrtle warbler, and blue-gray gnatchatcher, present in winter. Bobwhite, mourning dove, ground dove, common flicker, red-bellied woodpecker, great-crested flycatcher, blue jay, Carolina wren, catbird, yellowthroat, common grackle, and cardinal are additional common birds in the habitats found on the tract.

John Fitzpatrick and Debra Moskovits (1979) surveyed the scrub jay population of the tract in June 1979. They recorded 13 active territories, consisting of 36 adult jays, located partly or entirely in the tract. Four
territories were entirely contained within the tract. The approximate adult density was 5.2 pairs and 13.2 total individuals per 100 acres. Compared with the adjoining Archbold Biological Station where the species is being intensively studied, the Lake Annie tract has both higher population density and productivity, suggesting better overall habitat conditions. Fitzpatrick and Moskovits point out that if productivity is higher around the lake then these territories may serve as an important source of dispersing jays to surrounding areas where opportunities for replacing lost breeders may not be as good. In addition, the substantial scrub jay population of the Lake Annie tract probably contributes to maintenance of the genetic stability of the species in the general region.

Mammals. Linzey et al. (1975, 1976) surveyed small mammals in various habitat types around Lake Annie by means of live and snap trapping and general observation. Characteristic species of the mixed scrub association were the eastern mole, Florida mouse, old field mouse, cotton mouse, southern flying squirrel, and cotton rat. The following small mammals were recorded in other habitat types sampled:

Bayhead - gray squirrel, rice rat, cotton rat, cotton mouse, Florida mouse, black rat

Swamp thicket - short-tailed shrew, black rat, rice rat, cotton rat, cotton mouse

Seasonal pond - black rat, cotton rat

Larger mammals, such as opossum, raccoon, and bobcat, range through all habitats of the tract.

ENCROACHMENTS AND POTENTIAL THREATS

Past and present encroachments on the Lake Annie Tract have been minimal, and the lake and surrounding lands constitute exceptionally high quality
natural areas. Lumbering was the major environmental disturbance in earlier years, but the effects of this activity now appear to have been largely erased by natural reforestation.

Other encroachments include the two ditches extending across the property to the lake, the old roadbed between the lake and present State Route 70, old firebreaks, several sandy roads leading from the highway to the lake, a trail along the edge of the lake for about three-fourths of its perimeter, and a trail extending from the south boundary to the previous one. There are also a few small disturbed sites made by fishermen or campers along the edge of the lake.

Some littering occurs around the north and western sides of the lake where human activity is concentrated and scattered trash has accumulated on the land and beer and soft drink cans are often encountered in the water along the edge of the lake. However littering has not, at present, reached serious proportions, although it appears to be on the increase.

The north side of the lake is readily accessible from the highway and, although trespassing is discouraged, the lake receives moderate use for picknicking, swimming, boating, and fishing; and there is an indication that such activities are increasing.

Potential threats to the lake and surrounding area include increased use by the public, resulting in more trash, destruction of vegetation, and possible deterioration of the lake through pollution from use of motorboats or introduction of exotic water weeds such as hydrilla, which is already established in other lakes of the southern ridge area and is easily transported on boats and motors. Accidental or deliberate introduction of non-native fishes is another potential problem.
The two ditches entering the lake also provide a possible avenue of pollution. This is especially true of the one entering on the southeast side, as it drains an agricultural and industrial (asphalt mixing plant) area, and also receives runoff from the railroad embankment. However, the ditches do not appear to be having a significant impact on the lake at the present time. Water in the south ditch flowing from Archbold property was tested on several occasions in 1977-78 and was found to be of good quality. To my knowledge, similar tests of the water from the southeast ditch have not been conducted. The fact that the ditches do not flow continuously and are well vegetated, which provides good filtering capacity, further mitigates against their having a harmful impact on the lake. In addition, control structures on both ditches at their exits from the Archbold property are kept closed in order to retain as much water as possible on the Station lands.

