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WATERFOWL OF THE SAVANNAH RIVER PLANT

Comprehensive Cooling Water Study

Final Report

BY

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Volume Summary

Large numbers of waterfowl have been present on the Savannah River Plant (SRP) since the closure of the site in the 1950s. Waterfowl are important to the operations on the SRP as potential vectors of radionuclides and others contaminants off of the site. Thirty-one species of waterfowl have been documented on the SRP. The Savannah River Ecology Laboratory (SREL) has been conducting waterfowl research on the site for the past 15 years. This research has included work on waterfowl utilization of the SRP, wood duck reproductive biology, and waterfowl wintering ecology.

Waterfowl utilization of the site has been assessed through aerial surveys in the Par Pond Reservoir System (PPRS) and Savannah River Swamp System (SRSS), and roost counts in the Steel Creek drainage. Aerial surveys have proven to be the most successful method of assessing the number of waterfowl in the SRSS. Nine species of waterfowl have been observed during these surveys. Mallards and wood ducks were consistently the most abundant species. Both of these species have increased over the four year period during which this survey has been conducted. Mid-winter mallard numbers have increased 72.6 percent in the SRSS, while mallard mid-winter numbers in both the Atlantic Flyway and in South Carolina have decreased 33.0 and 70.4 percent respectively during the same time period. Steel Creek and Four-Mile Creek deltas had significantly more mallards than did Beaver Dam Creek or Pen Branch delta. No differences were found for wood duck counts between Four-Mile Creek, Steel Creek delta or Beaver Dam Creek. The SRSS has been used extensively for foraging by both mallards and wood ducks. Wood ducks are more selective in food habits than are mallards. Waterfowl roost counts have been conducted each year from 1981-1985 in the Steel Creek delta. Eleven species of waterfowl have been observed during these counts. As with the aerial surveys, mallards and wood ducks were the most abundant species. Peak numbers of mallards in the roost site occurs in January and February, while peak wood duck numbers are present from November through mid-January. Waterfowl primarily use post-thermal and non-thermal areas of reactor effluent streams where both cover and forage species have not been significantly impacted. The relative use of different foraging habitats on the SRP changes with seasonal availability of important foods, with thermal, post-thermal and cool areas of the river swamp providing forage species. Preferred roosting sites for waterfowl in the SRSS are characterized by dense overhead and lateral cover, consisting mainly of buttonbush. Major use areas in the SRSS are non-thermal portions of Four Mile Creek delta and post-thermal Steel Creek delta. River flood events can affect the waterfowl use of areas of Four Mile Creek delta.

Aerial surveys over the PPRS have been flown during the winter to early spring from 1981 up to the present. A total of 19 species have been identified during these surveys. Lesser scaup were the most numerous species observed, followed by ring-necked ducks, ruddy ducks and buffleheads. Over this four year period, waterfowl numbers on the PPRS have increased 74.7 percent, while mid-winter numbers have declined in the Atlantic Flyway (19.0 percent) and the state of South Carolina (24.5 percent). Lesser scaup, buffleheads, and ruddy ducks were found in significantly fewer numbers in North Arm than in all four other areas of Par Pond. Ruddy ducks were significantly more frequently observed in the Hot Arm than in the West Arm. The other three species were significantly more abundant in the West Arm. Time budget studies on Par Pond suggest that lesser scaup, ring-necked ducks, and ruddy ducks yse different behavioral strategies to exploit available wintering ground resources. An analysis of the foods consumed by lesser scaup, ring-necked ducks, and ruddy ducks on Par Pond showed significant differences in food item selection among the three species. Ring-necks were generalists in their food habits. Ruddy ducks consumed about 59 percent animal material with midges comprising 97 percent of the animal volume. Animal foods comprised 89 percent of the lesser scaup diet. Dietary habits have been used to explain the variation in radiocesium and mercury body burdens observed in various aquatic avian species which winter on Par Pond. Major concentrations of wintering diving ducks on Par Pond are located in water that is 6 meters or less in depth. The distribution of plants utilized by waterfowl as forage species does not vary greatly between heated and unheated areas of Par Pond. Studies have shown that the richness of some benthic invertebrates consumed by waterfowl is generally lower in the vicinity of the Hot Dam. However, the distribution of other invertebrate forage species, such as the Asiatic clam, do not appear to be affected by the thermal effluent in the PPRS. There is no significant impact of wintering diving ducks on Par Pond macroinvertebrate taxa in terms of numbers or biomass.

Lesser scaup and ring-necked duck counts were found to fluctuate significantly within reactor cycles, although no discernible trends could be attributed to thermal influence. Only the ruddy ducks showed significant differences in counts between the warm and ambient areas of Par Pond during the reactor cycles. Common moorhens may be utilizing the thermal water within the Hot Areas as a source of incubation heat, such that, when the nest is unattended, the eggs may have a lower rate of heat loss. Pond C has limited use by waterfowl during the wintering season. The majority of this use is during the reactor down periods. The abundance of the four main species on Pond B is similar to Par Pond, with ring-necked ducks being most frequently sighted.

Wood ducks are the only waterfowl species to commonly breed on the SRP. A nest box utilization survey has been conducted on the site since 1973. A total of 151 nest boxes were available in the 1985 nesting season. Nest initiations and duckling production were down from 1984 because of lower water levels at the nest sites. Dump nesting was found to be a common behavior among wood duck hens on the SRP. Nest success among those nests initiated this past year was down because of predation by red-headed woodpeckers. Utilization of nest boxes by other species has only slightly reduced nest box availability for wood ducks. Mark-recapture studies in Steel Creek delta produced estimates of population size of 29 to 63 breeding female wood ducks, and recruitment estimates varied from 10 to 37 individuals. Results of the mitigation program cannot be assessed to date because the impact on the critical brood rearing habitat in Steel Creek delta and corridor by the restart of L-Reactor has not been determined.

Radiocesium and mercury uptake by migratory waterfowl on the SRP has been documented. Both Par Pond and Steel Creek delta have been identified as areas of radiocesium uptake. American coots have the highest body burdens of radiocesium of any waterfowl species analyzed on Par Pond. The vegetarian diet of this species is theorized to be the cause of this increased contamination. Rates of radiocesium accumulation for free-living wood ducks in Steel Creek delta were determined to attain practical equilibrium at 17.3 days. Radiocesium elimination of wood ducks under penned conditions was described as: 4.60-0.13 days (in percent initial body burden). Concentrations of radiocesium from the waterfowl collected on the SRP in 1985 were found to be within the range of levels reported for previous years. These were well below that which would suggest a health hazard for persons ingesting these birds as food. American coots on Par Pond were found to be lower in mercury contamination levels than four other aquatic bird species which are more carnivorous in their food habits.

In the future, waterfowl numbers on the SRP will probably reflect the declines expected in the continental numbers of these species. These declines on the site, however, will likely not be to the extent observed in other wintering areas in the Southeast. This is because of the reduced human disturbance (e.g., no sport hunting) on the SRP. During the first wintering season in which L-lake was in existence, 12 species of waterfowl were observed using that impoundment. As forage and cover species increase in that system, waterfowl use will increase and become more diversified. The impact of the L-Reactor restart on the wood ducks nesting in the Steel Creek corridor and delta has yet to be assessed.

1) WATERFOWL OF THE SRP

1.1) Introduction

Waterfowl (Aves: Anseriformes, Gaviiformes, Podicipediformes, and Gruiformes) have been present in large numbers on the Savannah River Plant (SRP) since the closure of the site to the public in the early 1950s (Jenkins and Provost, 1964; Mayer et al., 1984). The existence of these birds on the SRP is important for both ecological and economic reasons. Waterfowl are major primary and secondary consumers in wetland areas where they occur on the site. In general, waterfowl are mainly plant feeders (Martin et al., 1951). However, ducks (Anatidae: Anatinae), the most common group of waterfowl on the SRP (Mayer et al., 1984; Gladden et al., 1985a), are almost all omnivorous (Martin et al., 1951). This allows ducks to occupy a number of trophic levels within the food webs of the various aquatic ecosystems on the SRP. Economically, waterfowl are very important as popularly harvested game species, with an estimated minimum of one hundred million dollars spent annually on the sport harvest of these species in the United States and Canada (Johnsgard, 1975).

Because of their migratory nature, these species are of concern to the operation of the SRP as potential vectors of radionuclides and other contaminants off of the site. Since some of these species leave the site during the sport hunting season, contaminants may readily be picked up to enter the food chain for direct human consumption elsewhere. Several localities on the SRP have been identified as prime areas of concern with respect to radionuclide uptake by waterfowl (Marter, 1970; Brisbin et al., 1973; Fendley et al., 1977).

The above factors are increased in importance by the extensive use of the SRP by waterfowl during the wintering season (Gladden et al., 1985a). Since 1952, a total of 31 species of waterfowl have been documented on various locations on the SRP (Table 1). Waterfowl utilization of both the Par Pond Reservoir System (PPRS) and Savannah River Swamp System (SRSS) has been and still is very significant. Waterfowl use of smaller aquatic sites on the SRP such as Carolina bays, old farm ponds and settling basins has not been assessed thoroughly to date but was documented as early as 1952 (Norris, 1957, 1963). The use of these smaller habitats has continued up through the present (R. T. Hoppe, pers. obser.). The use of Par Pond by migratory waterfowl was noted within one year of the filling of that reservoir (Norris, 1963). Within two years, seven species of waterfowl were present there from November to January (Norris, 1963). Within five years of the completion of Par Pond, an estimated 10,000 ducks and American coots (Fulica americana) were wintering on that impoundment (Jenkins and Provost, 1964). During that same year, approximately 2,000 ducks and American coots were estimated to overwinter in the SRSS and on the Savannah River. In 1973, an estimated 5,000 to 10,000 migratory waterfowl were using the PPRS as a wintering refuge (Brisbin et al., 1973). Large numbers of waterfowl continue to winter in both the PPRS and SRSS (Mayer et al., 1984; Gladden et al., 1985a). Regionally, the presence of such large concentrations of waterfowl is significant. During the past five years, mid-winter numbers of diving ducks (Anatinae: Athyini) on the PPRS have been higher than in the entire northern half (Zone I) of South Carolina as determined by the Mid-winter Waterfowl Survey counts for those species

Table 1. Listing of the waterfowl species known to occur on the SRP and the localities on the site where the presence of each species has been documented between 1952 and 1985. These records were assembled from Norris (1963), the SRP waterfowl aerial surveys, Steel Creek roost counts, the SRP Christmas Bird Counts, sightings by the authors, and reliable sightings by other biologists on the site.

Species Common Name	Par Pond	Pond C	Pond B	Beaver Dam Creek	Four-Mile Creek	Pen Branch Creek	Steel Creek	Upper Three Runs Creek	Carolina Bays & Ponds	Settling & Seepage Basins
Whistling Swan	+									
Canada Goose	+	+								+
Blue/Snow Goose									+	+
Mallard	+		+	+	+	+	+		+	+
Black Duck	+		+	+	+		+		+	
Gadwall	+	+	+	+	+		+			+
Pintail	+						+		+	+
Green-winged Teal	+						+			+
Blue-winged Teal	+			+	+		+		+	+
American Wigeon	+			+	+		+		+	+
N. Shoveler	+		+				+		+	+
Wood Duck	+	+	+	+	+	+	+	+	+	+
Redhead	+									+
Ring-necked Duck	+	+	+	+			+		+	+
Canvasback	+									
Greater Scaup	+									
Lesser Scaup	+	+	+							+
C. Goldeneye	+									
Bufflehead	+	+	+				+			+
Oldsquaw	+									
White-winged Scoter	+									
Ruddy Duck	+	+	+							+
Hooded Merganser	+	+	+	+	+		+	+		+
Red-brested Merganser	+									+

Table 1. continued.

Species Common Name	Par Pond	Pond C	Pond B	Beaver Dam Creek	Four-Mile Creek	Pen Branch Creek	Steel Creek	Upper Three Runs Creek	Carolina Bays & Ponds	Settling & Seepage Basins
Common Loon	+									
Horned Grebe	+								+	
Pied-billed Grebe	+	+	+				+		+	+
King Rail						+			+	
Common Moorhen	+								+	
Purple Gallinule	+								+	
American Coot	+	+	+				+		+	+

(Mayer et al., 1984; Gladden et al., 1985a). These concentrations on the SRP are unexpected since this area of the Savannah River drainage is not a major wintering area for any of the four most abundant duck species found on the PPRS (Bellrose, 1976). In addition, with the exception of 1984, mid-winter duck numbers in the Atlantic Flyway have been generally declining since 1965. Over the last three years, the mid-winter numbers on the PPRS have increased. These facts serve to further emphasize the importance of the SRP as a major waterfowl wintering refuge area.

Waterfowl research conducted by the Savannah River Ecology Laboratory (SREL) over the past 15 years has been in three principal areas. These include: 1) assessment of waterfowl utilization of the site; 2) a wood duck (*Aix sponsa*) nest box survey, reproductive biology study, and mitigation of nesting habitat loss; and 3) waterfowl wintering ecology studies. In addition to being important inland staging areas for 17 species of migratory waterfowl in South Carolina, the aquatic habitats of the SRP offer a unique situation where public disturbance is minimized thus allowing an excellent opportunity to study waterfowl. Waterfowl species surveys and censuses on the SRP have been conducted since the early 1970s. These were performed in order to determine what waterfowl species were using the SRP, how many of each species were present, where they were found on the site, and when they were present on the site. Since 1981, both aerial surveys of the PPRS and SRSS and roost counts in the delta of Steel Creek have been used in this assessment (Gladden et al., 1985a). These surveys have been the sole source of documentation of the substantial waterfowl use of the SRP during the wintering period from November through March.

The wood duck nest box survey was initiated to assess the impact of the restart of L-Reactor on wood duck reproduction in the Steel Creek corridor and delta. This survey was expanded in 1983 and has been continued up through the present. Most waterfowl research in the United States has concentrated on breeding biology over the past 50 years. In general, the attention given to waterfowl breeding ecology has been at the expense of wintering ecology. Recent studies have shown that further research is needed in post-breeding waterfowl ecology and how it relates to continental and flyway population levels. The goal in performing wintering ecology studies is to provide the necessary data for the management of waterfowl on the SRP and the Atlantic Flyway, and to improve the overall understanding of waterfowl wintering ecology. Those wintering ecology studies which have been completed on the site include: 1) time budget studies of diving ducks on Par Pond; 2) diving duck flock behavioral observations on Par Pond; 3) body condition indices of three species of diving ducks on Par Pond; 4) waterfowl food resource exclosure study on Par Pond; 5) genetic variability survey of four species of diving ducks on Par Pond; and 6) food habit survey of three species of diving ducks on Par Pond. Those studies in progress include: 1) habitat segregation of four species of diving ducks on Par Pond, and 2) wood duck growth study on the SRP.

2) WATERFOWL UTILIZATION OF THE SRP

2.1) Introduction and Methodology

Waterfowl utilization of the SRP is significant. Almost every available open-water site on the SRP serves as habitat for ducks, especially during the wintering season. This use has been assessed by two methods: 1) aerial surveys, and 2) roost counts. The aerial surveys were flown over both the PPRS and SRSS. The roost counts were conducted in the Steel Creek drainage. The goals of these assessment methods were: 1) to compile a species list of waterfowl that use these systems; 2) to determine the approximate number of each species in these systems; 3) to determine the degree of utilization by waterfowl; and 4) to determine the distribution of waterfowl in these areas as related to migratory status and reactor "up-down" cycles in the lentic and lotic thermal effluent systems. These data are used to monitor trends in the waterfowl distribution and use of the aquatic systems on the SRP. These surveys allow for monitoring the potential impact of thermal effluent on the wintering waterfowl use of the site. In addition, these data provide supportive information for ongoing food habits and parasite studies of waterfowl on the SRP.

The waterfowl aerial surveys have been flown since the 1981-82 wintering season. These surveys were conducted once a week, usually on Saturdays, from November 1 to April 1. Surveys were done from a Piper SuperCub fixed-wing aircraft at an airspeed of 130 km/h at an altitude of 90 m. An observer sat in the back seat of the aircraft and noted the number and species of all waterfowl sighted. The observer used a small pocket recorder, which allowed the rapid dictation of the number, species, and location of all waterfowl seen. The pilot was directed to fly approximately 200 m offshore around the perimeters of the three impoundments being surveyed. This allowed the observer to record all species on either side of the aircraft. In the SRSS, the pilot was directed to fly over the four drainages being censused, starting at Beaver Dam Creek and ending at Steel Creek Delta. At the end of each aerial survey, the data were compiled and placed on permanent record maps. The aerial surveys were originally only conducted over Par Pond proper and four drainage systems in the SRSS, i.e., Beaver Dam Creek, Four-Mile Creek, Pen Branch Creek, and Steel Creek. In January of 1984, Ponds B and C were added to the aerial surveys.

The roost counts in the Steel Creek corridor and delta have also been conducted since the 1981-1982 wintering season. Evening roost counts were made at approximately weekly intervals. Observers positioned themselves either within the roost or under the main flight route to the roost just before sunset, and remained until dark, since many species of waterfowl move just after sunset. These ducks travel from feeding sites to a common night roosting area. Since this behavior is especially common to wood ducks, that species is easily censused. The observers tallied the number and species of all waterfowl seen flying into the roosting area. During that first sampling period in 1981-1982, the counts were made by observers either positioned on the railroad trestle over Steel Creek, from a canoe located in the delta, or from an old blind located near the SREL Steel Creek canoe landing. From the 1982-1983 wintering period to the present, these counts have been made from an elevated blind located specifically within the roost site in Steel Creek Delta.

2.2.1) Waterfowl Utilization of the Savannah River Swamp System

Aerial surveys of the Savannah River Swamp System were initiated in the fall of 1981 to determine the utilization of this portion of the Savannah River Plant by waterfowl. This study was begun in conjunction with other ecological investigations in order to evaluate the potential impacts of the restart of the SRP's L-Reactor. Figure 1 shows the areas of the SRSS which were surveyed for waterfowl during the four-year study period. These areas include the moderately-thermal Beaver Dam Creek, thermal Four-Mile Creek, thermal Pen Branch, and post-thermal Steel Creek.

Aerial surveys of the SRSS were initiated on 20 October, 1981 and were conducted at approximately weekly intervals. During the winter of 1981-1982, 23 flights were recorded including the final survey on 30 March, 1982.

Aerial surveys conducted during the winter of 1982-1983 over the SRSS were initiated on 24 September, 1982 and included 18 flights. The last survey for this winter period was on 29 March, 1983.

SRSS waterfowl aerial surveys conducted during the winter of 1983-1984 were initiated on 4 October, 1983. Twenty-four flights were made, including the final flight on 7 April, 1984.

During the winter of 1984-1985, aerial surveys conducted over the SRSS included 21 flights beginning on 27 October, 1984, and ending on 23 March, 1985. These aerial surveys were conducted at weekly intervals with the exception of a flight schedule for 2 February, 1985, which was cancelled due to poor flight conditions. These flights were all conducted on Saturday to minimize the disturbance of waterfowl by normal weekday human activities in the SRSS.

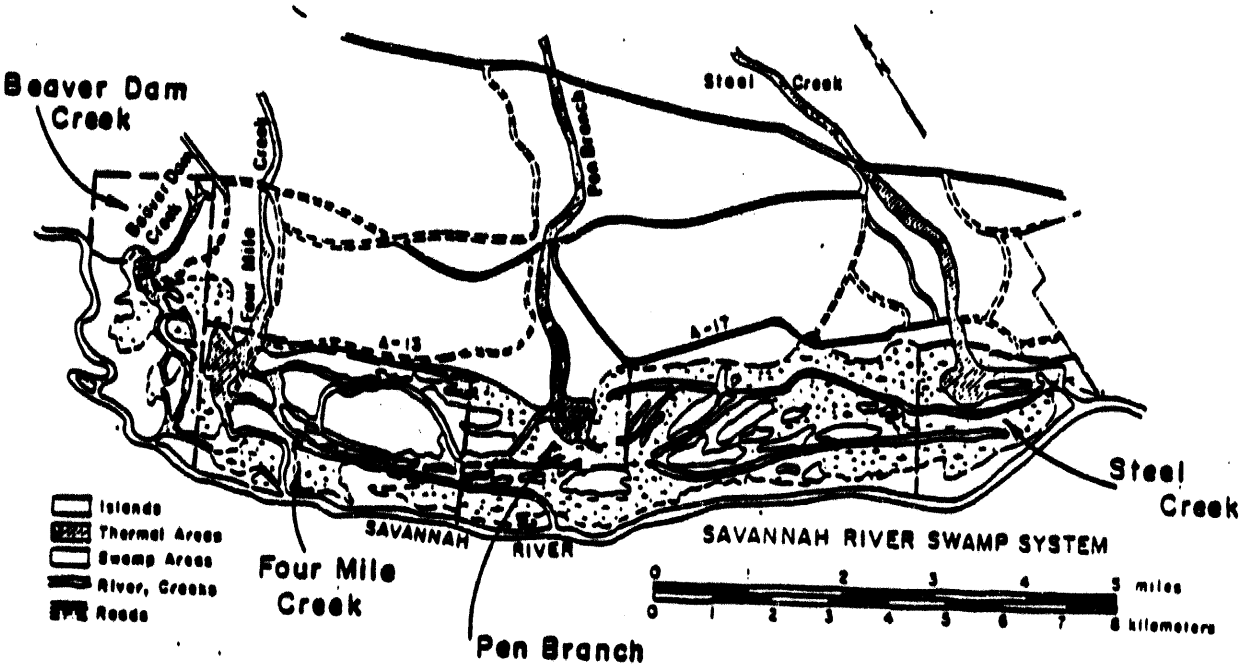

FIGURE 1. Areas in the Savannah River Swamp system surveyed by the Waterfowl aerial surveys from 1981 to 1985.