The most serious potential threat to the Lake Annie Tract is development. Any large scale development around the lake would not only destroy most of the natural features of the uplands but, even with the most stringent precautions to protect the lake, would most likely ultimately result in a deterioration of the water quality and biota of the lake.

PRESERVATION AND MANAGEMENT POTENTIAL

The potential for preserving and managing the Lake Annie Tract to maintain and enhance its high environmental values is excellent. Because of its location at the beginning of the drainage system and limited surface inflow, the lake is subject to few influences external to its boundaries. Although the two ditches
entering the lake do not presently appear to be a significant problem, it would probably be advisable to close them. This could be accomplished with no harmful effect on adjacent land owners whose property is drained by the ditches. The major source of water to the lake is groundwater flow, and a significant portion of the area from which the groundwater flow is received is already protected as part of the Archbold Biological Station. Although the north shore of the lake is close to a well-travelled highway, the deep, sandy soil and dense scrub vegetation between the road and lake would appear to provide complete protection from highway runoff. At this time, there are no land uses around the periphery of the tract that would appear to represent a serious present or future threat to the environmental integrity of the lake and adjacent natural areas. The southern boundary and approximately the south half of the western boundary adjoin the Archbold Biological Station, where habitats are maintained in their natural state. The remainder of the west boundary is contiguous with undisturbed habitats similar to those included in the tract and extending one-half mile to the west. This parcel of land is also owned by the Consolidated Land Company. The area north of State Route 70 consists primarily of mixed scrub and bayhead vegetation and citrus groves. In addition, a small State Forestry Division tree nursery is located on the north side of the highway opposite the northwest corner of the tract. The most disturbed area in proximity to the Lake Annie Tract lies on the eastern boundary between the railroad and State Route 17. This land is crossed by a spur track and contains farms, a small industrial site (asphalt mixing plant), and a commercial building. The railroad right-of-way serves as a buffer between this developed area and the tract. There are no houses or other buildings, transmission lines, public road right-of-ways, or other developments within the tract that would complicate management of the property.
In summary, it is believed that the Lake Annie Tract as here defined is of sufficient size and configuration to adequately protect the lake and adjacent terrestrial habitats from any existing or future potentially adverse impacts from development or other land-use practices in the surrounding region.

On the basis of present knowledge of the lake and surrounding lands, the following minimum management measures to preserve the environmental integrity of the Lake Annie Tract are recommended:

1. Fencing the property and installation of locked gate(s) to more effectively control access and reduce littering and vandalism.

2. Closing the two drainage ditches entering the lake.

3. Prohibiting use of boats with motors on the lake.

4. Preventing accidental or intentional introduction of nonnative organisms into the lake.

5. Establish a program of regular monitoring of the physical, chemical, and biological conditions of the lake to insure early detection of any adverse trends in water quality.

6. Controlled burning of the uplands as required to maintain vegetation in the natural successional stages.
REFERENCES CITED


Appendix 1. Phytoplankton and zooplankton recorded from Lake Annie by McDuffett (1979).

PHYTOPLANKTON

Division Chlorophyta
Class Chlorophyceae
Order Volvocales
Family Desmidiaceae
Bambusina brebissonii var. gracilescens Wolle
Closterium sp.
Micrasterias fimbriata Ralfs
Micrasterias radiata var. gracillima G. M. Smith
Staurastrum cornutum Archer
Staurastrum Teptocladum Nordst
Order Oedogoniales
Family Oedogoniaeae
Oedogonium spp. (3)
Order Chlorococcales
Family Scenedesmaceae
Scenedesmus sp.
Family Botryococcaceae
Botryococcus sp.
Order Ulothricales
Family Ulothrichaceae
Ulothrix spp. (2)
Binuclearia tatraea Wittrock

Division Bacillariophyta
Class Bacillariophyceae
Order Naviculales
Family Naviculaceae
Navicula spp. (3)
Order Eupodisccales
Family Coscinodiscaceae
Stephanodiscus sp.
Order Fragilariales
Family Fragilariaceae
Synedra sp.

Division Chrysophyta
Class Chrysophyceae
Order Phaeoplacales
Family Synuraceae
Synura sp.
Family Dinobryonaceae
Dinobryon cylindricum Imhof.
Appendix 1. continued

Division Pyrrophyta
Class Dinophyceae
Order Peridionales
  Family Peridiniaceae
    *Peridinium wisconsinense* Eddy
  Family Ceratiaceae
    *Ceratium carolinianum* (Bailey) Jorgenson
Order Gymnodiniales
  Family Gymnodiniaceae
    *Gymnodinium* sp.

Division Cyanophyta
Class Cyanophyceae
Order Chroococcales
  Family Chroococcaceae
    *Apharocapsa* sp.
Order Oscillatoriales
  Family Oscillatoriaceae
    *Oscillatoria* spp. (2)

ZOPLANKTON

Phylum Rotifera
Class Monogonta
Order Ploima
  Family Brachionidae
    Subfamily Brachioninae
      *Kelliocottia bostoniensis*
    *Keratella cochlearis*
    *Keratella taurocephala*
      Keratella sp.
  Family Trichocercidae
    Trichocerca sp.
  Family Hexarthridae
    *Hexarthra* sp.
  Family Conochilidae
    *Conochiloides nutans*
    *Conochilus unicornis*
Appendix 1. continued

Phylum Arthropoda
Class Crustacea
Subclass Branchiopoda
Superorder Diplostraca
Order Cladocera
Suborder Eucladocera
Superfamily Sidoidea
Family Holopediidae
Diaphanosoma brachyurum
Superfamily Chydoroidea
Family Daphnidae
Daphnia sp.
Family Bosminidae
*Bosmina coregoni

Subclass Copepoda
Order Calanoida
Family Diaptomidae
*Diaptomus sp.
Order Cyclopoida
Family Cyclopidae
1 sp.

Class Arachnida
2 sp. water mite

*Species relatively abundant
Appendix 2. Benthic diatoms recorded from Lake Annie by Eckblad et al. (1974) as a percentage of total sample at a given depth.

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Phylum Annelida
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1 sp.

Phylum Arthropoda
Class Crustacea
Subclass Malacostraca
Order Amphipoda
2 spp.
Class Insecta
Order Odonata
Suborder Anisoptera
Family Gomphidae
1 sp.
Order Diptera
Family Culicidae
Subfamily Chaoboridae
*Chaoborus sp.
Family Ceratopogonidae
Subfamily Ceratopogoninae
1 sp.
Family Chironomidae
1 sp.
Order Ephemeroptera
Family Baetidae
1 sp.

*Species relatively abundant

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<td>Enallagma sp.</td>
<td>1</td>
</tr>
<tr>
<td>Corixidae</td>
<td>4</td>
</tr>
<tr>
<td>Naucoridae</td>
<td>2</td>
</tr>
<tr>
<td>Ranatra</td>
<td>1</td>
</tr>
<tr>
<td>Hydrometridae</td>
<td>1</td>
</tr>
<tr>
<td>Mesovelia sp.</td>
<td>2</td>
</tr>
<tr>
<td>Leptoceridae</td>
<td>1</td>
</tr>
<tr>
<td>Nymphula sp.</td>
<td>2</td>
</tr>
<tr>
<td>Dineutes sp.</td>
<td>4</td>
</tr>
<tr>
<td>Haliplus sp.</td>
<td>1</td>
</tr>
<tr>
<td>Hydrophilus sp.</td>
<td>2</td>
</tr>
<tr>
<td>Eretes sp.</td>
<td>1</td>
</tr>
<tr>
<td>Dytiscidae</td>
<td>3</td>
</tr>
<tr>
<td>Elmidae</td>
<td>1</td>
</tr>
<tr>
<td>Ceratopogonidae</td>
<td>2</td>
</tr>
<tr>
<td>Chironomidae</td>
<td>9</td>
</tr>
<tr>
<td>Culex</td>
<td>1</td>
</tr>
<tr>
<td>Spongillidae</td>
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* Number of stations out of a total of ten at which organisms were collected.
Appendix 5. Dragonflies (Order Odonata) recorded from the Lake Annie Tract.