2.2.2) Review of Past Utilization of the SRSS

Aerial surveys have proven to be the most successful method of acquiring reasonable estimates of waterfowl using the SRSS each winter. Nine species were identified by aerial survey using the SRSS in the winter of 1984-1985. Of these nine species, seven were dabbling duck species, one was a species of rail, and one was a species of merganser. Specifically, these are the mallard (Anas platyrhynchos), wood duck, American black duck (Anas rubripes), gadwall (Anas strepera), American wigeon (Anas americana), green-winged teal (Anas crecca), blue-winged teal (Anas discors), American coot, and hooded merganser (Lophodytes cucullatus). Other species are known to be infrequent winter visitors to the SRSS, but were not identified during aerial surveys. These include the northern pintail (Anas acuta), northern shoveler (Anas clypeata), ring-necked duck (Aythya collaris), lesser scaup (Aythya affinis), and bufflehead (Bucephala albeola). The highest waterfowl count recorded on any single aerial survey of the SRSS during the winter of 1984-1985 was 1,444 on 12 January, 1985.

During the 1983-1984 winter season, seven species of waterfowl were identified within the SRSS by aerial survey. Species observed in the winter of 1984-1985, but not seen in the winter of 1983-1984 include the blue-wing teal and American coot. It is probable that these species were present in small numbers but they remained undetected. The greatest number of waterfowl recorded on any flight during the winter of 1983-1984 was 765 on 30 December, 1983.

Identified by aerial survey of the SRSS during the winter of 1982-1983 were three species of waterfowl. Species observed in 1984-

1985, but not in the winter of 1982-1983 include the gadwall, American widgeon, blue-wing teal, greenwing teal, American coot, and hooded merganser. The greatest number of waterfowl recorded during any aerial survey of the SRSS during the winter of 1982-1983 was 486 on 10 February, 1983.

During the winter of 1981-1982, eight species of waterfowl were identified by aerial survey in the SRSS. Only the American coot was seen in the winter of 1984-1985 but not the winter of 1981-1982. The greatest number of waterfowl recorded on any aerial survey of the SRSS during the winter of 1981-1982 was 695 on 11 February, 1982.

The most consistently-occurring and abundant species of waterfowl found in the SRSS each winter was the mallard. Mallards are more successfully censused by aerial survey than other more secretive species such as the wood duck, a year-round resident of the SRSS. Although the dabbling ducks are the dominant species of waterfowl found in the SRSS, occasional diving ducks are found in areas of the SRSS which have been altered by thermal streams entering the Savannah River floodplain. Figure 2 presents the maximum number of the two major dabbling duck species observed in the SRSS during any single aerial survey for each of the four winter periods surveyed. Mallards were consistently the most numerous species observed in the SRSS each winter. There was a net increase in this species in the SRSS of 939 percent from the winter of 1981-1982 to the winter of 1984-1985. Wood ducks were the second most abundant waterfowl species observed during aerial surveys of the SRSS. A net increase of 344.0 percent was recorded for wood ducks observed by aerial survey from the winter of 1981-1982 to the winter of 1984-1985. However, due to the secretive

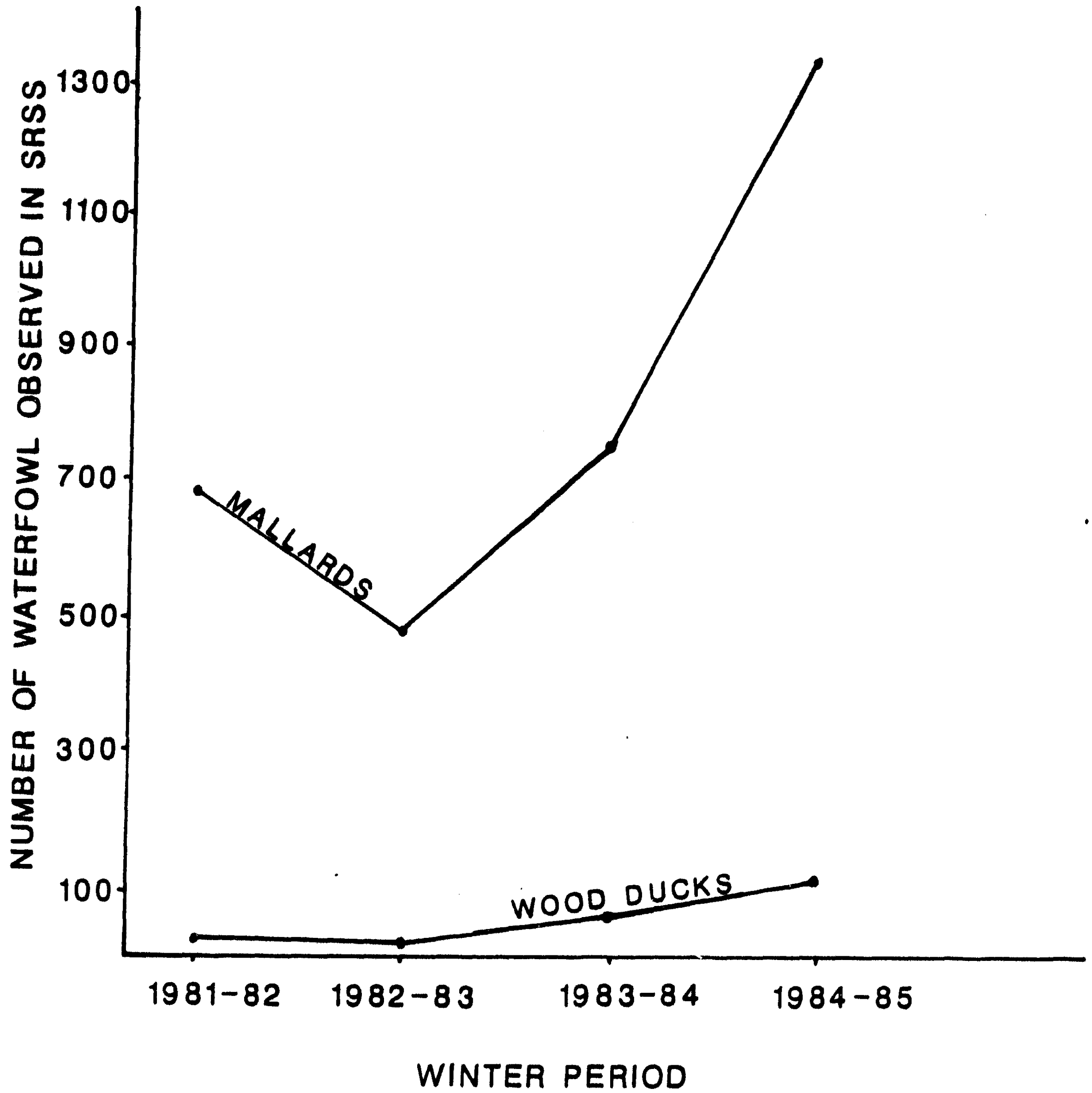

FIGURE 2. Maximum number of mallard and wood duck observed in the SRSS during any single aerial survey from 1981 to 1985.

behavior of wood ducks and highly variable observability, conventional aerial inventories are considered to be inadequate indicators of wood duck relative abundance (Bellrose, 1980).

The U.S. Fish and Wildlife Service midwinter surveys from January 1982 to January 1985 indicate a net decline of 33.0 percent in numbers of mallard wintering within the Atlantic Flyway (Figure 3). Numbers of mallard in the state of South Carolina declined by 70.4 percent during the same period. However, the number of mallards observed during January aerial surveys of the SRSS were found to increase by 72.6 percent. The SRSS can be considered to be an important winter refuge to locally-wintering waterfowl. With declines in natural wetlands available to water fowl in the interior of South Carolina, this swamp system may come to support larger numbers of wintering dabbling ducks in the future. The need for preservation and protection of such a site will undoubtedly increase if waterfowl numbers continue to drop as they have in recent years.

2.2.3) Utilization of Areas Within the SRSS

Waterfowl of the SRSS were assigned to drainage systems in which they were found to determine sites preferred by waterfowl. Mallard and wood ducks were the only two waterfowl species with adequate numbers for an analysis of variance of site use to be determined. Only aerial survey data from the winter of 1984-1985 were examined by this method.

The Beaver Dam Creek portion of the SRSS (Figures 4, 5, 6, and 7) had significantly fewer mallards than both Four-Mile Creek Delta and

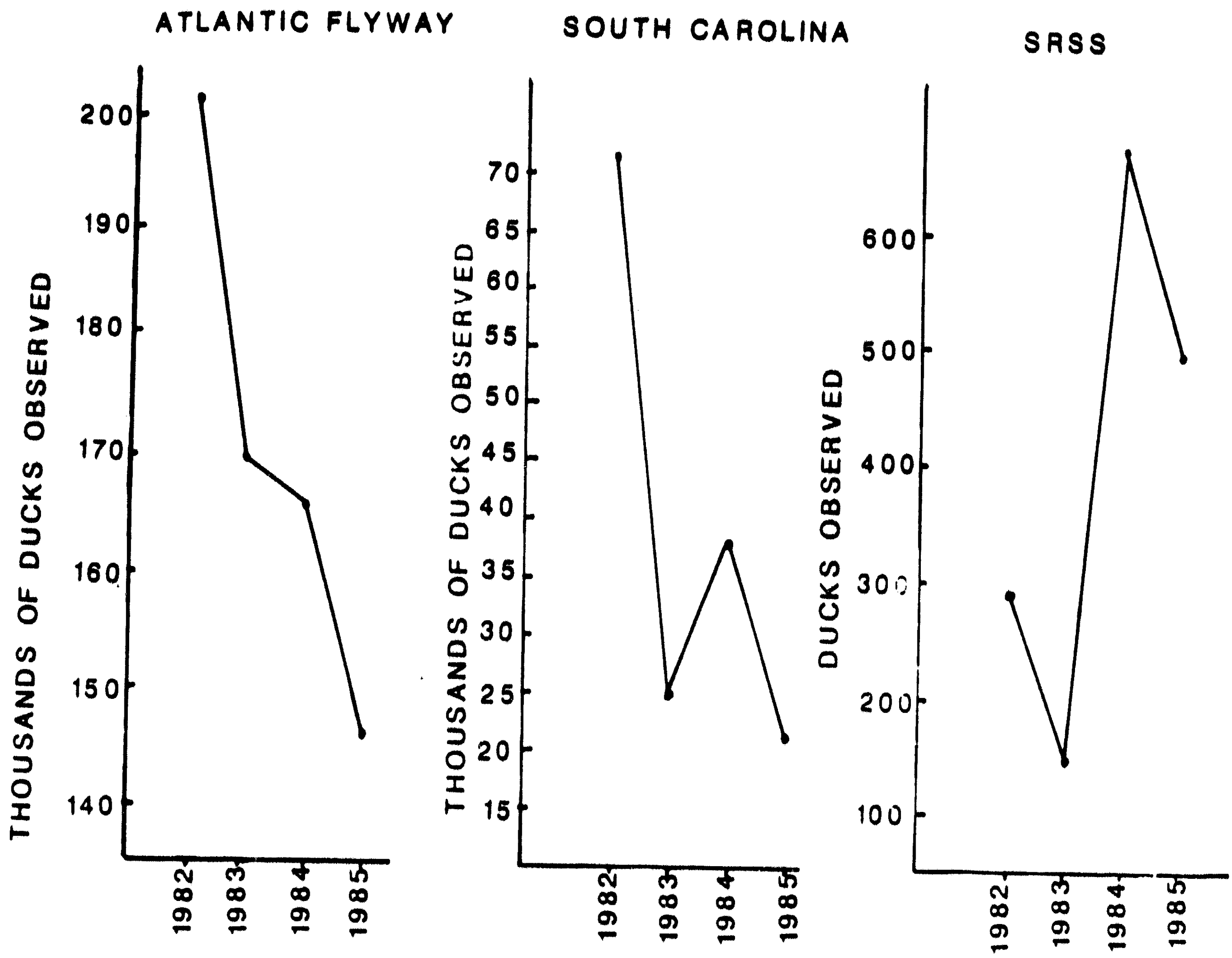

FIGURE 3. Comparison of mallard numbers in the Atlantic Flyway, in South Carolina, and in the SRSS from 1982 to 1985 as determined by mid-winter counts.

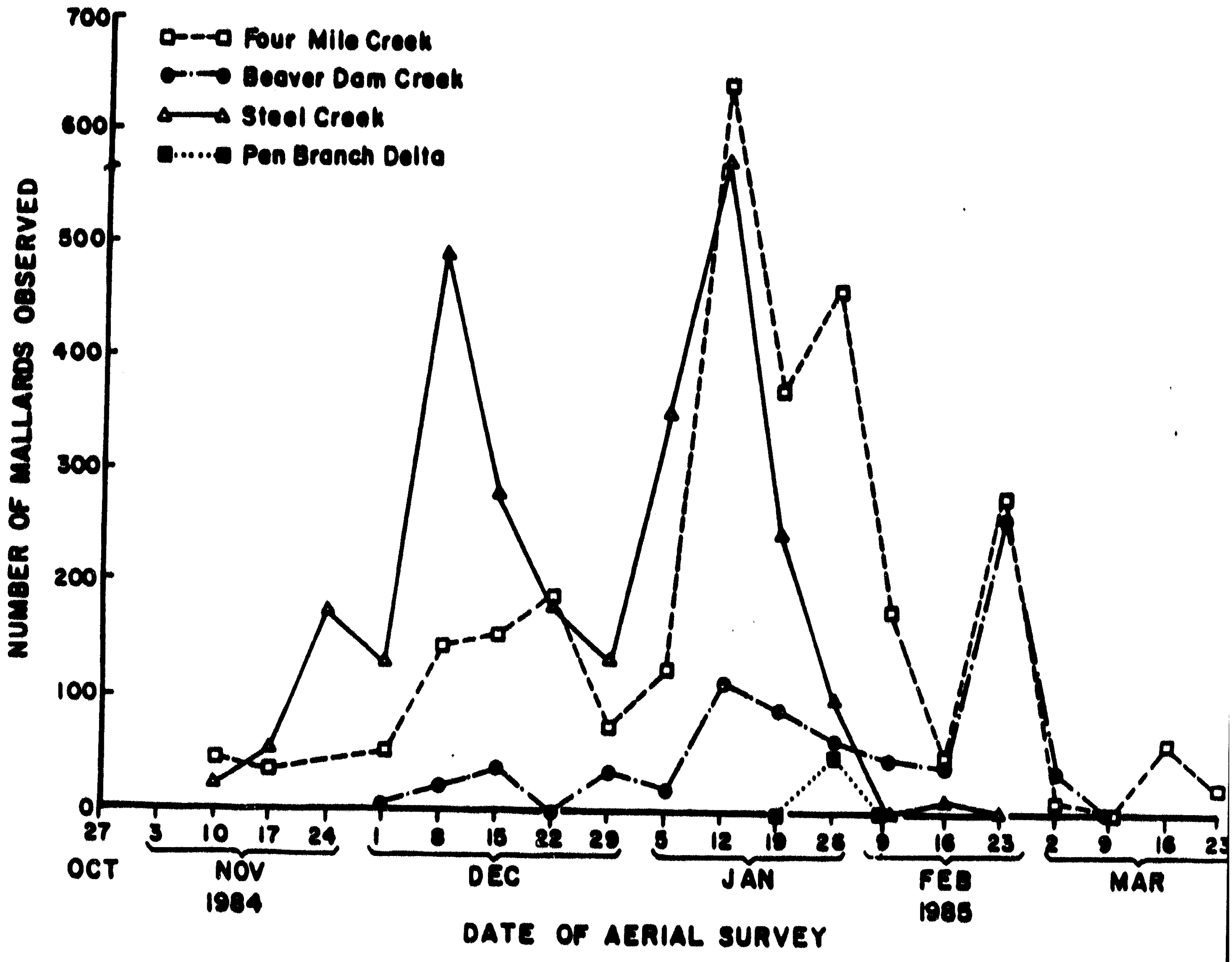

FIGURE 4. Number of mallards observed by drainage system in the SRSS by aerial survey during the 1984-1985 winter.

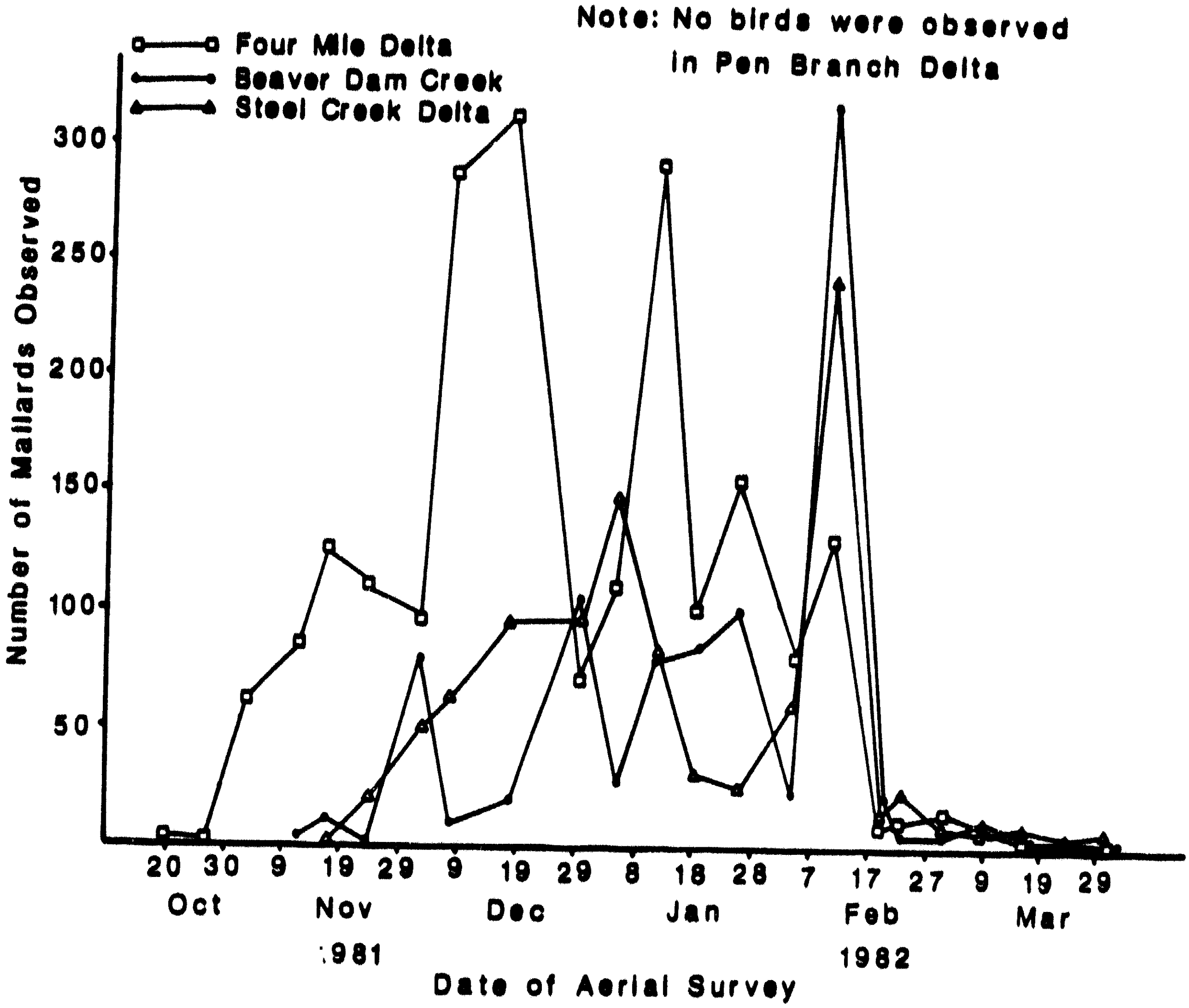

FIGURE 5. Number of mallards observed by drainage system in the SRSS by aerial survey during the 1981-1982 winter.

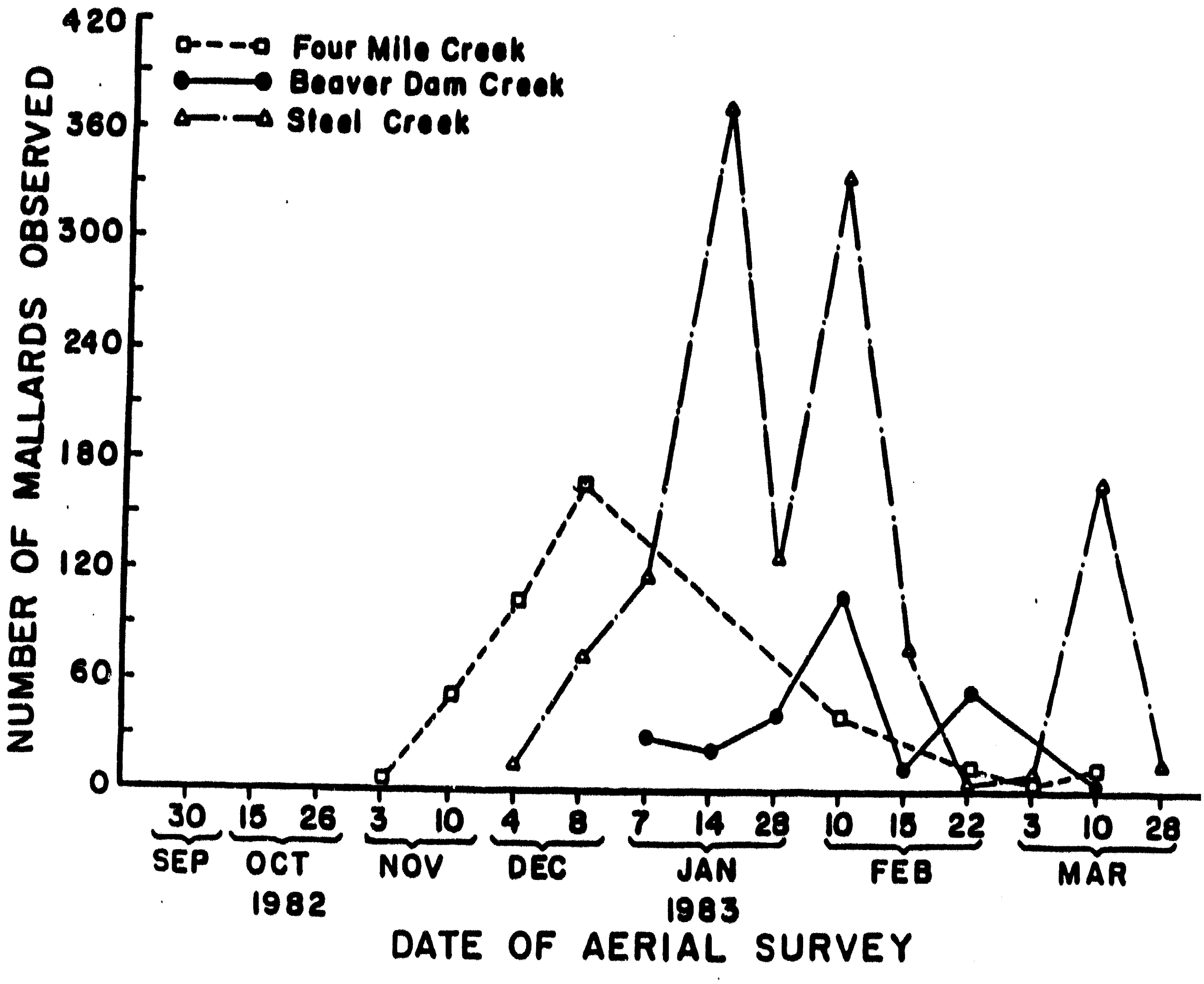

FIGURE 6. Number of mallards observed by drainage system in the SRSS by aerial survey during the 1982-1983 winter.