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Source of Record</th>
</tr>
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<tbody>
<tr>
<td><strong>Family Coenagrionidae</strong></td>
<td></td>
</tr>
<tr>
<td>Argia fumipennis atra Gloyd</td>
<td>Belle (1978)</td>
</tr>
<tr>
<td>Enallagma sulcatum Will.</td>
<td>Belle (1978)</td>
</tr>
<tr>
<td>Ischnura ramburi (Sel.)</td>
<td>Belle (1978)</td>
</tr>
<tr>
<td><strong>Family Gomphidae</strong></td>
<td></td>
</tr>
<tr>
<td>Progomphus alachuensis Byers</td>
<td>Belle (1978), Paulson (1966)</td>
</tr>
<tr>
<td>Gomphus cavillaris Needham</td>
<td>Paulson (1966)</td>
</tr>
<tr>
<td><strong>Family Aeshnidae</strong></td>
<td></td>
</tr>
<tr>
<td>Coryphaeschna ingens (Ramb.)</td>
<td>Belle (1978)</td>
</tr>
<tr>
<td>Nasiaeschna pentacantha Rambur</td>
<td>Needham (1946)</td>
</tr>
<tr>
<td><strong>Family Macromiidae</strong></td>
<td></td>
</tr>
<tr>
<td>Didymops floridensis Davis</td>
<td>Paulson (1966)</td>
</tr>
<tr>
<td><strong>Family Cordulidae</strong></td>
<td></td>
</tr>
<tr>
<td>Neurocordulia alabamensis Hodges</td>
<td>Paulson (1966)</td>
</tr>
<tr>
<td>Tetroneuria spp. (either T. sepia or T. stella)</td>
<td></td>
</tr>
<tr>
<td><strong>Family Libellulidae</strong></td>
<td></td>
</tr>
<tr>
<td>Celithemis eponina (Drury)</td>
<td>Belle (1978)</td>
</tr>
<tr>
<td>Celithemis fasciata Kirby</td>
<td>Belle (1978), Paulson (1966)</td>
</tr>
<tr>
<td>Celithemis ornata Rambur</td>
<td>Paulson (1966)</td>
</tr>
<tr>
<td>Erythrodiplax connata minuscula Rambur</td>
<td>Paulson (1966)</td>
</tr>
<tr>
<td>Idiataphe cubensis (Scudd.)</td>
<td>Belle (1978)</td>
</tr>
<tr>
<td>Lepthemis simplicicollis (Say)</td>
<td>Belle (1978), Paulson (1966)</td>
</tr>
<tr>
<td>Libellula auripennis Burm.</td>
<td>Belle (1978)</td>
</tr>
<tr>
<td>Libellula axilena Westw.</td>
<td>Belle (1978)</td>
</tr>
<tr>
<td>Libellula incesta Hag.</td>
<td>Belle (1978)</td>
</tr>
<tr>
<td>Libellula needhami Westf.</td>
<td>Belle (1978)</td>
</tr>
<tr>
<td>Pachydiplax longipennis (Burm.)</td>
<td>Belle (1978)</td>
</tr>
<tr>
<td>Pantala flavescens (Fabr.)</td>
<td>Belle (1978), Paulson (1966)</td>
</tr>
<tr>
<td>Perithemis tenera seminole Calvert</td>
<td>Paulson (1966)</td>
</tr>
<tr>
<td>Orthemis ferruginea Fabricius</td>
<td>Paulson (1966)</td>
</tr>
<tr>
<td>Tramea carolina (L.)</td>
<td>Belle (1978)</td>
</tr>
</tbody>
</table>
Appendix 6. Fishes of Lake Annie recorded by Nester (1976) and Werner et al. (1978).

Order SEMIONOTIFORMES

Family Lepisosteidae - gars
  Florida Gar  Lepisosteus platyrhincus

Order AMIIFORMES

Family Amiidae - bowfins
  Bowfin  Amia calva

Order CYPRINIFORMES

Family Cyprinidae - minnows
  Golden Shiner  Notemigonus crysoleucas

Family Catostomidae - suckers
  Lake Chubsucker  Erimyzon sugetta

Order SILURIFORMES

Family Ictaluridae - freshwater catfishes
  Yellow Bullhead  Ictalurus natalis
  Brown Bullhead  Ictalurus nebulosus

Order ATERINIFORMES

Family Cyprinodontidae - killifishes
  Golden Topminnow  Fundulus chrysotus
  Starhead Topminnow  Fundulus notti lineolatus

Family Poeciliidae - livebearers
  Mosquitofish  Gambusia affinis holbrooki
  Least Killifish  Heterandria formosa

Family Atherinidae - silversides
  Brook Silverside  Labidesthes sicculus vanhynngi

Order PERCIFORMES

Family Centrarchidae - sunfishes
  Everglades Pygmy Sunfish  Elassoma evergladei
  Bluespotted Sunfish  Enneacanthus gloriosus
  Warmouth  Lepomis gulosus
  Bluegill  Lepomis macrochirus purpurescens
  Largemouth Bass  Micropterus salmoides floridanus
  Black Crappie  Pomoxis nigromaculatus

Family Percidae
  Swamp Darter  Etheostoma fusiforme barratti
Appendix 7. Amphibians and reptiles recorded from the Lake Annie Tract by Linzey and Linzey (1975, 1976) and staff and visiting investigators of the Archbold Biological Station.

### Amphibians

**Order ANURA**

**Family Hylidae - treefrogs**  
Florida Cricket Frog  
*Acris gryllus dorsalis*

**Family Ranidae - true frogs**  
Bullfrog  
*Rana catesbeiana*

Pig Frog  
*Rana grylio*

Southern Leopard Frog  
*Rana sphenocephala*

### Reptiles

**Order TESTUDINES**

**Family Emydidae - box and water turtles**  
Peninsula Cooter  
*Chrysemys floridana peninsularis*

**Family Testudinidae - gopher tortoises**  
Gopher Tortoise  
*Gopherus polyphemus*

**Order CROCODILIA**

**Family Alligatoridae - alligators**  
American Alligator  
*Alligator mississippiensis*

**Order SQUAMATA**

**Family Iguanidae - iguanid lizards**  
Green Anole  
*Anolis carolinensis carolinensis*

Florida Scrub Lizard  
*Sceloporus woodi*

**Family Teiidae - whiptail lizards**  
Six-lined Racerunner  
*Cnemidophorus sexlineatus sexlineatus*

**Family Scincidae - skinks**  
Ground Skink  
*Scincella lateralis*

Southeastern Five-lined skink  
*Eumeces inexpectatus*

**Family Colubridae - colubrid snakes**  
Florida Water Snake  
*Nerodia fasciata pictiventris*

Peninsula Ribbon Snake  
*Thamnophis sauritus sackeni*

Southern Black Racer  
*Coluber constrictor priapus*

Eastern Coachwhip  
*Masticophis flagellum flagellum*

Eastern Indigo Snake  
*Drymarchon corais couperi*
Appendix 8. Birds recorded from the Lake Annie Tract by Linzey and Linzey (1975, 1976) and staff and visiting investigators at the Archbold Biological Station.