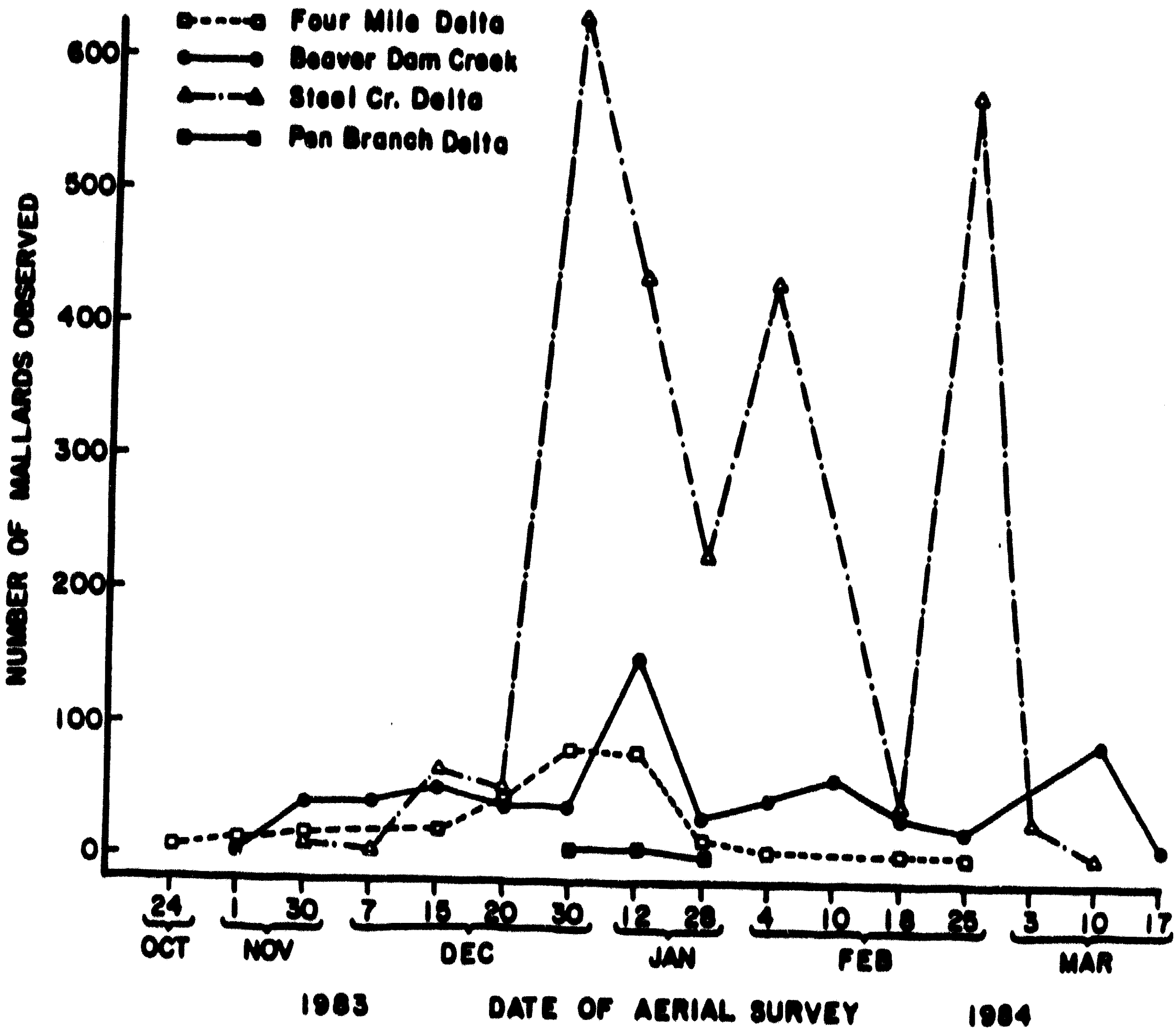

FIGURE 7. Number of mallards observed by drainage system in the SRSS by aerial survey during the 1983-1984 winter.

Steel Creek Delta during the winter of 1984-1985 ($\underline{P}$ = 0.0014 and $\underline{P}$ = 0.027, respectively for 21 surveys). Only in Pen Branch Delta were there fewer mallards observed than in Beaver Dam Creek (Figure 4). No significant differences ($\underline{P}$ > 0.05) were found between Beaver Dam Creek Delta, Four-Mile Creek Delta, or Steel Creek Delta in counts of wood ducks during aerial surveys. However, more wood ducks were seen in Beaver Dam Creek Delta than in Pen Branch Delta ($\underline{P}$ = 0.006). These same observations of duck distributions relative to Beaver Dam Creek generally hold true for the winter of 1981-1982 through 1983-1984 also (Figure 8). Other waterfowl species identified by aerial survey in the Beaver Dam Creek portion of the SRSS include the green-winged teal, American wigeon, gadwall, and black duck. Mean 48-hour air temperatures including the day before and day of the aerial survey were compared with each flight count. The comparisons of aerial counts with mean air temperatures above and below 7.2 degrees Centigrade, revealed no significant redistribution of waterfowl relative to the Beaver Dam Creek portion of the SRSS and mean air temperatures.

The Four-Mile Creek portion of the SRSS (Figures 4, 5, 6, and 7) had significantly higher mallard counts than either Beaver Dam Creek delta or Pen Branch delta during the winter of 1984-1985 ($\underline{P}$ = 0.0014 and $\underline{P}$ = 0.0001, respectively for 21 surveys). No significant differences were observed in numbers of mallards observed using Four-Mile Creek delta and Steel Creek delta. These patterns of mallard use of Four-Mile Creek and Steel Creek are not typical however, and show much variation from year to year (Figure 9). Observed annual variations in Four-Mile Creek and Steel Creek mallard usage can be explained by annual variations in precipitation, river levels, C-Reactor schedules

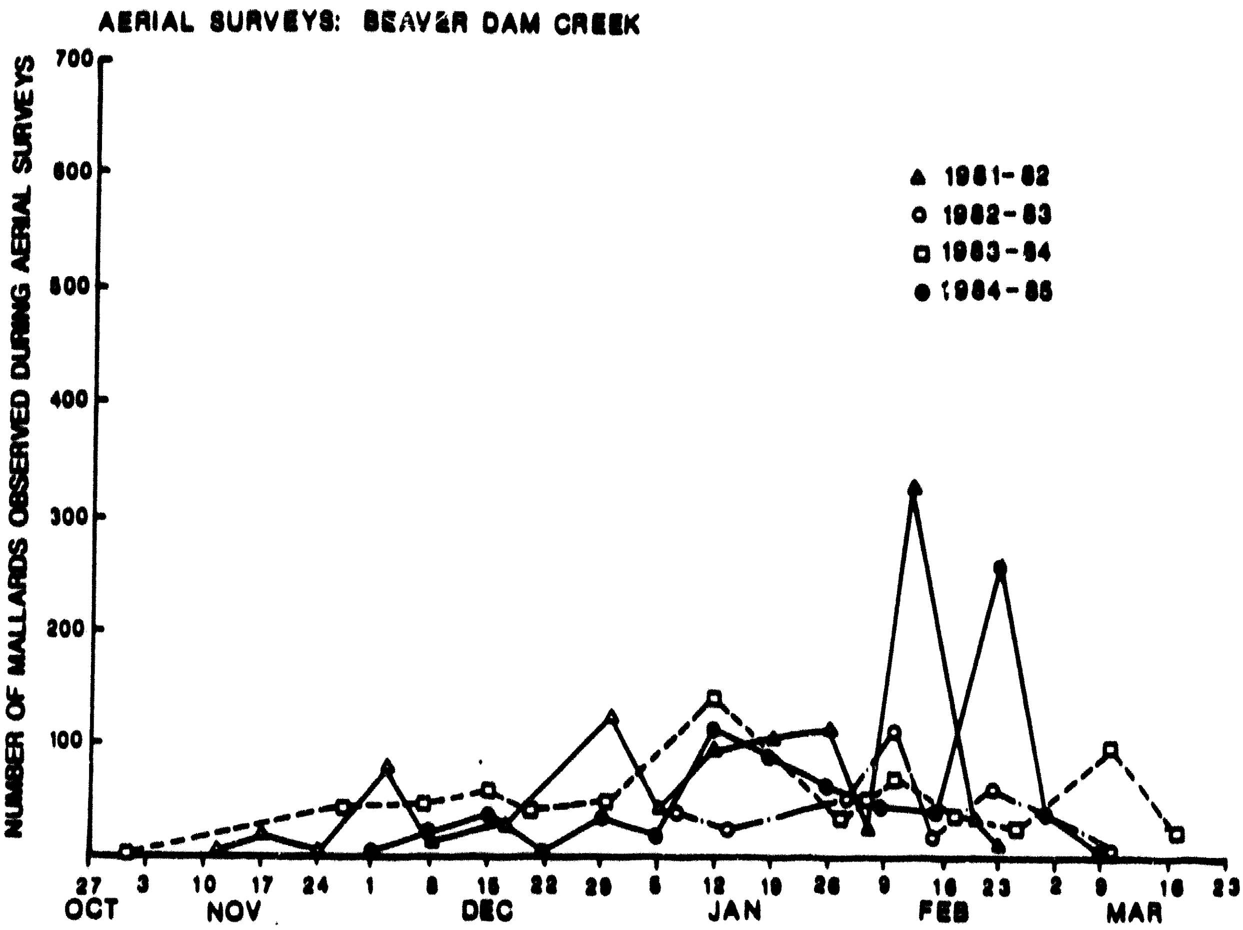

FIGURE 8. Number of mallards observed during aerial surveys in Beaver Dam Creek from 1981 to 1985.

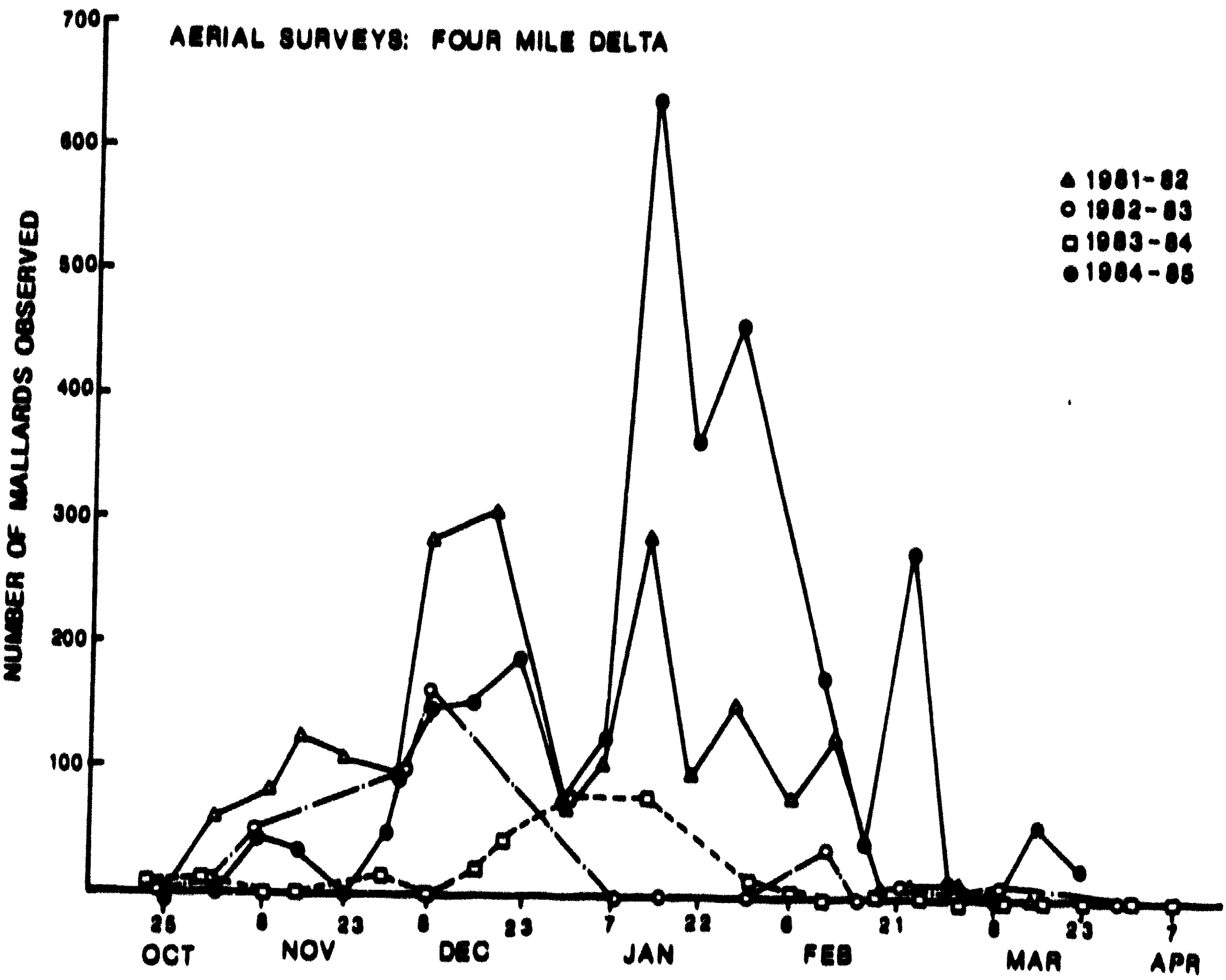

FIGURE 9. Number of mallard observed in Four Mile Creek delta during aerial surveys from 1981 to 1985.

and available forage species. Four-Mile Creek delta had significantly higher wood duck counts than either Pen Branch Delta or Steel Creek delta during the 1984-1985 winter period (P = 0.0008 and P = 0.0117, respectively for 21 surveys). There were no differences, however in wood duck counts from Four-Mile Creek delta and Beaver Dam Creek delta. Waterfowl species other than mallard and wood ducks which were observed in the Four-Mile Creek delta vicinity include the green-winged teal, blue-winged teal, American wigeon, gadwall, black duck, redhead duck, hooded merganser, and American coot.

The Pen Branch portion of the SRSS (Figures 4, 5, 6, and 7) had significantly lower mallard counts than any other section of the SRSS surveyed ($P \leq 0.0004$) during the winter of 1984-1985. This observation is typically true for all years of waterfowl aerial surveys. Pen Branch also had significantly lower wood duck counts than either Beaver Dam Creek or Four-Mile Creek. Counts of wood ducks in Pen Branch delta were not significantly different from Steel Creek delta counts however ($P > 0.05$). Only mallards and wood ducks have been seen in the Pen Branch delta vicinity during aerial surveys and even these species are not seen with any regularity (Figure 10). This is thought to be due primarily to the habitat attributes of the Pen Branch delta and surrounding swamp.

The Steel Creek delta portion of the SRSS (Figures 4, 5, 6, and 7) had significantly higher counts of mallard than either Beaver Dam Creek or Pen Branch (P = 0.027 and P = 0.0001, respectively for 21 surveys) during aerial surveys from the winter of 1984-1985. No differences were found, however, between Steel Creek delta mallard counts and Four-Mile Creek delta mallard counts (P = 0.604).

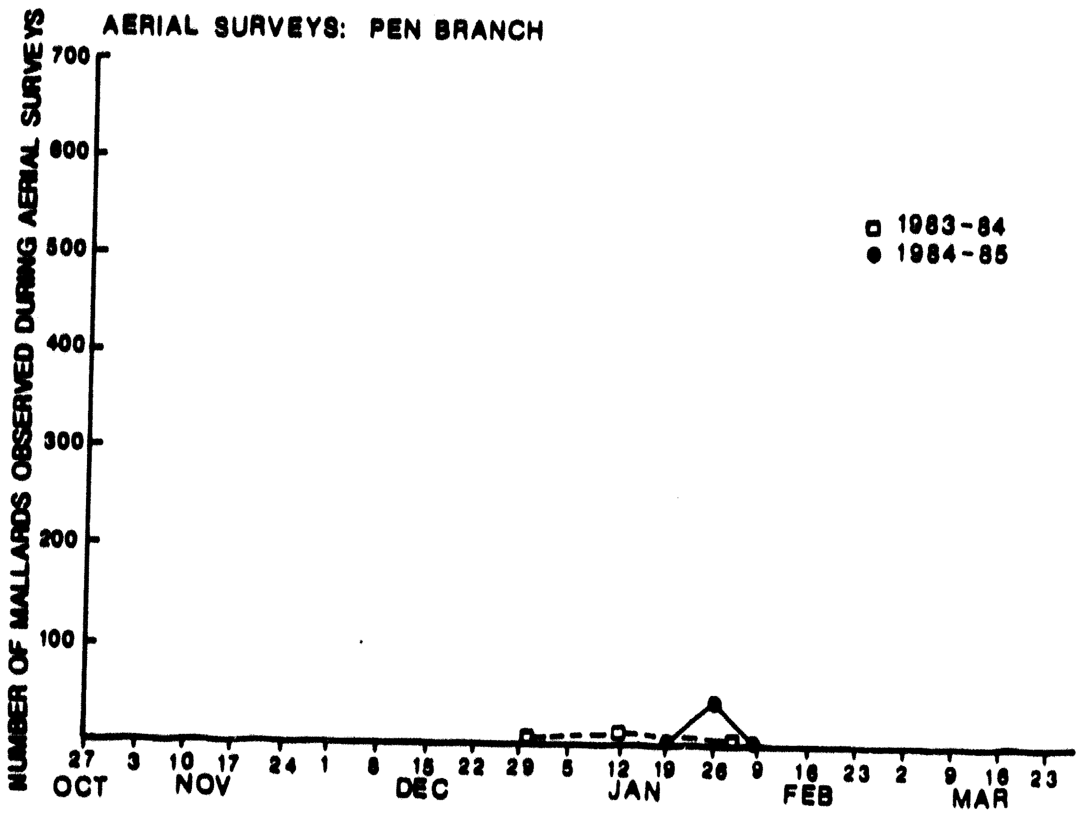

FIGURE 10. Number of mallard observed during aerial surveys in Pen Branch delta from 1981 to 1985.

No significant differences were observed between wood duck counts from Steel Creek delta and Beaver Dam Creek delta or Pen Branch delta ($P \geq 0.05$), although Four-Mile Creek delta did have higher counts of wood ducks than Steel Creek delta ($P = 0.0117$). Other waterfowl species identified in Steel Creek delta during aerial surveys include blue-winged teal, gadwall, black ducks and hooded mergansers. The results of aerial surveys from the winter of 1981-1982 to the winter of 1984-1985 are presented in Figure 11.

2.2.4) Waterfowl Roost Counts in Steel Creek Delta

Waterfowl roost counts have been conducted each year from 1981-1985 in the Steel Creek delta. The 1981 data is incomplete and will not be presented. A permanent elevated blind was built in the delta for observation of waterfowl. The Steel Creek delta is the only place within the SRSS where roost counts have been conducted. The two main species observed roosting were mallards and wood ducks although other species occasionally use the delta for roosting (Table 2). Migratory species are primarily using the delta from October through March. Toward the end of March, numbers decrease as birds begin their spring migration. Wood ducks also decrease as non-resident birds move north, and breeding in the area is initiated. Even though wood ducks breed in the southeast, roosting in large flocks from March through August is no longer common, due to wood duck pairing activities and initiation of nests.

Numbers of mallards and wood ducks roosting in the delta from October through March show definite trends in utilization (Figures 12, 13, 14, and 15). Fall migrant wood ducks start congregating in SRP

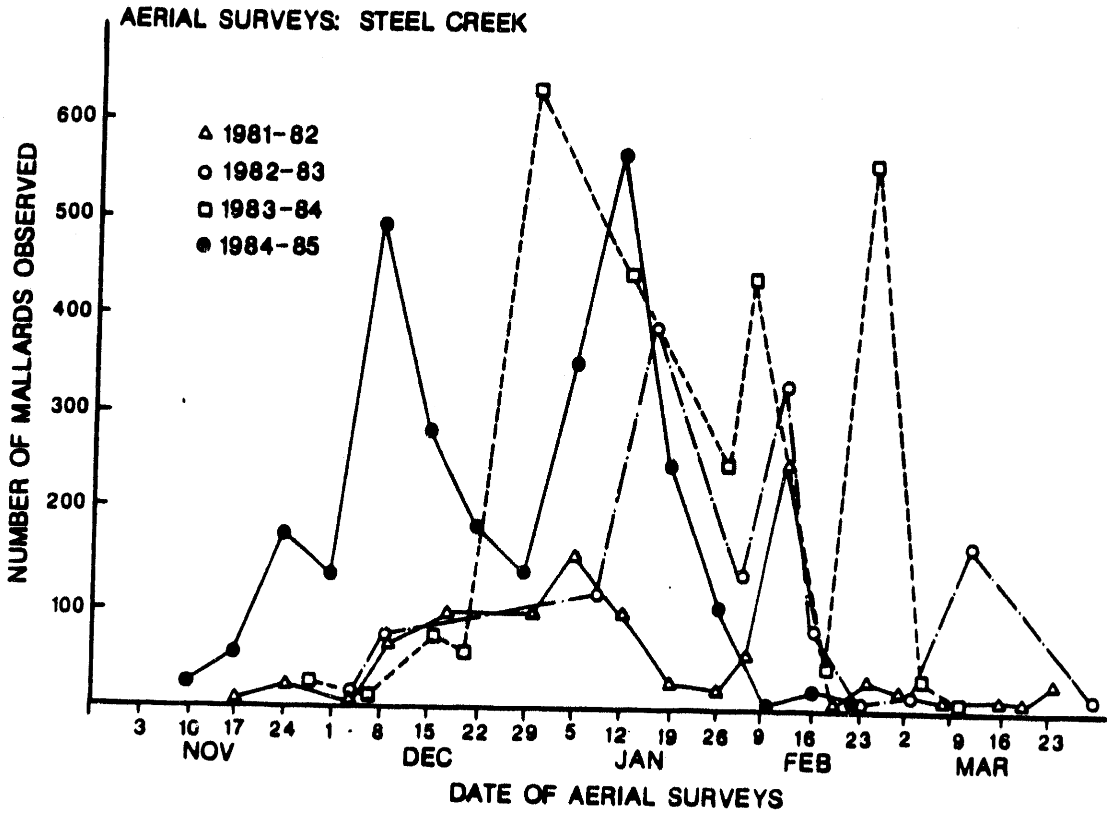

FIGURE 11. Number of mallard observed during aerial surveys in Steel Creek delta from 1981 to 1985.

Table 2. Waterfowl species observed in the Steel Creek delta during the winter roost counts from 1982 to 1985.

Common Name	Scientific Name	Years Observed 1982-83	1983-84	1984-85
mallard	*Anas platyrhynchos*	x	x	x
wood duck	*Aix sponsa*	x	x	x
blue-winged teal	*Anas discors*	x	x	x
green-winged teal	*Anas crecca*	x	x	x
black duck	*Anas rubripes*	x	x	x
northern shovler	*Anas clypeata*			x
pintail	*Anas acuta*	x	x	
American wigeon	*Anas americana*	x	x	
ring-necked duck	*Aythya collaris*	x		x
hooded merganser	*Lophodytes cucullatus*		x	x
American coot	*Fulica americana*	x	x	x

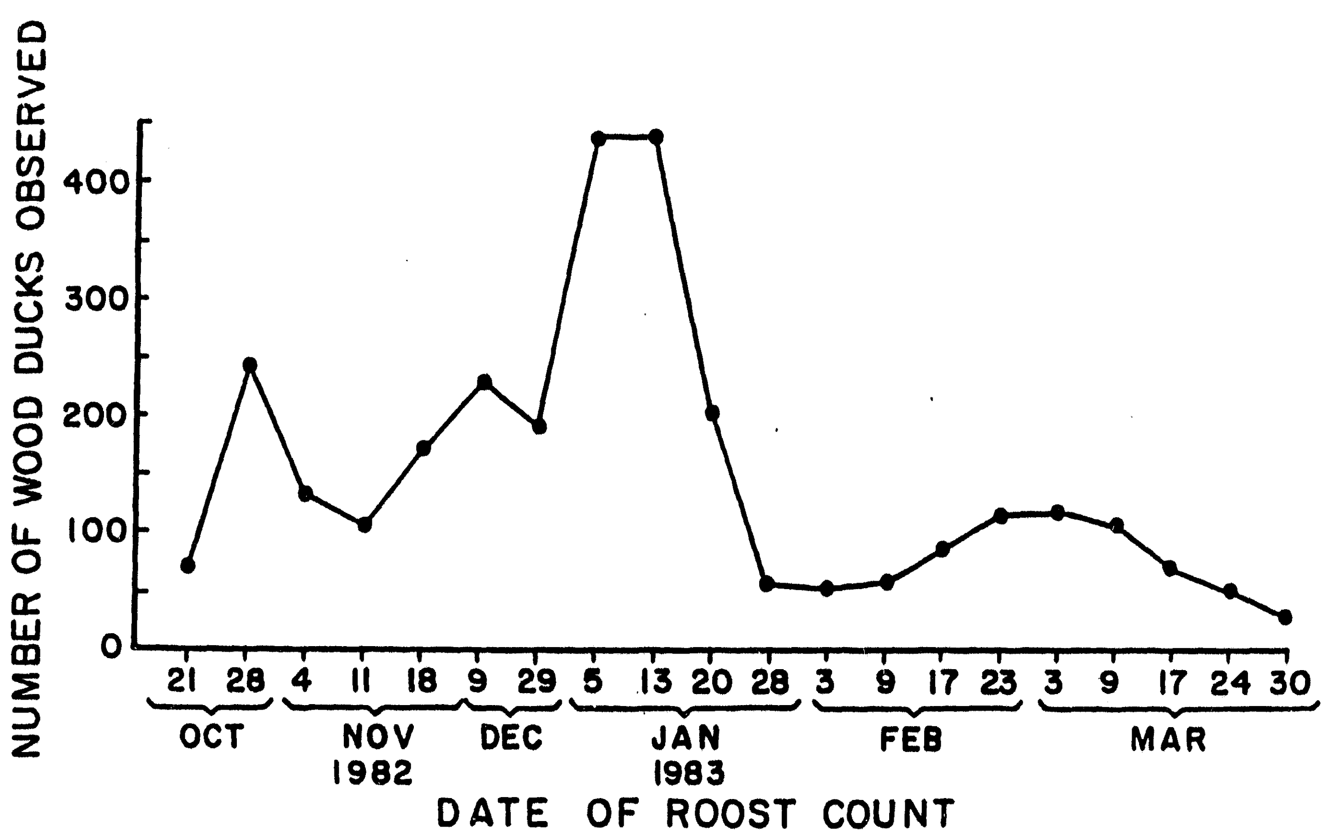

FIGURE 12. Number of wood ducks observed using the Steel Creek delta roosting area, 1982-1983.

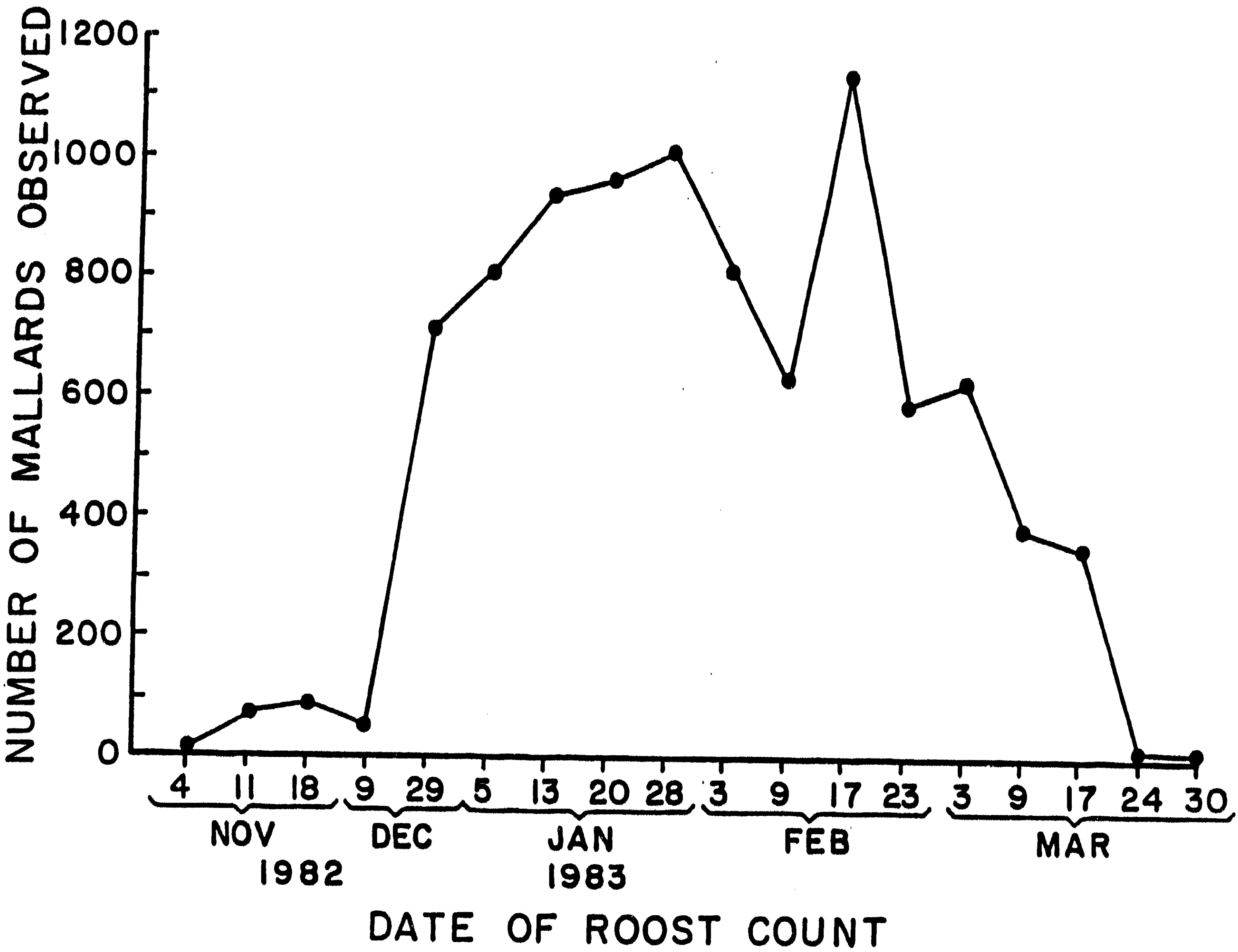

FIGURE 13. Number of mallards observed using the Steel Creek delta roosting area, 1982-1983.

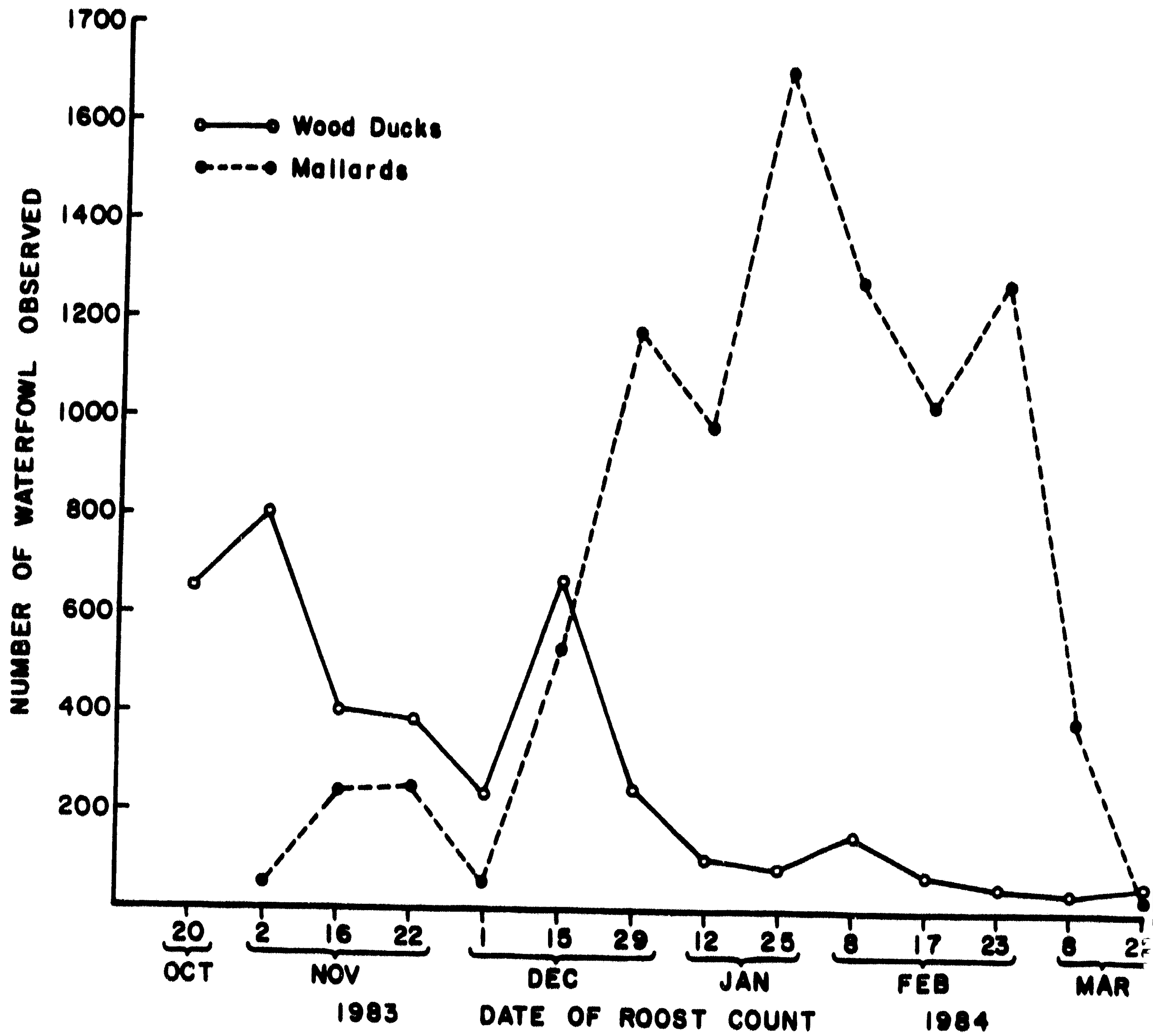

FIGURE 14. Number of mallard and wood duck observed in Steel Creek delta during the roost counts in the winter of 1983-1984.

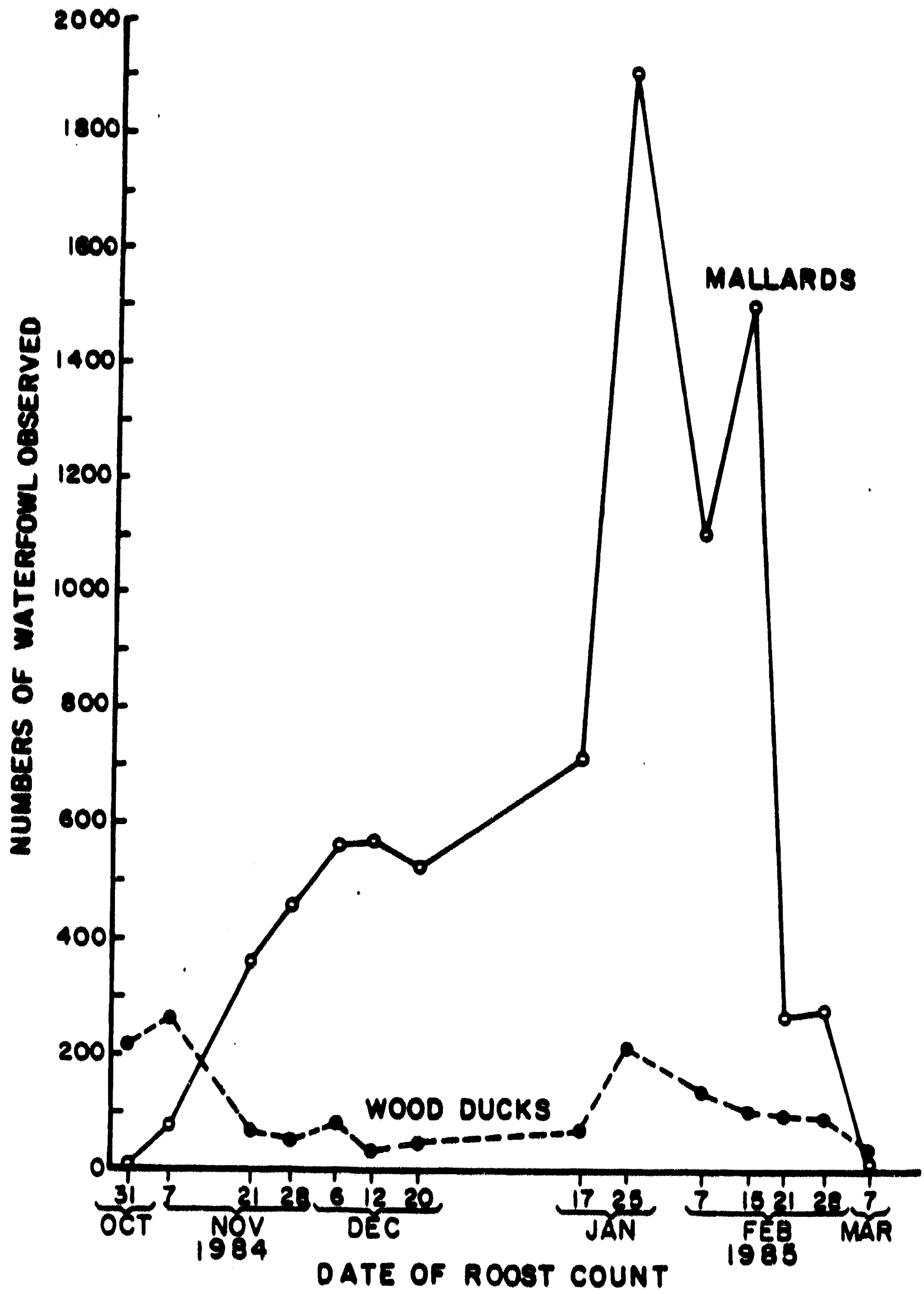

FIGURE 15. Number of mallard and wood duck observed in Steel Creek delta during the roost counts in the winter of 1984-1985.

roosting sites from mid-October to the first week in November as these birds utilize the SRSS for loafing and feeding. In the past 3 years, predictable increases in numbers of wood ducks have always occured (Figures 12, 14, and 15) at this time. Roost counts for wood ducks in years 1982-1983 show 4 distinct peaks occuring October 28, December 9, and January 5, 13, with numbers of 250, 250, 450, 450, respectively. In 1983-1984, numbers of wood ducks were consistently high the first 3 months with counts ranging from 200 to 800. November 2, 800 birds were reported roosting in the delta. This number has been the highest ever reported for wood duck roost counts. During 1984-1985 an exceptionly dryer than normal year for the Southeast, wood duck roost counts were consistently low. Only twice did counts exceed 200, once on October 7, and again on January 25. During low water years, roosting and loafing sites are unavailable, thus birds are moving to more preferred areas. Such preferred areas may be elsewhere in the SRSS, but an investigation of further roosting sites has not been initiated.

No correlation exists between wood duck aerial survey results and roost count results. Wood ducks have always been recorded during aerial surveys, but the aerial estimates have been low and inconsistent with roost counts. Roost counts are much better for determining wood duck utilization of cypress-tupelo swamp ecosystems than are aerial surveys. Wood ducks have a tendency to congregate in small flocks, and disperse throughout the non-impacted swamp. These areas supply an ideal loafing habitat for the wood ducks. The mixed deciduous swamps are much more secluded, causing aerial observation to be difficult. Investigators conducting aerial surveys of this species in similar habitats have reached the same conclusion (Bellrose 1980).

Peak numbers of mallards and wood ducks using the Steel Creek delta swamp occur at different times (Figures 16 and 17). Mallards arrive at the roosting site in early November. Maximum numbers of mallards use the delta during January and February. During 17th February 1982-1983 mallard numbers reached a high of 1,137. Mean number of mallards during 1982-1983 roost counts were the lowest of the three wintering periods (1983-1984, 1984-1985). The wintering period of 1983-1984 had three main peaks December 29th, January 25th, and February 23rd. The highest of these being in January, where 1,716 mallards were observed using the delta. The roost counts during 1984-1985, were quite different than the other two periods. Numbers of mallards using the roost were higher during the first month, while during earlier years numbers were low. As the season progressed, the greatest number of mallards were observed on January 25th, with near 1,900 in the delta. Late in February, numbers dropped off abruptly, while during the former years numbers usually dropped off in late March. Possible reasons for the seasonal variation over these years may be due to climatic conditions effecting migration, water levels, and feeding conditions.

Roost counts of wood ducks indicate high numbers during early season with gradual decrease throughout the winter. During late November through mid-January high numbers are typically observed in the delta as spring migrants pass through. In 1982-1983 peak numbers did not occur early as in the other two periods, but high counts occurred during January. The following two periods 1983-1984, 1984-1985, had consistently higher counts early, with 1983-1984, having the greatest number of wood ducks (803) on November 2. On December 15, 1983 a second pulse of 671 wood ducks was observed in the roost.

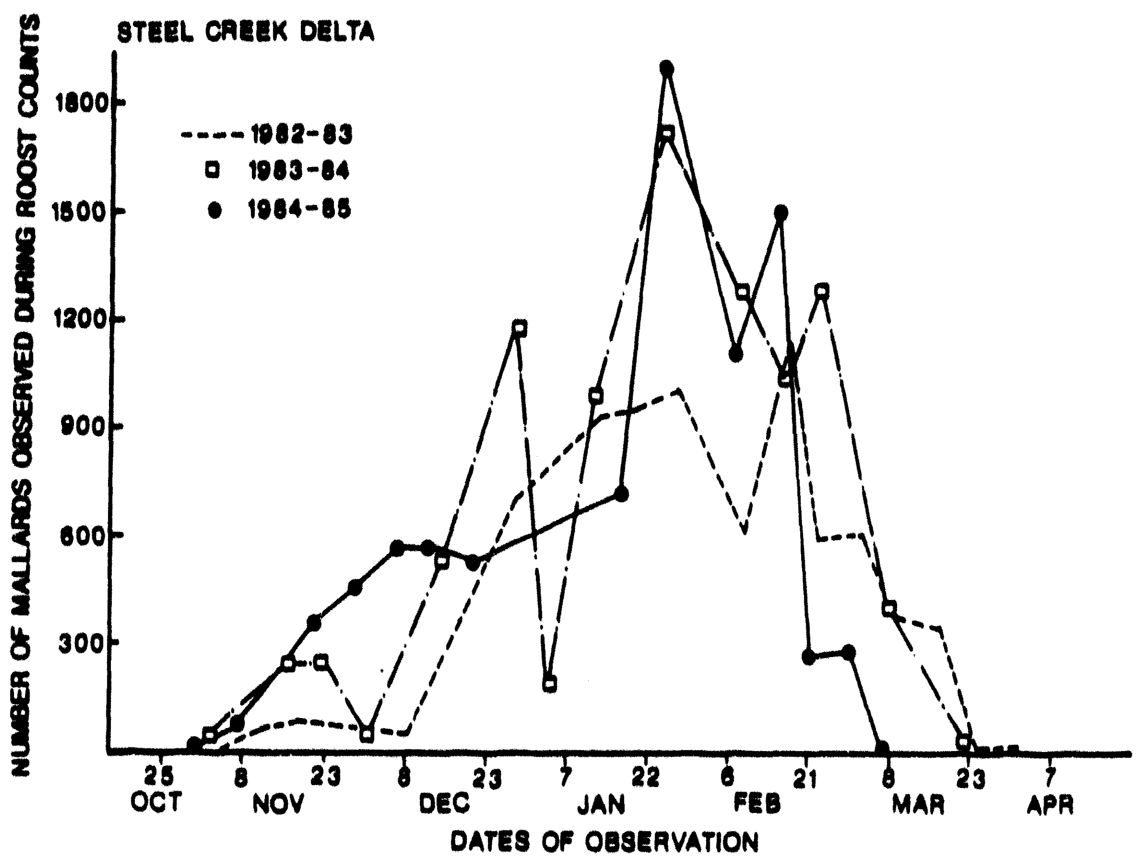

FIGURE 16. Number of mallard observed during roost counts in Steel Creek delta from 1982 to 1985.