Order PELECANIFORMES

| Family Phalacrocoracidae - cormorants | Phalacrocorax auritus |
| Family Anhingidae - darters | Anhinga anhinga |

Order CICONIIFORMES

| Family Ardeidae - herons, egrets, and bitterns | Ardea herodias  
| Great Blue Heron | Butorides striatus  
| Green Heron | Florida caerulea  
| Little Blue Heron | Bubulcus ibis  
| Cattle Egret | Egretta thula  
| Snowy Egret | Hydranassa tricolor  

| Family Ciconiidae - storks | Mycteria americana |
| Wood Stork |

| Family Threskiornithidae - ibises and spoonbills | Eudocimus albus |
| White Ibis |

Order ANSERIFORMES

| Family Anatidae - swans, geese, and ducks | Anas platyrhynchos |
| Mallard | Anas fulvigula  
| Mottled Duck | Aix sponsa  
| Wood Duck | Mergus serrator |

| Family Cathartidae - American vultures | Cathartes aura |
| Turkey Vulture | Coragyps atratus |

| Family Accipitridae - kites, hawks, eagles, and old world vultures | Elanoides forficatus  
| Swallow-tailed Kite | Buteo jamaicensis  
| Red-tailed Hawk | Buteo lineatus  
| Red-shouldered Hawk | Haliaeetus leucocephalus  
| Bald Eagle | Circus cyaneus |

| Family Pandionidae - ospreys | Pandion haliaetus |
| Osprey |

| Family Falconidae - caracaras and falcons | Falco sparverius |
| American Kestrel |
Appendix 8. continued

Order GALLIFORMES

Family Phasianidae – quails and pheasants
  Bobwhite
  *Colinus virginianus*

Order CHARADRIIFORMES

Family Charadriidae – plovers and turnstones
  Killdeer
  *Charadrius vociferus*

Family Scolopacidae – woodcock, snipe, and sandpipers
  Spotted Sandpiper
  *Actitis macularia*
  Solitary Sandpiper
  *Tringa solitaria*

Order COLUMBIFORMES

Family Columbidae – pigeons and doves
  Mourning Dove
  *Zenaida macroura*
  Ground Dove
  *Columbina passerina*

Order STRIGIFORMES

Family Strigidae – typical owls
  Great Horned Owl
  *Bubo virginianus*

Order CAPRIMULGIFORMES

Family Caprimulgidae – goatsuckers
  Chuck-will’s-widow
  *Caprimulgus carolinensis*
  Common Nighthawk
  *Chordeiles minor*

Order CORACIIFORMES

Family Alcedinidae – kingfishers
  Belted Kingfisher
  *Megaceryle alcyon*

Order PICIFORMES

Family Picidae – woodpeckers
  Common Flicker
  *Colaptes auratus*
  Pileated Woodpecker
  *Dryocopus pileatus*
  Red-bellied Woodpecker
  *Melanerpes carolinus*
  Red-headed Woodpecker
  *Melanerpes erythrocephalus*

Order PASSERIFORMES

Family Tyrannidae – tyrant flycatchers
  Great Crested Flycatcher
  *Myiarchus crinitus*
  Eastern Phoebe
  *Sayornis phoebe*
Appendix 8. continued

Family Hirundinidae - swallows
  Tree Swallow
  Barn Swallow
  Purple Martin
  Iridoprocne bicolor
  Hirundo rustica
  Progne subis

Family Corvidae - jays, magpies, and crows
  Blue Jay
  Scrub Jay
  Common Crow
  Fish Crow
  Cyanocitta cristata
  Aphelocoma coerulescens
  Corvus brachyrhynchos
  Corvus ossifragus

Family Troglydytidae - wrens
  House Wren
  Carolina Wren
  Troglodytes aedon
  Thryothorus ludovicianus

Family Mimidae - mockingbirds and thrashers
  Mockingbird
  Gray Catbird
  Brown Thrasher
  Mimus polyglottos
  Dumetella carolinensis
  Toxostoma rufum

Family Turdidae - thrushes, solitaires, and bluebirds
  American Robin
  Turdus migratorius