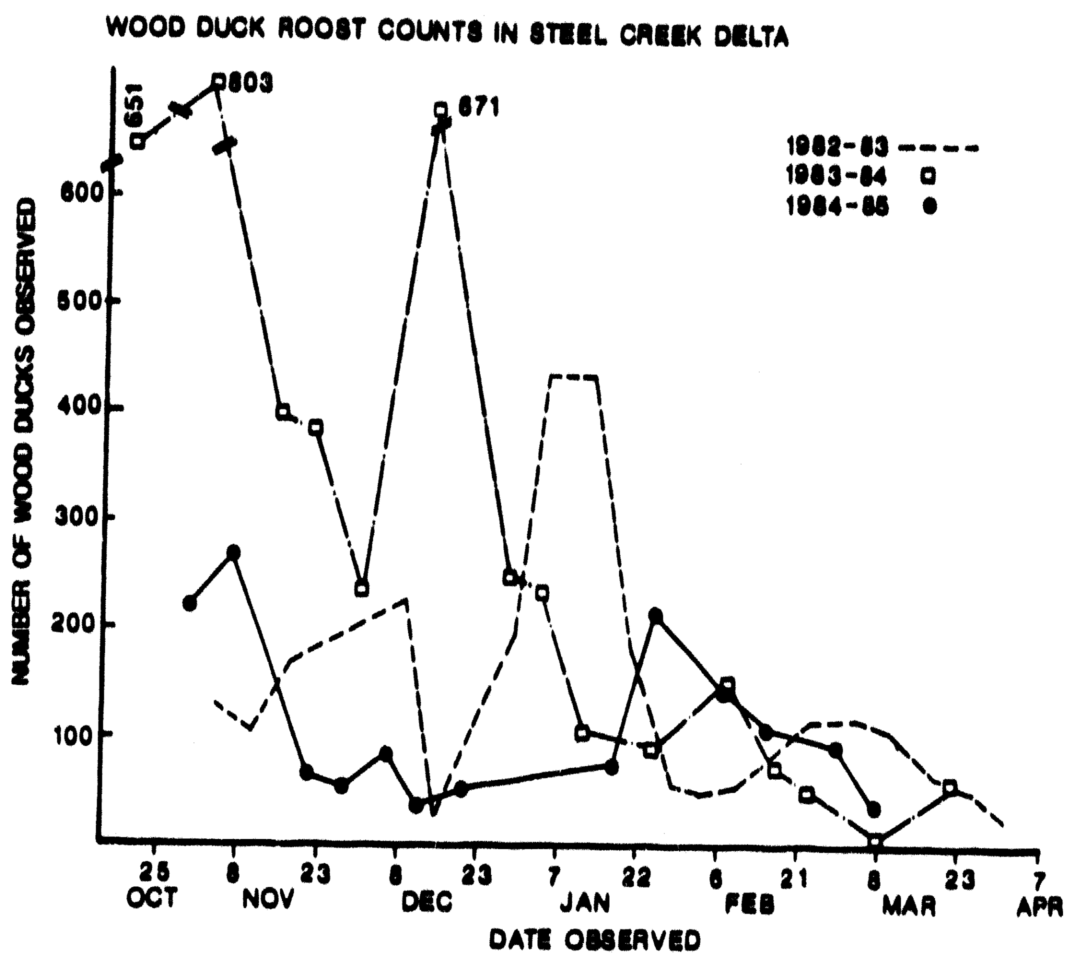

FIGURE 17. Number of wood ducks observed in Steel Creek delta during roost counts from 1982 - 1985,

During 1984-1985 wood duck numbers were very low after the early pulse on October 7, where the greatest number of 267 wood ducks were observed. A second peak indicating a possible northern spring migration occurred on January 25, with 215 wood ducks observed in the roost. Fluctuations in numbers during late winter may also indicate a northern spring migratory pulse.

The importance of the delta as a roost site can not be over emphasized. The Steel Creek delta roost is only one of possibly many within the SRSS.

In comparing mallard aerial surveys to roost counts, a significant difference exists between these two methods. Each method is indirectly related to the other in predicting usage within the Steel Creek delta. However, when studied alone, each method provides only a portion of the mallard numbers using the delta. By using both methods separately, a greater understanding of usage can be determined with respect to loafing, feeding, and roosting. The delta may be more favorable as a roosting site than a feeding site at certain times of the year.

Roost counts showed increasing numbers of mallards using the delta from 1982-1983 to 1984-1985 (Fig. 18, 19, and 20). This data would seem to indicate the delta is being used more extensively as a roosting site each year.

On January 28, 1983 a difference of 870 mallards was observed between roost and aerial survey. This is just one extreme, but typically roost counts will have greater numbers of mallards than aerial surveys.

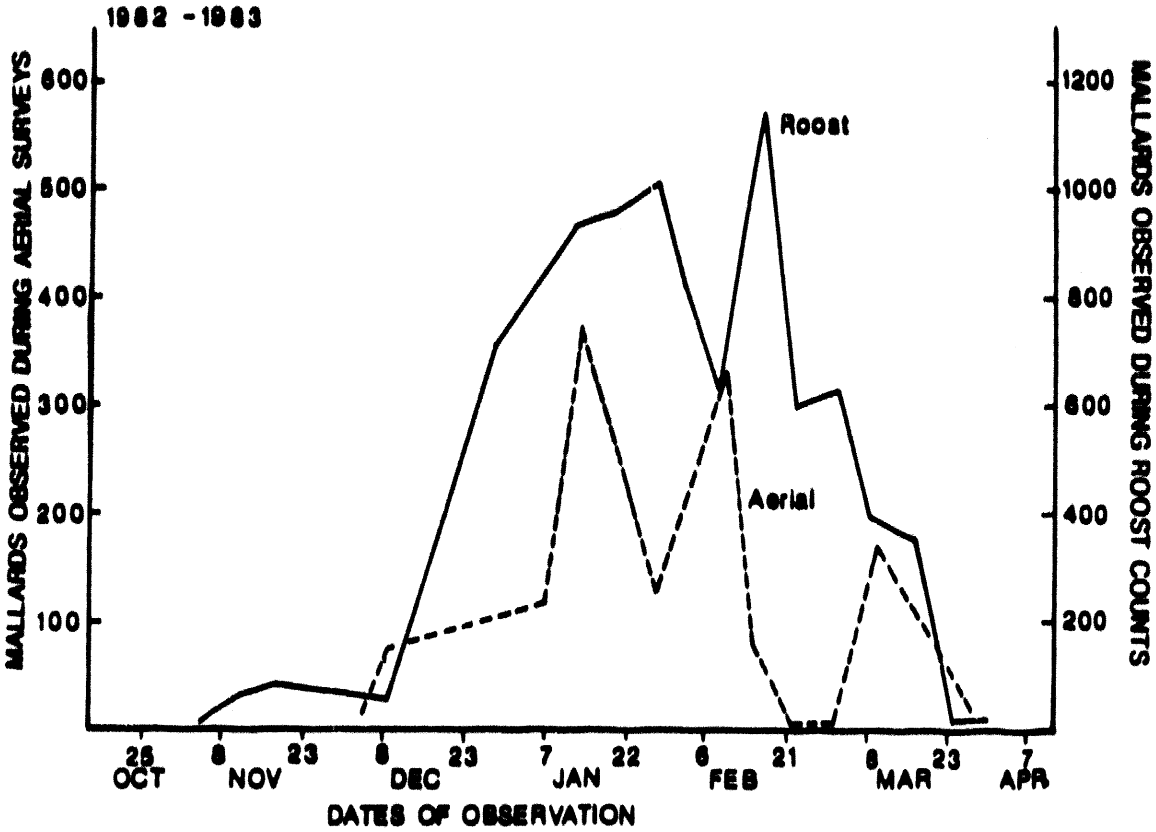

FIGURE 18. Comparison of numbers of mallards observed in Steel Creek delta from 1982-1983 during aerial surveys and roost counts.

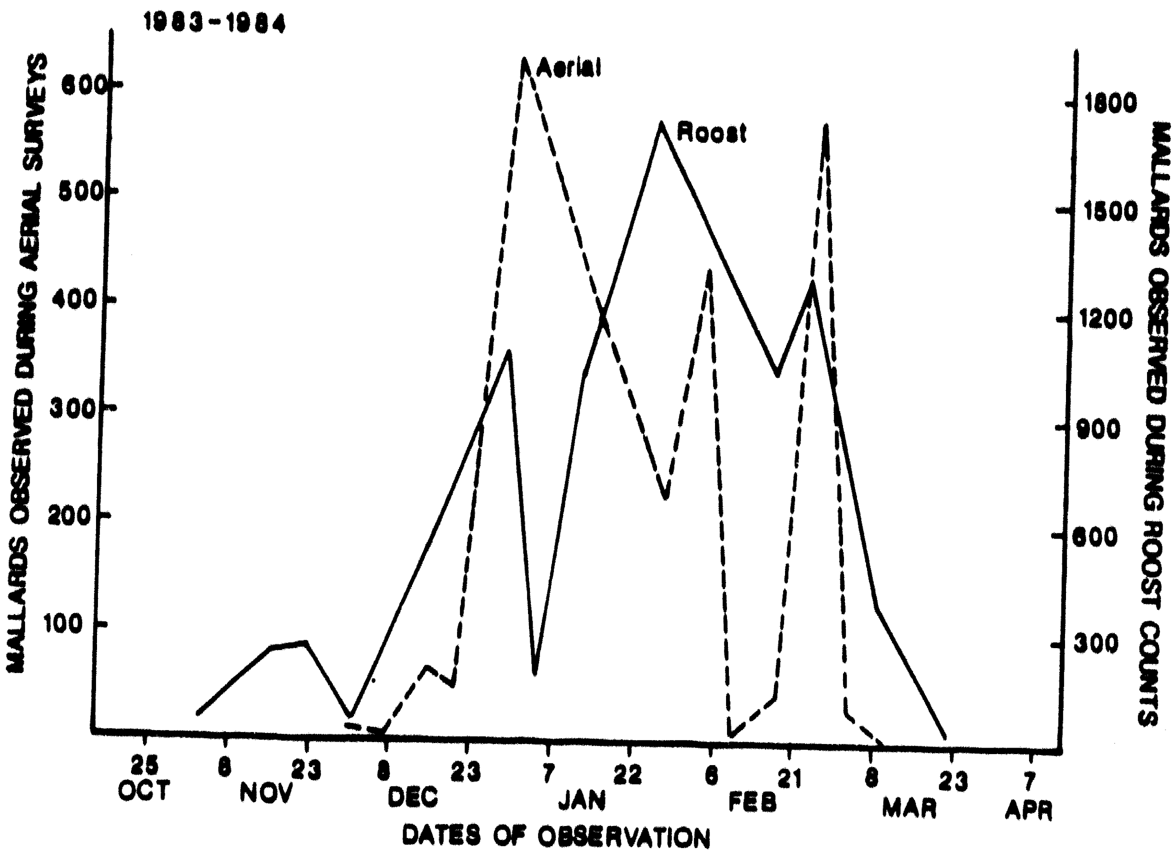

FIGURE 19. Comparison of numbers of mallards observed in Steel Creek delta from 1983-1984 during aerial surveys and roost counts.

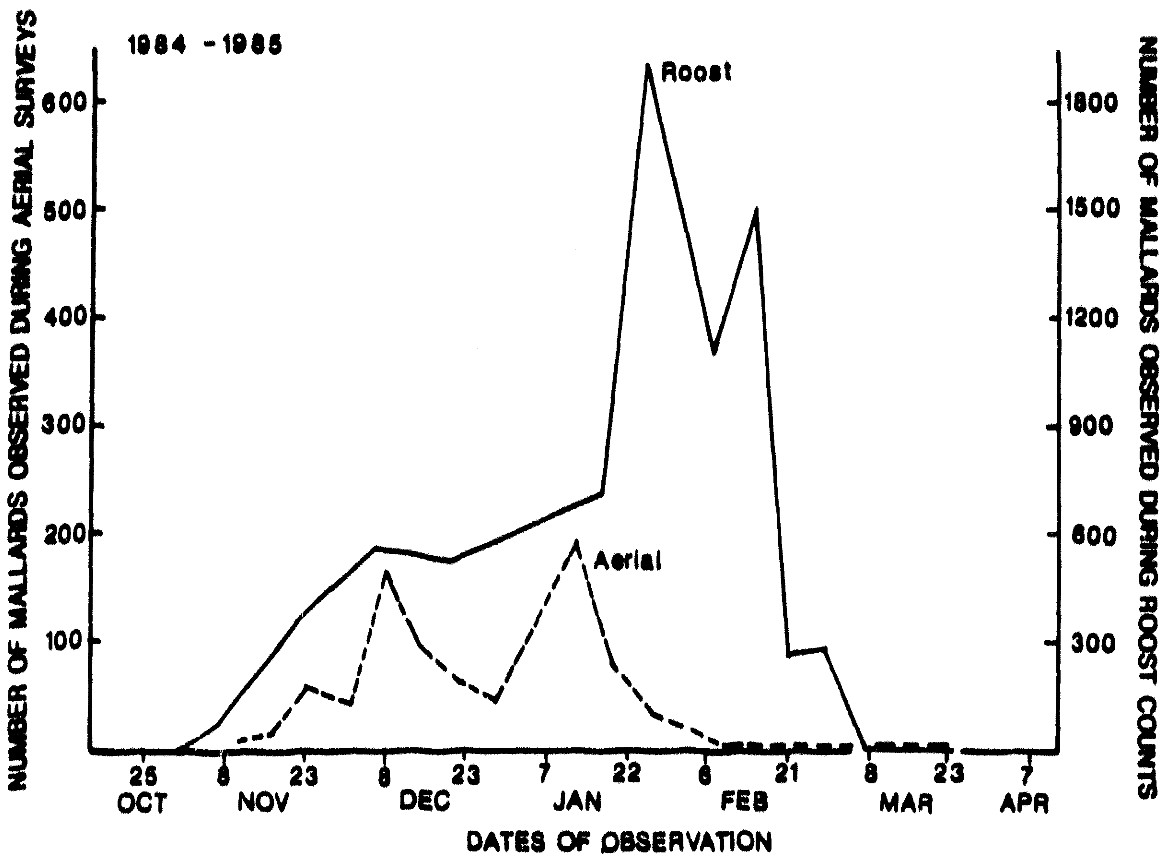

FIGURE 20. Comparison of numbers of mallards observed in Steel Creek delta from 1984-1985 during aerial surveys and roost counts.

During 1983-1984, aerial and roost counts both have three periods of high usage with aerial survey method having greater numbers.

Of the past three wintering periods, 1984-1985 had the greatest number of mallards observed during roost counts. A total of 1,903 mallards were observed roosting while only approximatly 50 were observed during aerial surveys, a difference of 1,853.

2.2.5) Habitat Utilization in the SRSS

Habitat is a key component with respect to wildlife in the SRSS. It not only provides foraging, roosting and brooding sites for waterfowl, but also serves as spawning and nursery grounds for many commercially-important fish species. In order to fully understand how wintering waterfowl are distributed among Beaver Dam Creek, Four-Mile Creek, Pen Branch, and Steel Creek availability of habitat and important habitat attributes must be determined. At present, information pertaining to Beaver Dam Creek is unavailable and only Four-Mile Creek, Pen Branch, and Steel Creek will be discussed.

Savannah River Plant cooling water effluents are discharged to onsite streams that empty into the SRSS. The cypress-tupelo canopies as well as emergent plant communities have been altered and deltas have been defined where sediments deposit upon the entrances into the swamp. Pen Branch and Four-Mile Creek are currently expanding at a rate of 5 to 6 ha/yr (Christensen et al., 1984a; 1984b). Steel Creek delta no longer receives thermal discharge and floral succession continues. Cooling water effluents have changed and diversified normal swamp vegetation. The dense cypress-tupelo is being replaced by a mixture of scrub-shrub, persistent and nonpersistent marsh vegetation (Figure 21).

Four-Mile Creek is a tributary of the SRSS which has been thermally impacted from C-Reactor since the early 1950s. Flooding has increased both water temperature and sediment deposition and has had major impact on vegetation of the swamp around the mouth of Four-Mile Creek entering the swamp. Foraging habitat for waterfowl were identified from data collected in 1982 (Smith et al., 1982) (Figure 22; Table 3). Available vegetation of the Four-Mile Creek delta and surrounding swamp were determined for waterfowl using this portion of the SRSS. Also determined were importance values of the food sources (Table 6). The number of mallards using Four-Mile, may differ depending on reactor schedules and river water levels. In all years, significantly more mallards were observed using the post-thermal recovery zones of the Four Mile Creek delta than the thermal zones (Figures 23, 24, and 25). Between mid-December, 1981 and mid-January, 1982, numbers of mallards using the non-thermal area declined while those using the thermal area increases. Reasons for this are unclear, for C-reactor was in full operation during late December and early January. Perhaps climatic conditions and a Savannah River flood event may have contributed to birds using this area.

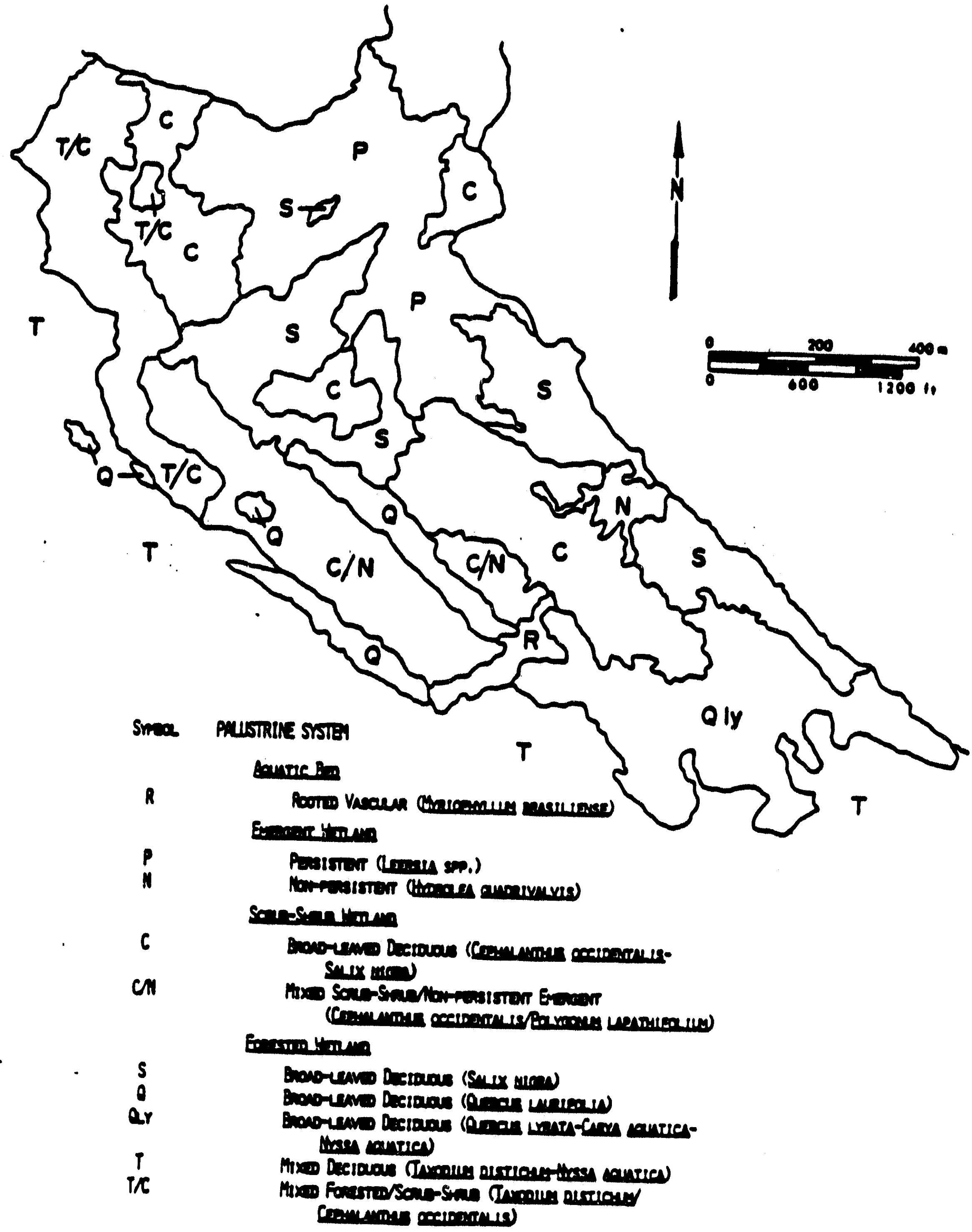

FIGURE 21. Vegetation map of Steel Creek delta based on 1978 aerial photographs and 1981 field studies.

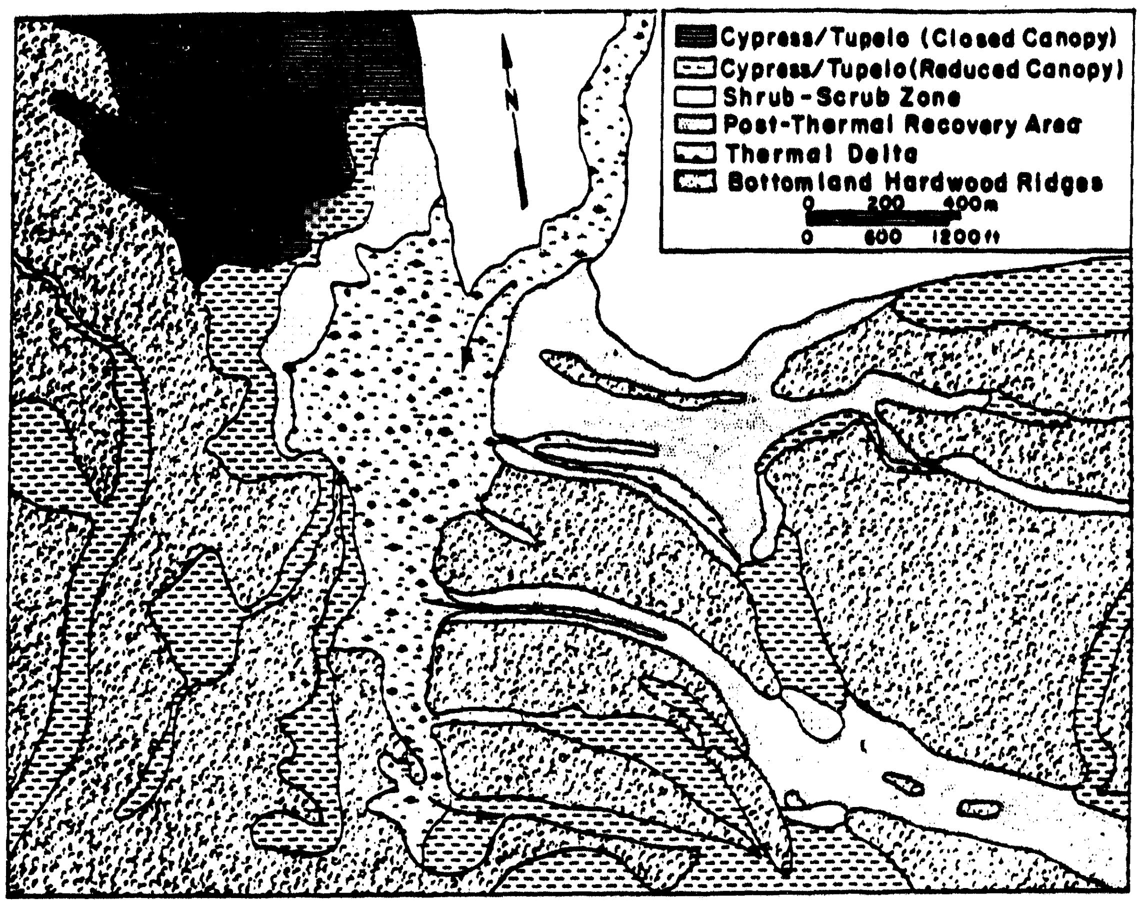

FIGURE 22. Vegetation map of Four Mile delta and swamp based on 1981 aerial photographs. Arrows indicate direction of waterflow.

Table 3. Species composition of the vegetational communities of Four Mile Creek delta.

SYSTEM	PLANT SPECIES
Thermal Delta (nonpersitent emergent)	water primrose amarania rotala
Post-thermal recovery (persistent emergent)	marsh sedges false nettle cutgrass knotweed wapato
Shrubs (shrub-scrub)	water elm lycopus pepper-vine St. John's Wort willow buttonbush
Reduced canopy cypress-tupelo (mixed deciduous forest)	cypress water tupelo ash Virginia willow

Table 3. continued

SYSTEM	PLANT SPECIES
Bottomland Hardwood	water oak
(broad-leaved deciduous)	laurel oak
	sweetgum
	elms
	possum haw
	hackberry
	ironwood
	sedges
	poison oak
	greenbrier
	grape

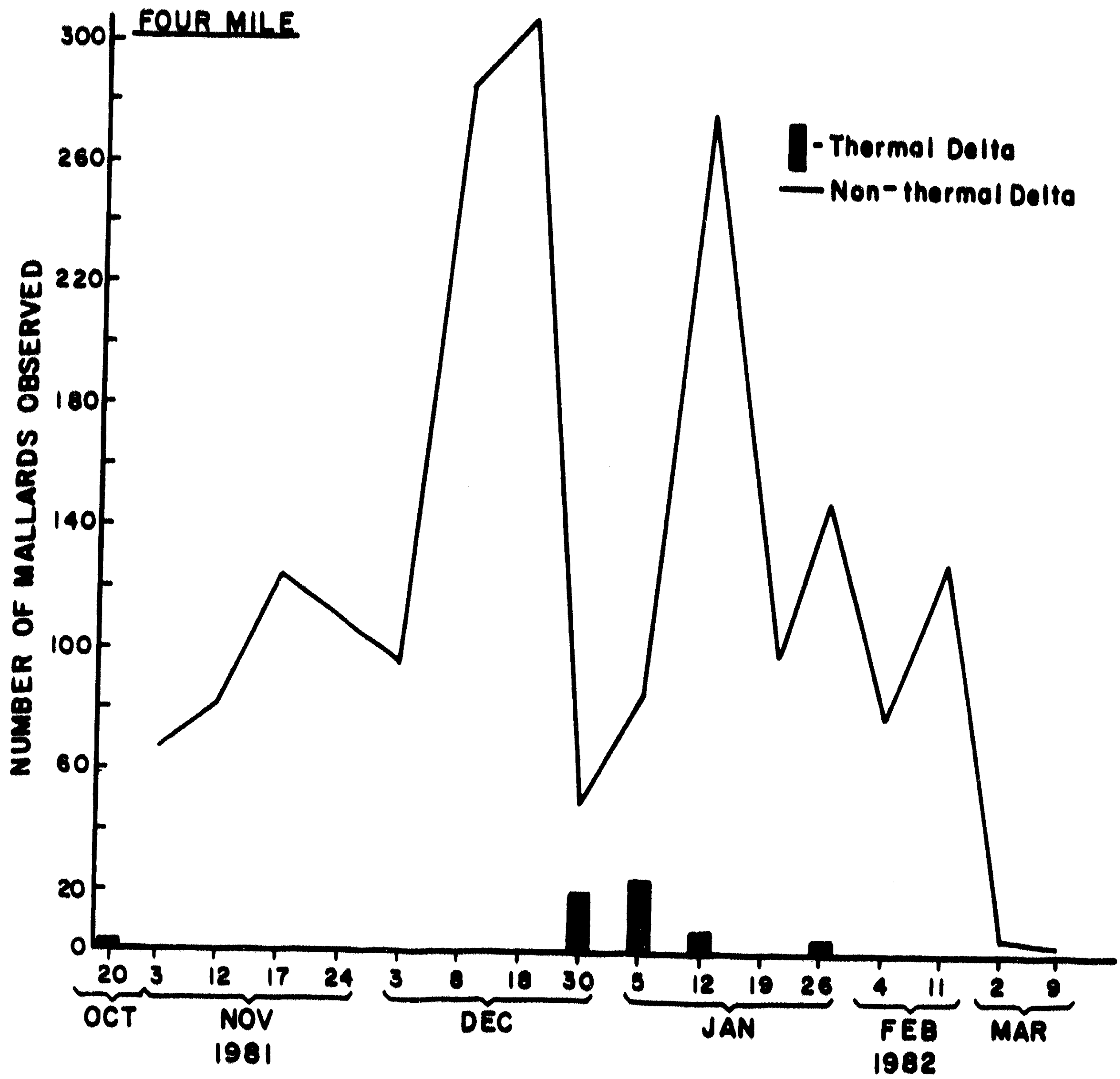

FIGURE 23. Comparison of number of mallards using thermal and non-thermal areas of Four Mile Creek delta during 1981-1982.

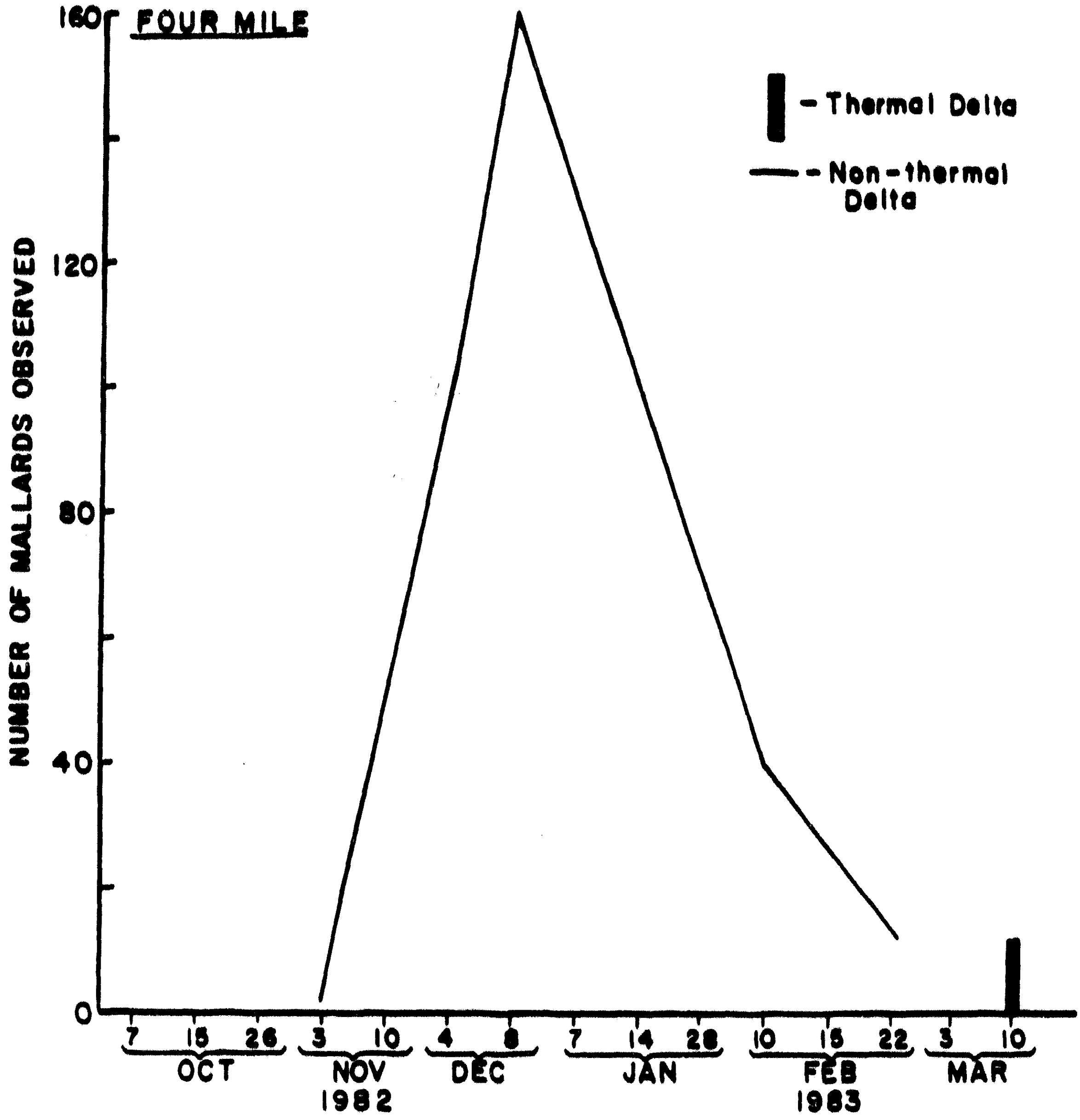

FIGURE 24. Comparison of number of mallards using thermal and non-thermal areas of Four Mile Creek delta during 1982-1983.

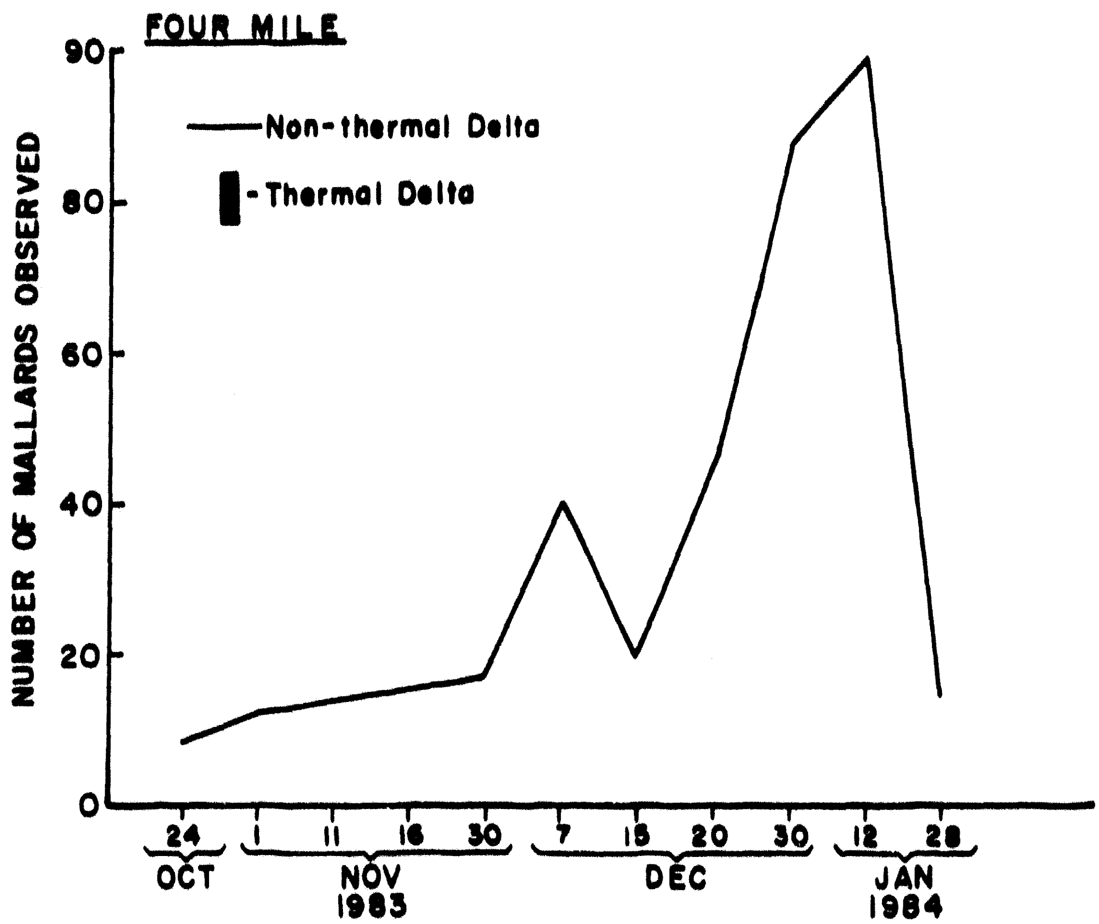

FIGURE 25. Comparison of numbers of mallards using thermal and non-thermal areas of Four Mile Creek delta during 1983-1984.

Table 4. Species composition of the vegetational communities of Pen Branch delta.

SYSTEM	PLANT SPECIES
Algal Bed	
Theral area (nonpersistent emergent)	water primrose
Post-thermal recovery (persistent emergent marsh)	knotweed
	cutgrass
	false nettle
Shrubs (shrub-scrub)	willow
	buttonbush
Reduced canopy cypress-tupelo (mixed deciduous bottomland)	oak
	loblolly pine
	sweetgum
	red maple
	hickory

Table 5. Abundance in each mapping unit of Steel Creek delta of plant species which are used as food by mallards and wood ducks. Mapping unit symbols are (dominant species of each unit in parentheses): R - rooted vascular aquatic bed (*Myriophyllum brasiliense*); P - persistent emergent wetland (*Hydrolea quadrivalvis*); C - broad-leafed deciduous scrub-shrub wetland (*Cephalanthus occidentalis* and *Salix nigra*); C/N - mixed scrub-shrub/non-persistent emergent wetland (*C. occidentalis*/*Polygonum lapathifolium*); S - brod-leafed deciduous forested wetland (*Salix nigra*); Q - brod-leafed deciduous forested wetland (*Quercus lyrata* - *Carya aquatica* - *Nyssa aquatica*; T - mixed deciduous forested wetland (*Taxodium distichum* - *Nyssa aquatica*); T/C - mixed forested/scrub-shrub forested wetland (*Taxodium distichum*/ *Cephalanthus occidentalis*). Abundance scale: 4 - abundant; 3 - frequent; 2 - occasional; 1 - present. Waterfowl species abbreviations are: M - mallard; W - wood duck.

Plant Species	Mapping Unit										Waterfowl Feeding on This Species
	R	N	P	C/N	C	S	T/C	T	Qly	Q	
Herbs											
Aneilema	2	4	3	4	2	3	3	2			W
Bidens frondosa			1		3	2	3				W
Boehmeria cylindrica	3		3	3	3	3	4	2	2	1	W
Commelina virginica									1		W
Eleocharis quadrangulata			1								M
Eleocharis sp.			2								M
Hypericum walteri	1		3	3	3	3	1	2			W
Leersia spp.		3	4	4	4	4	4				MW
Lemna perpusilla	3							2			MW
Ludwigia leptocarpa			1	2	2	1	1				W
Myriophyllum brasiliense	3	4		3	2						M
Panicum agrostoides			3		3	3	4				W
Panicum spp.			1							1	W
Paspalum fluitans	3										MW
Paspalum urvillei			1								W

Table 5. (continued)

Plant Species	Mapping Unit R	N	P	C/N	C	S	T/C	T	Qly	Q	Waterfowl Feeding on This Species
Polygonum hydropiperoides		4	4	4	3	4	3	1			MW
Polygonum lapathifolium	2	4	1	3							MW
Polygonum sagittatum			1								MW
Potamogeton berchtoldii	2										MW
Sagittaria graminea								3			MW
Sagittaria latifolia		4	4	4	4	3	3				MW
Saururus cernuus						1	2		1		W
Scirpus cyperinus			4	2	4	2	2				M
Spirodela oligorrhiza	1										MW
Shrubs and Saplings											
Cephalanthus occidentalis	2	1	3	3	4	2	4	1		1	MW
Fraxinus americana						1			2		W
Fraxinus caroliniana	2			4	2	2	4	3		1	W
Liquidambar styraciflua	1			1					1	1	M
Planera aquatica	2	1		3		2			2	1	W
Taxodium distichum	2	2	1	3	1	2	2	1	2		W
Ulmus alata	1									1	W
Ulmus americana					1						W
Trees											
Liquidambar styraciflua					2				2	2	M
Planera aquatica							4	3		1	W
Quercus laurifolia				1			1			4	
Quercus lyrata									3	2	MW
Quercus michauxii										3	MW
Quercus nigra										2	MW
Taxodium distichum	3			3			4	4	3		W
Ulmus alata										2	W
Ulmus americana									2	2	W

Table 6. List of plant food species consumed by 6 waterfowl species commonly observed utilizing Steel Creek Delta. The number designation of each food species indicates the percent volume composition in the diet of each waterfowl species; (4)=10 to 25%; (3)=5 to 10%; (2)=2 to 5%; (1)=0.5 to 2%. Data taken from Martin et al. (1951), Bellrose (1980), Cottam (1939), McGilvrey (1966a), and McGilvrey (1966b).

Floral Food Species	Waterfowl* Species						Floral Food Species	Waterfowl* Species					
	MA	WD	BW	GW	BD	AW		MA	WD	BW	GW	BD	AW
Oak	2	4			1		Pickerelweed					1	
Hickory		3					Panic grass			2	4		
Wildmillet	3		1	2			Muskgrass	2	2	1	1		1
Smartweed	3	1	4	2	3		Cyperus			1	2	3	
Bulrush	3		3	4	2		Waterhyssop						
Duckweed	3	3	1	3			Paspaulm				1		
Spikerush	3	1	2	2	3	4	Shoalgrass						
Pondweed	3		1	2	4		Water primrose						
Rice	3		2				Hydrochloa						
Naiad	2				3		Ananapus						
Widgeongrass	2		3	1	3		Glasswort						
Arrowhead	2						Water lilly	1	3	1		2	
Coontail	2	2					Watermilfoil				1		
Buttonbush	2	1	1	1	3	1	Sedge						
Chufa	1						Mannagrass		2				
Bald cypress	2	4	2	2			Ash		2				
Wildrice	1		1	1	2		Blackgrum		2				
Beak rush	1	1			1		Water-elm		2				
Sawgrass	1	1	2	1			Buttercup		2				
Watershield	1			2			Bidens		2				
Cordgrass	1				2		Redroot		1				
Burreed	1		1		4		Hawthorn	1	1			3	
Sweetgum	1	3			4		Hornbeam		1				
Horn-pondweed	1						Fanwort		1				
Algae			2		3		Rice cutgrass	4	1			1	4
Wild celery					1		Lizardtail		1				
Saltgrass					1		Holly					1	

*MA = mallard; WD = wood duck; BW = blue-winged teal; GW = green-winged teal; BD = black duck; AW = American vigeon

Pen Branch, a thermally-impacted area resulting from K-Reactor operations, has had continuous loss of plant species where this drainage empties into the SRSS. Listings of available plant species for waterfowl in Pen Branch (Mike Scott, pers. comm.) as well as Steel Creek delta (Smith et al., 1981) show floral community diversity attributable to the effects of thermally-loaded drainages (Table 4 and 5).

Many species of waterfowl are observed in the SRSS between mid-September and March (Table 1). Wood ducks are present throughout the year but a substantial turnover of individuals occurs seasonally. Wintering populations are larger than summer populations due to the influx of migratory wood ducks. Wood ducks banded at the SRP during August through November have been recovered in Minnesota, Wisconsin, and Ontario, as well as in South Carolina. The remaining species are present only during the fall and/or winter months, although hooded mergansers may occasionally breed on the SRP during the spring and summer.