Family Sylviidae - old world warblers, gnatcatchers, and kinglets
  Blue-gray Gnatcatcher
  Ruby-crowned Kinglet
  Polioptila caerulea
  Regulus calendula

Family Bombycillidae - waxwings
  Cedar Waxwing
  Bombycilla cedrorum

Family Laniidae - shrikes
  Loggerhead Shrike
  Lanius ludovicianus

Family Vireonidae - vireos
  White-eyed Vireo
  Vireo griseus

Family Parulidae - wood warblers
  Black-and-white Warbler
  Northern Parula
  Yellow-rumped Warbler
  Yellow-throated Warbler
  Blackpoll Warbler
  Pine Warbler
  Prairie Warbler
  Palm Warbler
  Ovenbird
  Common Yellowthroat
  Mniotilta varia
  Parula americana
  Dendroica coronata
  Dendroica dominica
  Dendroica striata
  Dendroica pinus
  Dendroica discolor
  Dendroica palmarum
  Seiurus aurocapillus
  Geothlypis trichas
Appendix 8. continued

<table>
<thead>
<tr>
<th>Family Icteridae - meadowlarks, blackbirds, and orioles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern Meadowlark</td>
</tr>
<tr>
<td>Red-winged Blackbird</td>
</tr>
<tr>
<td>Boat-tailed Grackle</td>
</tr>
<tr>
<td>Common Grackle</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Family Fringillidae - grosbeaks, finches, sparrows, and buntings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardinal</td>
</tr>
<tr>
<td>American Goldfinch</td>
</tr>
<tr>
<td>Rufous-sided Towhee</td>
</tr>
<tr>
<td>Savannah Sparrow</td>
</tr>
<tr>
<td>Bachman's Sparrow</td>
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<tr>
<td>Swamp Sparrow</td>
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Appendix 9. Mammals recorded from the Lake Annie Tract by Linzey and Linzey (1975, 1976) and staff and visiting investigators at the Archbold Biological Station.

Order MARSUPIALIA

Family Didelphidae - opossums
  Virginia Opossum
  Didelphis virginiana pigra

Order INSECTIVORA

Family Soricidae - shrews
  Southern Short-tailed Shrew
  Blarina carolinensis peninsulae

Family Talpidae - moles
  Eastern Mole
  Scalopus aquaticus australis

Order EDENTATA

Family Dasypodidae - armadillos
  Nine-banded Armadillo *
  Dasypus novemcinctus mexicanus

Order LAGOMORPHA

Family Leporidae - rabbits and hares
  Marsh Rabbit
  Sylvilagus palustris paludicola
  Eastern Cottontail
  Sylvilagus floridanus floridanus

Order RODENTIA

Family Sciuridae - squirrels
  Gray squirrel
  Sciurus carolinensis extimus
  Southern Flying Squirrel
  Glaucomys volans querceti

Family Muridae - rats and mice
  Marsh Rice Rat
  Oryzomys palustris natator
  Oldfield Mouse
  Peromyscus polionotis rhoodsi
  Cotton Mouse
  Peromyscus gossypinus palmarius
  Florida Mouse
  Peromyscus floridanus
  Golden Mouse
  Ochrotomys nuttalli floridanus
  Cotton Rat
  Sigmodon hispidus floridanus
  Black Rat *
  Rattus rattus
Appendix 9. continued

Order CARNIVORA

Family Procyonidae - raccoons, coatis, and allies
   Raccoon                       Procyon lotor elucus

Family Mustelidae - weasels, skunks, otters, and allies
   Eastern Spotted Skunk        Spilogale putorius ambarvalis
   River Otter                  Lutra canadensis lataxina

Family Felidae - cats
   Bobcat                       Lynx rufus floridanus

Order ARTIODACTyla

Family Cervidae - deer, elk, moose, and allies
   White-tailed Deer            Odocoileus virginianus seminolus (?)

*Introduced