As was noted earlier, mallards and wood ducks dominate the waterfowl species present in the SRSS. Mallards do not arrive until late October with the greatest number present during January and February (Figure 18, 19, and 20). Mallard numbers decline from late February until late March. Mallards present during March are late spring migrants which spend only one to two weeks in the SRSS. Use of the SRSS area by other species were generally low. Flocks of green-winged teal (*Anas crecca*), blue-winged teal (*Anas discors*), gadwall (*Anas strepera*), American wigeon (*Anas americana*), American black duck (*Anas rubripes*), pintail (*Anas acuta*), northern shoveler (*Anas clypeata*), ring-necked duck (Aythya collaris), bufflehead (Bucephala albeola), coot (Fulica americana), and hooded mergansers (Lophodytes cucullatus) were observed using the SRSS (Table 1).

2.2.5.1) Foraging Habitat in the SRSS

The SRSS has been used extensively for foraging by mallards and wood ducks. Extensive data on food habits from the Southeast are available for wood ducks but minimal work has been completed on mallards. Fall food habits of wood ducks and mallards were reported by McGilvrey (1966b) near Santee Refuge, South Carolina. Most food consumed by these two species consisted of plant food with very little animal material. A listing of the plant food species consumed by 6 waterfowl species commonly observed using Steel Creek delta is presented in Table 6. The six most important plant species for wood ducks in order of importance were: oak seeds (Quercus sp.), bald cypress (Taxodium distichum), corn, green hawthorne (Crataegus visidis), sweetgum (Liquidambar styraciflua), and Asiatic dayflower (Aneilema keisak). Wood ducks are much more selective in their food habits than mallards. The six most important food items of mallards, in order of importance, were: Southern rice cut grass (Leersia hexandra), hydrochloa (Hydrochloa carolinensis), sweet gum, buttonbush (Cephalanthus occidentalis), smartweed (Polygonum hydropiperoides) and spike rush (Eleocharis obtusa). The dietary requirements of resident SRP wood duck populations during spring and early fall were discussed by Landers et al. (1977) with reference to seasonal habitat selection.

Relative use of different foraging habitats on the SRP changed with seasonal availability of important foods, but showed similarity in corresponding months of two separate years. The swamp consists of three main areas; the thermal, post thermal, and cool swamp. The cool swamp contributed acorns (Quercus hemisphaerica and Q. nigra), Asiatic dayflower, southern smartweed, panic grasses and water elm (Planera aquatica) to the diet. The post-thermal area was used intensively in October and November when it provided Asiatic dryflower and dotted smartweed, two of the foods taken in greatest volume during those months. The thermal area provided Asiatic dayflower, annual panic grasses, and nodding smartweed during January and February. With departure of the migrant wood ducks, relative use of thermal areas declined and use of the post-thermal and cool swamps increased during March to May, which coincides with the peak of nesting and brood rearing. Within these areas, female wood ducks are foraging for invertebrates.

Among the plant foods, acorns were the most important fall and early winter food in 1973. The food item taken most consistently during late fall and winter was Asiatic dayflower seeds. Smartweed seeds were taken inconsistently but were important from late fall to spring. During August and September, seeds of white waterlily were eaten in large quantities. Three plant foods were significant but not major items: sweetgum (Liquidambar styraciflua) seeds in January, duck potato (dogittania graminea) tubers in late winter, and vasey grass (Paspalum urvillei) seeds in May. Animal foods made up 23 percent of the diet in March, but accounted for less than 10 percent in other months (Table 7).

Table 7. Major foods by month of 200 wood ducks collected on the Savannah River Plant from August 1973 to August 1975 (Landers et al., 1977).

Food Item	(10) J	(14) F	(10) M	(10) A	(13) M	(10) J	(10) J	(20) A	(24) S	(21) O	(41) N	(17) D
	Aggregate Percentage											
Aneilema keisak	17	41	16			28			1	13	21	14
Panicum spp.	32		11		27	9			7	2	1	4
Paspalum fluitans												
Liquidambar styraciflua	9											1
Animal matter	7	5	23	4	9	4	8	9	6	4	1	1
Sagittaria graminea	4	2	9									1
Planera aquatica			9	70								
Scleria reticularis					9	1						
Paspalum urvillei					6	2	4					
Rubus cuneifolius					1	13	2					
Potamogeton spp.					28	13	30				2	
Spirodela polyrrhiza							30	2	10	5	2	11
Echinochloa walteri		1				20	34	5	15	1	2	
Nymphaea odorata								64	41	18		
Polygonum spp.	11	40	3	3	4	4	8	8	6	27	11	1
Leersia oryzoides			3		5	1		3	2	3	2	5
Brasenia schreberi								10	8	1		
Vitis rotundifolia									5	2	1	
Quercus spp.	20									11	32	25
Ludwigia leptocarpa	1									11	2	1
Taxodium distichum							2				1	16
Hypericum walteri										1	2	
Boehmeria cylindrica	1											1
Bidens frondosa									1		2	

These composed collectively at least 98.0 percent of the total diet each month.

Aggregate percentage is the average of individual volumetric percentages as defined by Martin et al. (1946) and Larimore (1957). Percentages are rounded to the nearest whole number. Values less than 0.51 are omitted.

Numbers in parentheses indicate sample sizes.

2.2.5.2) Seasonality of Waterfowl Food Species

Various habitats of the SRSS used as waterfowl foraging sites change depending on seasonal availability of important plant species. Thermal, post-thermal and cool areas of the swamp were used extensively by migrating wood ducks from October through January. The cool swamp contributes mast (Quercus hemisphaerica and Q. nigra), a highly preferred food item for wood ducks. Also present in the cool swamp area: Asiatic dayflower, Southern smartweed, panic grasses, and water elm (Planera aquatica). According to Landers et al. (1977) and aerial surveys conducted over the SRSS between 1981-1985, post-thermal areas of Steel Creek delta provided excellent foraging habitat for mallards and wood ducks with the majority of food items composed of Asiatic dayflower and dotted smartweed. Both of which are used intensively by wood ducks during October and November.

Four-Mile Creek and Pen Branch are both areas of the SRSS which are used by waterfowl. Four-Mile Creek delta is the more important of the two area as a foraging site for migrating mallards between October and February. Pen Branch is apparently of minor importance in this respect as evidenced by the paucity of ducks observed in this drainage system. Reasons for use of these sites were discussed earlier in this report. As determined by the aerial surveys conducted over the SRSS, these two areas receive little use by wood ducks.

With the departure of the migratory wood ducks during February and March, moderately thermal areas of Beaver Dam Creek, post-thermal areas, and the cool swamp were used extensively through May, the peak of nesting and brood rearing for wood ducks on the SRP. Female wood ducks foraged for invertebrates in the post-thermal and cool swamps more than any other area.

Landers et al. (1977) observed that during July, resident wood ducks moved to more open areas in the cool swamp and to upland Carolina bays. Wood ducks feed in Caroiina bays and man-made ponds during early morning from late July until mid-October and in the afternoon from November to December. During these times, wood ducks fed intensively on white waterlily, watershield, rice cutgrass, and paspalum. Landers et al. (1977) never found an abundant number of wood ducks in the mature cypress-tupelo riverswamp below post-thermal areas or along flooded hardwood bottomlands. These observations were different from those made during weekly canoe trips throughout the mature cypress-tupelo riverswamp during 1981-1984. Frequently, as many as 50 wood ducks would be flushed from these open understory/high canopy flooded areas. Small islands and numerous open areas throughout the cool swamp below the post-thermal area would act as preferred loafing sites during midday from October to February. In addition to the wood ducks, mallards would also frequently use these open pools surrounded by mature cypress-tupelo stands. Mallards also utilize these pools as foraging sites for duckweed (<u>Spirodela polyrrhiya</u>) and acorns. Plant food items make up the largest proportion of the wood duck diet during each month of the year (Table 7) (Landers et al., 1977). Acorns were the most important fall and winter food item in 1973. Acorns made up 40.4 percent of the winter diet in 1973, but only 3.7 percent in 1974 due to a mast crop failure in the region. That portion of the diet formed by acorns in 1973 was replaced in 1974 by seeds of primrose willow, sticktight (<u>Bidens frondosa</u>), St. John's wort (Hypericum walteri), Bald cypress (Taxodium distichum), and false nettle (Boehmeria cylindrica). The food item taken most consistently during late fall and winter was Asiatic dayflower seed. Where present, this species is preferred by wood ducks second only to acorns.

Wild millet and rice cutgrass were common and among the earliest available seed foods during late summer and fall. During August and September, seeds of white waterlily were eaten in large quantities. Watershield was abundant, but was taken in relatively small amounts. The shift from white waterlily corresponded with the availability and use of muscadines (Vitis rotundifolia) late in September. With the departure of wood ducks from ponds and Carolina bays, ring-necked ducks arrived and fed intensively on the seeds of watershield and waterlily which probably dropped to the bottom and became unavailable to the wood ducks.

Annual foods made up 23 percent of the diet in March, but accounted for less than 10 percent in other months (Table 7). Increased feeding on invertebrates in early spring may be related simply to availability relative to plant species, but from mid-January to early April, the period just before and during nesting season for wood ducks, females consumed more ($P<0.05$) animal foods than did males (Landers et al., 1977). During other times, intake of invertebrates never differed significantly between the sexes. These findings seem to follow other trends in food habits of waterfowl during this time of the year (Swansen et al., 1974; Krapu, 1974).

2.2.5.3) Waterfowl Foraging Habitat Enhancement

Foraging habitat enhancement for mallards and wood ducks could aid these species in meeting energy needs throughout the year. Seasonal differences in SRP waterfowl diets may be a reflection of availability and/or nutritional requirements.

Habitat manipulation practices in areas adjacent to the SRSS may increase available foraging sites. Management of selected emergent vegetation as waterfowl food sources can be very effective in attracting waterfowl. Perennial and annual food plants may be managed by drawdowns. Water control structures and adequate water level control are important in the management of these bays and impoundments. Drawing water down should be done as late as possible, yet early enough to allow seed production in such fast growing submergents such as wild millet, rice cutgrass, and smartweeds. Drawdown dates vary according to latitude. In the middle Atlantic states, June 20th is the established drawdown date with a reflooding by September 1st in order to serve early migrants. In South Carolina, a drawdown in mid-July and a reflooding by October would be appropiate.

Managing several different impoundments around the upland margins of the SRSS would be effective for manipulating cover as well as food resources for the waterfowl using that area. Cover species composition can be controlled by time and length of drawdowns. If soils remain wet, cattails and bulrush are those cover species favored. If it is allowed to dry, sedges and woodgrass (Scirpus sp.) are likely to invade. Late spring and summer drawdowns favor submerged plants; mid and late summer drawdowns favor weedy growth. If desired, planting of preferred foods for waterfowl can be done.

2.2.5.4) Waterfowl Roosting Habitat in the SRSS

While studying wintering habitat use by wood ducks in the SRSS, Costanzo (1980) noted that 93 percent of the wood ducks using the Steel Creek delta preferred marsh, shrub-marsh, and open water habitat types, mainly altered by reactor effluent discharges. These three habitat types are composed of knotweed, buttonbush, and open water sites. Through extensive ground searches by canoe, wintering wood ducks were observed during 1982-1985 utilizing cypress-tupelo swamp habitat. Use of this habitat was primarily for loafing with little use for roosting or foraging, although small island communities within the cypress-tupelo habitat do contribute acorns, a highly preferred food item for wood ducks.

Preferred roosting sites for wood ducks and mallards were characterized by dense overhead and lateral cover, consisting mainly of buttonbush. Throughout the roost area, buttonbush was interspersed with Asiatic dayflower and Southern smartweed. Steel Creek delta, the only documented roosting area in the SRSS, has a large contingent of mallards and wood ducks. Wood ducks were observed roosting in lesser numbers than mallards between the months of November through March. Within the past four years (1981-1985), definite changes in roosting sites have taken place in the delta. This probably has been caused by successional changes of habitat and the formation of small pools with lateral cover. Early roosting sites used extensively are shown in Figure 26. The area for mallard roosting increased and moved from deeply flooded areas with cypress-tupelo and buttonbush to shallowly flooded areas interspersed with buttonbush and deep water pools.

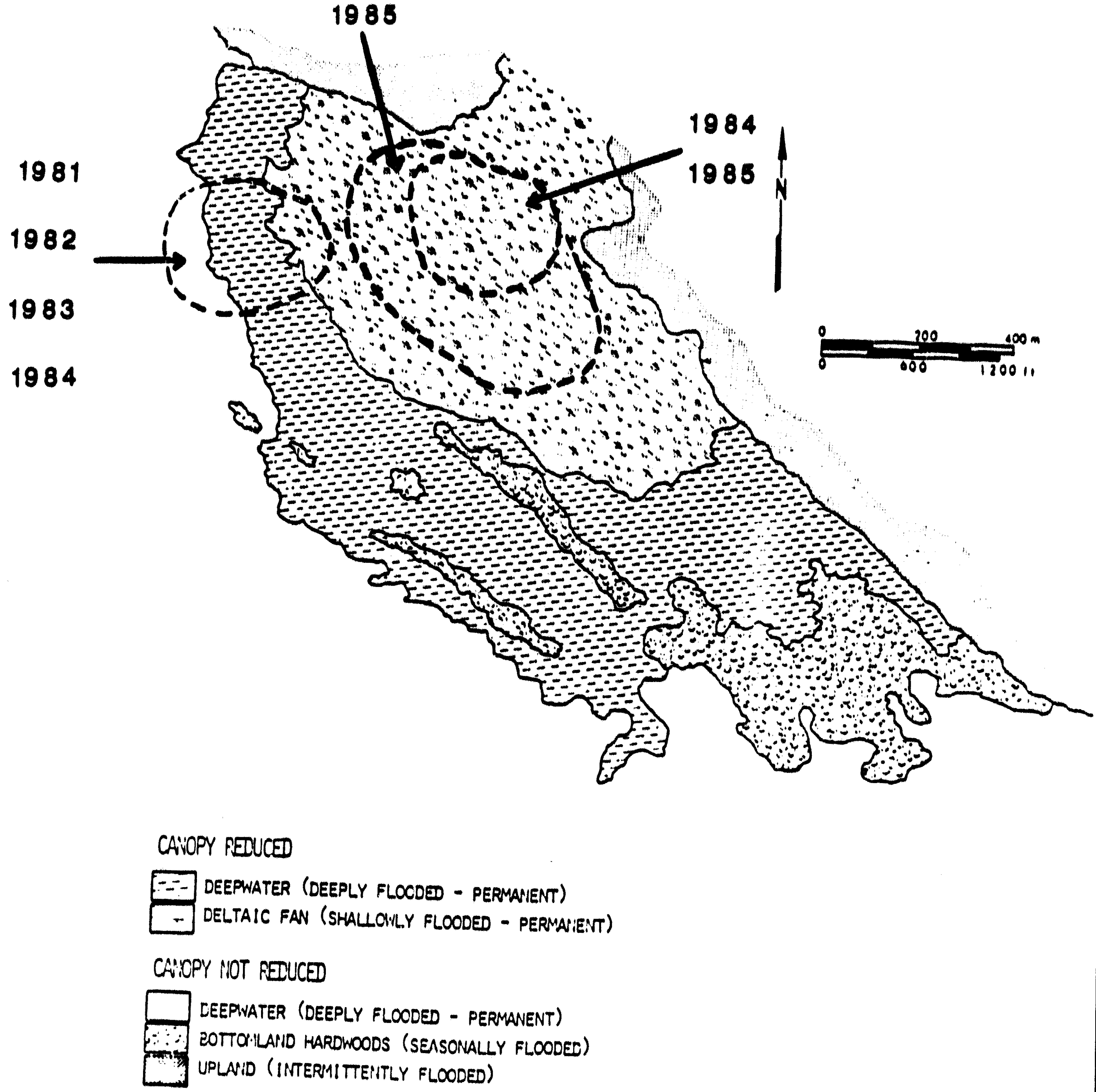

FIGURE 26. Annual changes in the wood duck and mallard roosting sites in Steel Creek delta from 1981 to 1985.

These shallow areas are ideal feeding sites with communities of Southern smartweed, Asiatic dayflower, pennywort, and parrot-feather. Beaver dams throughout the delta have contributed to the increased water levels in many of the roost sites. Wood duck roosting sites have also shifted, from a well established roost site in 1981-1984 to a much larger area encompassing much of the recovering area of the delta (Figure 26).

2.6) Effects of Thermal Effluent on Waterfowl Use of the SRSS

During the study period from fall 1981 until spring 1985, two nuclear production reactors (100-C Area Reactor and 100-K Area Reactor) and one coal-fired power plant (400-D Area Power) discharged thermal effluents into the SRSS, comprised of approximately 15 mi^2. Thermal effluents from K-Reactor via Pen Branch enter the SRSS at temperatures generally 4.5° centigrade higher than the effluents from C-Reactor via Four Mile Creek (48.5° C vs. 44.0°C) due to the 2.2 mile shorter route taken by the K-Reactor discharge (Neill and Babcock, 1971). The thermal loading to Beaver Dam Creek from the 400-D Area Power plant is considered to be significantly lower than loading attributed to reactor operations in other streams emptying into the SRSS.

The two major usage areas of the SRSS by mallards are the thermal Four Mile Creek delta area and the post thermal recovering Steel Creek delta area. The useage of these areas however can vary by significant proportions from year to year and even through a single winter period. Although adequate data are not available to quanitify the variables thought to be responsible for observed variations in useage of these two sites, general observations of swamp conditions (i.e., river stages, swamp water levels, reactor status) were noted during surveys and have led to these probable scenarios. Steel Creek delta useage may be directly influenced by water level conditions. In addition, there may be a threshhold water level below which access to much of Steel Creek delta is virtually eliminated and waterfowl consequently must seek other areas of the SRSS to use. Four Mile Creek delta useage, conversely, may be inhibited by unusually high water levels caused by periodic flooding of the SRSS by the Savannah River. These flood events when accompanied by a C-Reactor "up" period is thought to flush the normally southward thermal effluent slug into the eastward perpendicular channels thus changing an otherwise preferred waterfowl usage site into an intollerable area. Examples of such instances may be found during the winter of 1982-1983 and the winter of 1983-1984 (Figures 27, 28, and 29 respectively). Notice how mallard usage dropped from near 180 individuals in Four Mile Creek delta in early December, 1982 to zero in early Janaury, 1983 and from then remained extremely low for the balance of the winter season. Similarly, usage remained low all winter of 1983-1984 in Four Mile Creek delta. In both examples the Savannah river was noted to be breaching the dikes and the SRSS water level was abnormally high. Further, C-reactor was noted to be in operation during these surveys. Though quanitative data are not available from these flood events, strong evidence suggests these to be the relative consequences.

Presented in Figures 30 and 31 are water depths and water temperatures from Steel Creek delta and Four-Mile Creek delta respectively

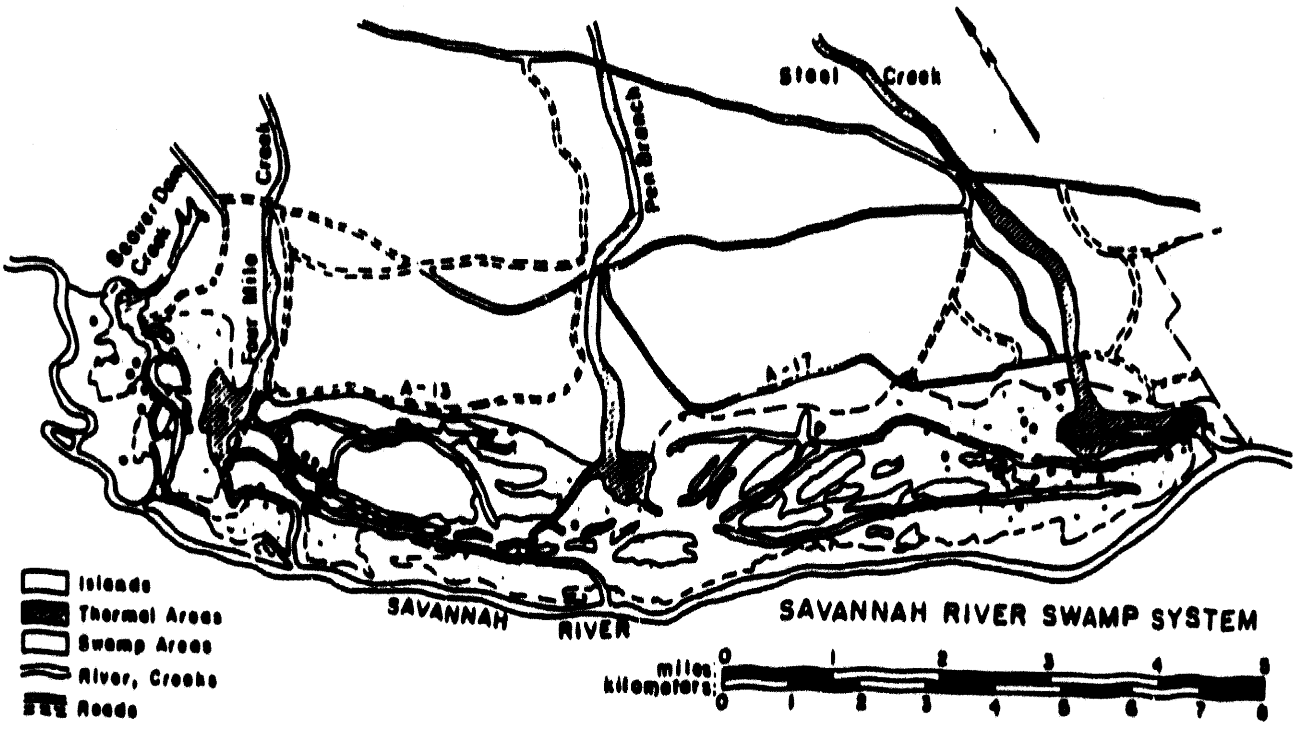

FIGURE 27. Locations of mallards (black dots) in the Savannah River Swamp System during 1981-1982 as determined using aerial surveys.

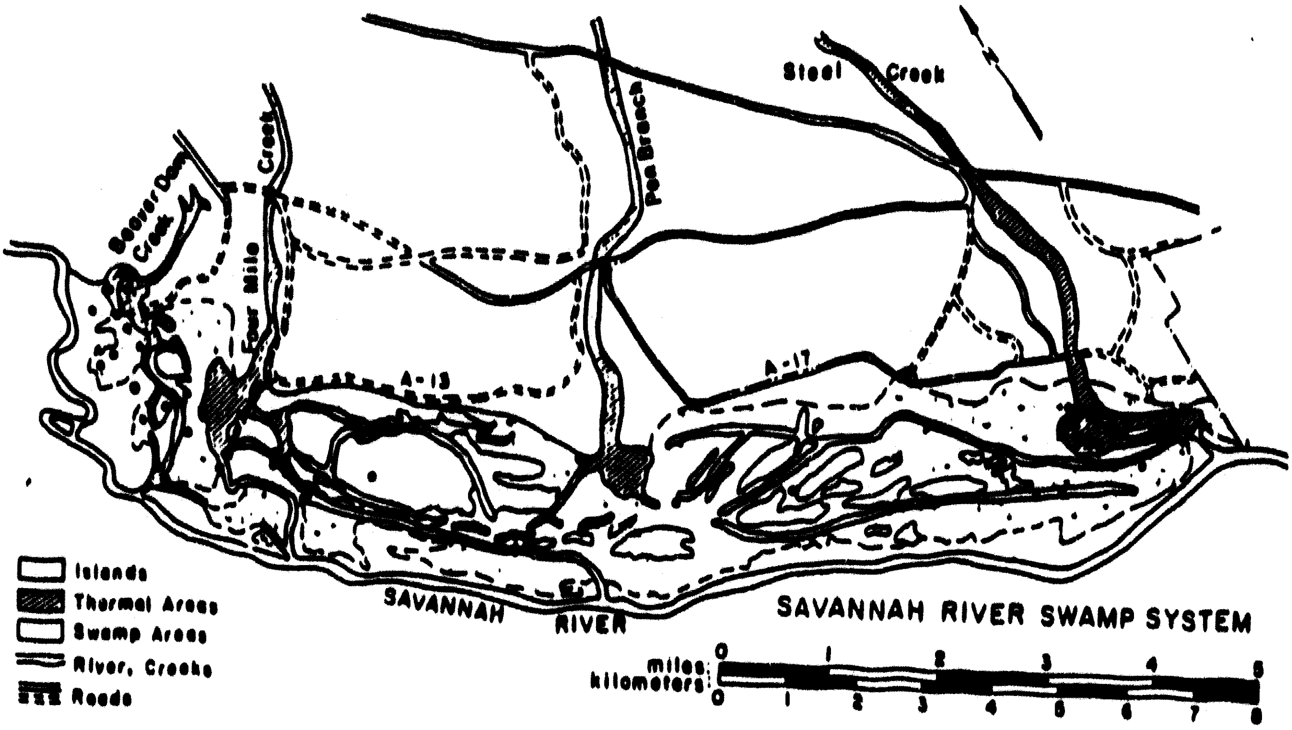

FIGURE 28. Locations of mallards (black dots) in the Savannah River Swamp System during 1982-1983 as determined using aerial surveys.

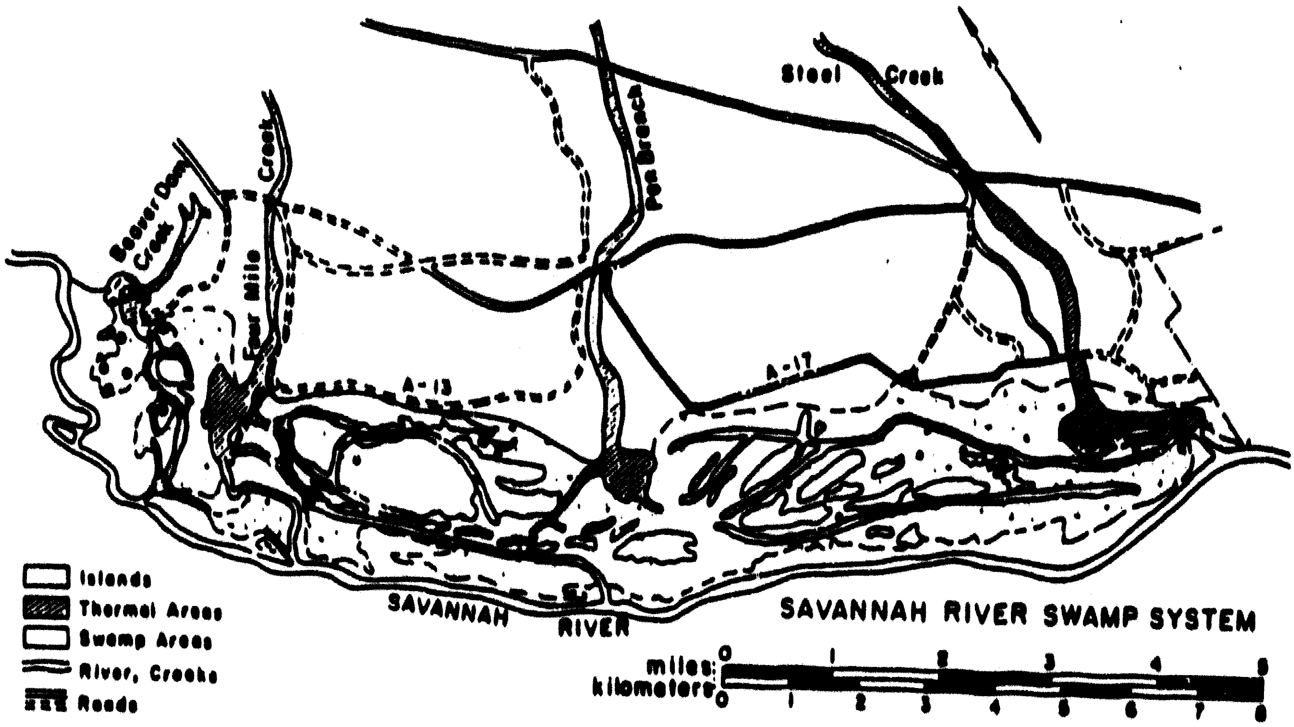

FIGURE 29. Locations of mallards (black dots) in the Savannah River Swamp System during 1983-1984.

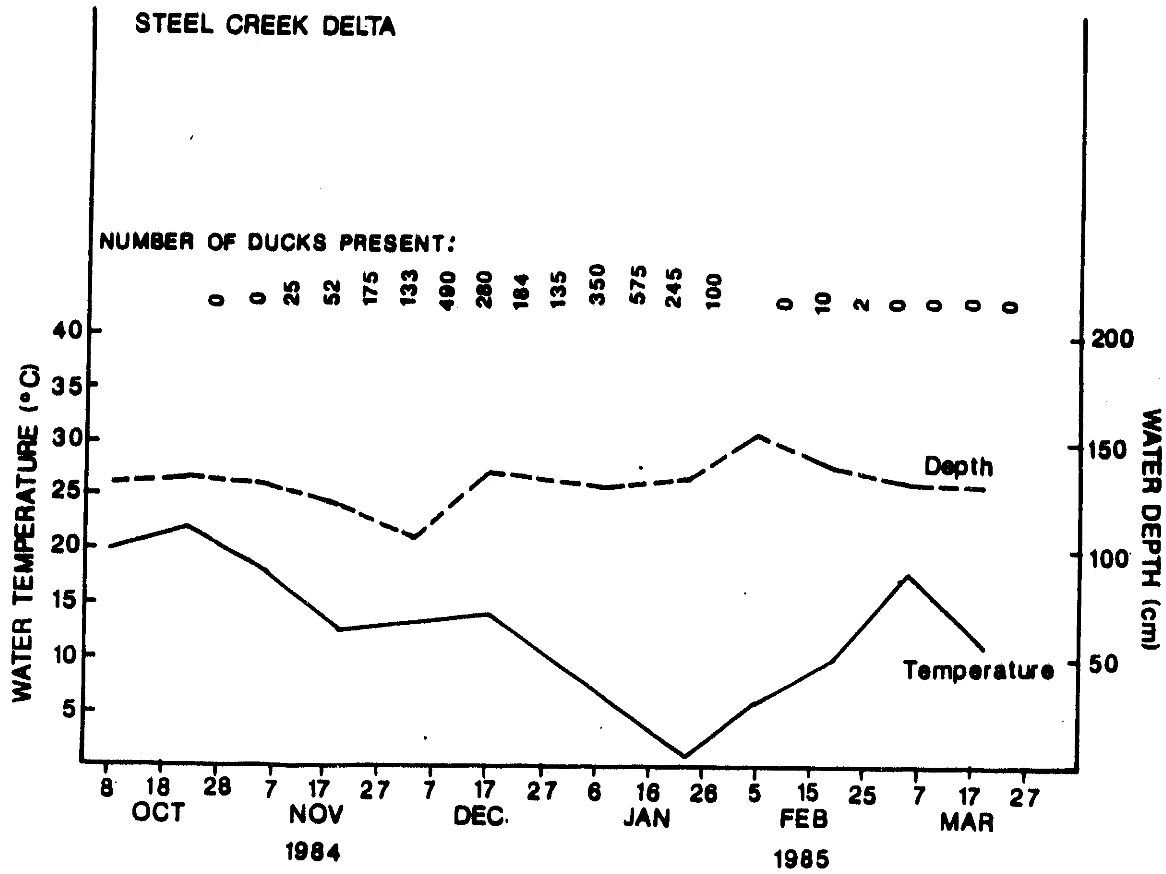

FIGURE 30. Relationship of water temperature and depth to numbers of mallards observed during aerial surveys in Steel Creek delta during 1984-1985.

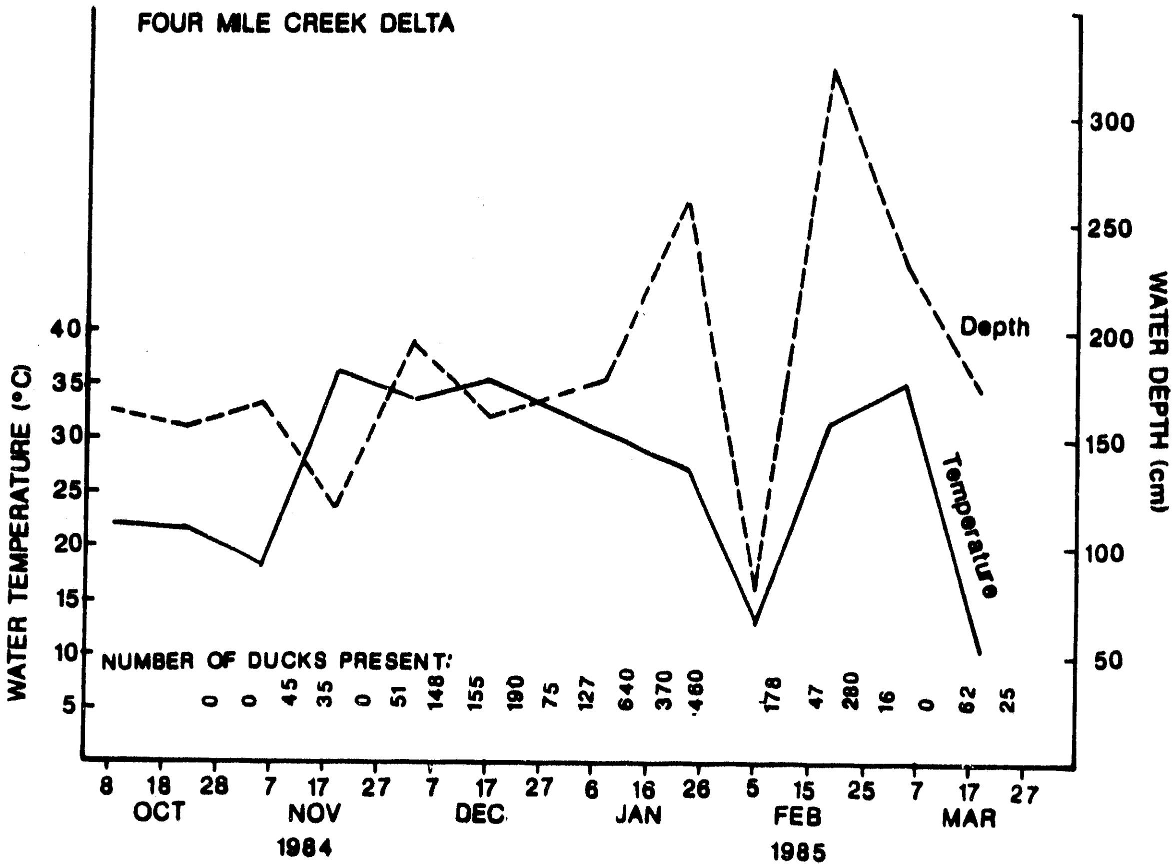

FIGURE 31. Relationship of water temperature and depth to numbers of mallards observed during aerial surveys in Four Mile Creek delta during 1984-1985.

during the winter of 1984-1985. Also shown in each figure are the number of mallards observed at the respective sites during the 21 aerial surveys of the winter period. This information is of little value in proving or disproving the scenarios set forth in the previous paragraph because no major flood events of the Savannah river and no major changes between site usage occurred during this winter period. This information is useful, however, for demonstrating conditions which are favorable for mallard use in both Steel Creek delta and Four-Mile Creek delta.

2.3.1) Waterfowl Utilization of the Par Pond Reservoir System

Aerial surveys of the Par Pond Reservoir System were undertaken in the fall of 1981 in conjunction with the more intense aerial surveys conducted over the Savannah River Swamp System. At that time, the primary concern of SRP Operations was the assessment of the SRSS waterfowl utilization as related to the restart of the SRP's dormant L-Reactor. Realizing the extensive use of Par Pond by wintering waterfowl, SREL personnel made frequent trips to Par Pond for counts of the waterfowl species there. These first Par Pond counts from the winter of 1981-1982 are somewhat limited in their scope and no specific locations of Par Pond were shown to be utilized by waterfowl. A total of 23 flights were recorded from 4 August, 1981 to 30 March, 1982.

Beginning in the fall of 1982, greater interest in waterfowl use of Par Pond prompted much closer observation and assessment of specific areas within the reservoir being used by waterfowl as well as the aforementioned frequency of species occurrence. These aerial surveys were initiated on 24 September, 1982, and were conducted at approximately one week intervals until 29 March, 1983, yielding a total of 18 flights during this period.

Aerial surveys of Par Pond for the winter of 1983-1984 were initiated on 4 October, 1983 and included 22 flights. New data collection techniques employed during this winter period enhanced the efficiency by which waterfowl were counted. During the previous winter, observers simply tabulated species and numbers on maps of Par Pond, which required the interruption of observations. The new technique of recording waterfowl by using hand held mini-cassette recorders allowed the observer continous uninterrupted viewing of the flight path around the Par Pond perimeter. Upon return to the laboratory, the cassette-recorded data were transferred onto maps according to 36 known specific locations about Par Pond. Problems were encountered with this new technique, however, when the recorded data for a January flight vanished, along with a cassette recorder, before the data were transferred onto maps. Thus, no data on Par Pond waterfowl are available from January of 1984. The last flight for this winter period was on 7 April, 1984.

The final winter period to be considered here will be the 1984-1985 season which included 21 flights beginning on 27 October, 1984, and ending on 23 March, 1985. These surveys were conducted at weekly intervals with the exception of a flight scheduled for 2 February, 1985, which was cancelled due to poor flight conditions. Unlike the previous year, the surveys of the 1984-1985 winter were all conducted on Saturday in order to minimize waterfowl disturbance by normal weekday human activities on the reservoir.

2.3.2) Review of Past Utilization of the PPRS

Use of the Par Pond Reservoir System as a migratory waterfowl staging area and winter refuge can be more clearly understood because of the surveys conducted each winter. A maximum of 19 species were identified by aerial survey in the winter of 1984-1985. Of these 19 identified species, six were diving duck species, eight were dabbling duck species, two were grebe species, one was a species of goose, one was a species of rail, and one was a species of merganser. Other species are known to be infrequent winter visitors to Par Pond, but were not identified during aerial surveys. These include the common goldeneye, oldsquaw, white-winged scoter, green-wing teal, red-breasted merganser, and common moorhen. The highest waterfowl count recorded on any single aerial survey of Par Pond during the winter of 1984-1985 was 3,526, on 17 November, 1984. This figure does not include American coots which numbered approximately an additional 2,000 individuals.

During the 1983-1984 winter season, 16 species of waterfowl were identified on Par Pond by aerial survey. Species observed in the winter of 1984-1985, but not seen in the winter of 1983-1984 include the redhead, black duck, and northern shoveler. The most waterfowl recorded on any single flight over Par Pond during the winter of 1983-1984 was 3,297, on 30 December, 1983. This figure does not include an approximate count of 2,000 American coots also present at that time.

Identified by aerial survey during the winter of 1982-1983 were 15 species of waterfowl on Par Pond. Species observed in the winter of 1984-1985, but not observed during the winter of 1982-1983 include the redhead, pintail, hooded merganser, and Canada goose. The most waterfowl recorded on any single aerial survey of Par Pond during the winter of 1982-1983 was 4,434, on 14 January, 1983. This figure does not include an approximate count of 2,800 American coots also present at that time.

The limited information available from the winter of 1981-1982 indicates a high of 4,035 waterfowl were on Par Pond during a survey on 3 December, 1981. This figure does not include an approximate count of 3,500 American coots also present at this time.

The most consistent occurring and abundant species of waterfowl found on Par Pond each winter were four diving duck species. These species include the lesser scaup, ring-necked duck, bufflehead, and ruddy duck. Counts of these four species of diving ducks during the four year study period are presented in Figures 32, 33, 23, and 35. These waterfowl are distinguished from another common group, the dabbling ducks, by the location of the feet, facilitating improved diving capabilities. Other distinguishing features of diving ducks are described by Bellrose (1980). These features of diving ducks make them more efficient users of greater portions of the Par Pond reservoir than the dabbling ducks. When dabbling ducks are seen on the reservoir, they are often found near shore and in shallow secluded coves, a less than dominant feature of Par Pond. Figure 36 shows the maximum number of these four diving duck species observed on Par Pond during any single aerial survey for each of the four winter periods surveyed. Lesser scaup were consistently the most numerous species observed on Par Pond for all winter periods in which data were collected. There was, however, a net decline of 21.2 percent from the

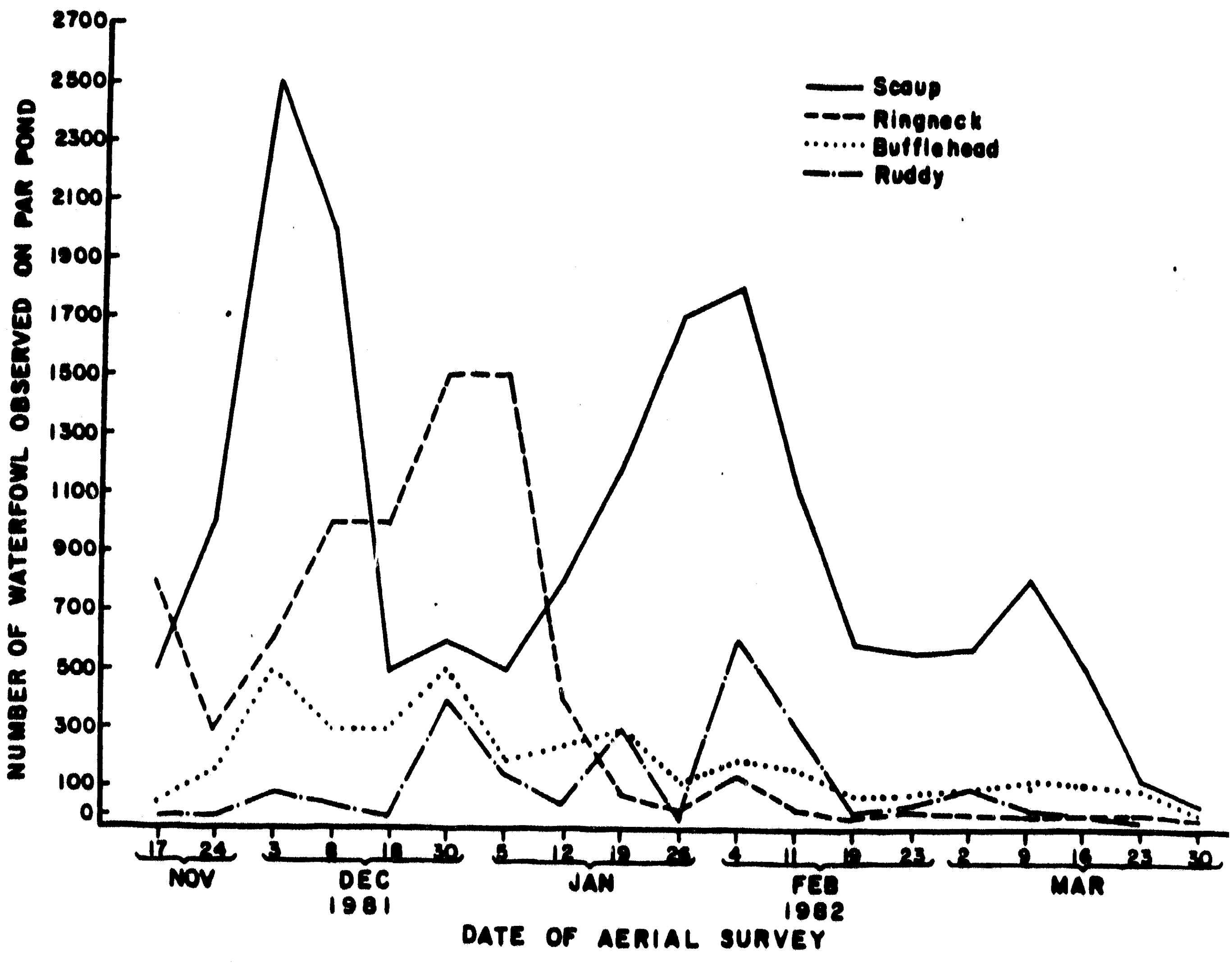

FIGURE 32. Waterfowl numbers on Par Pond during the 1981-1982 winter.

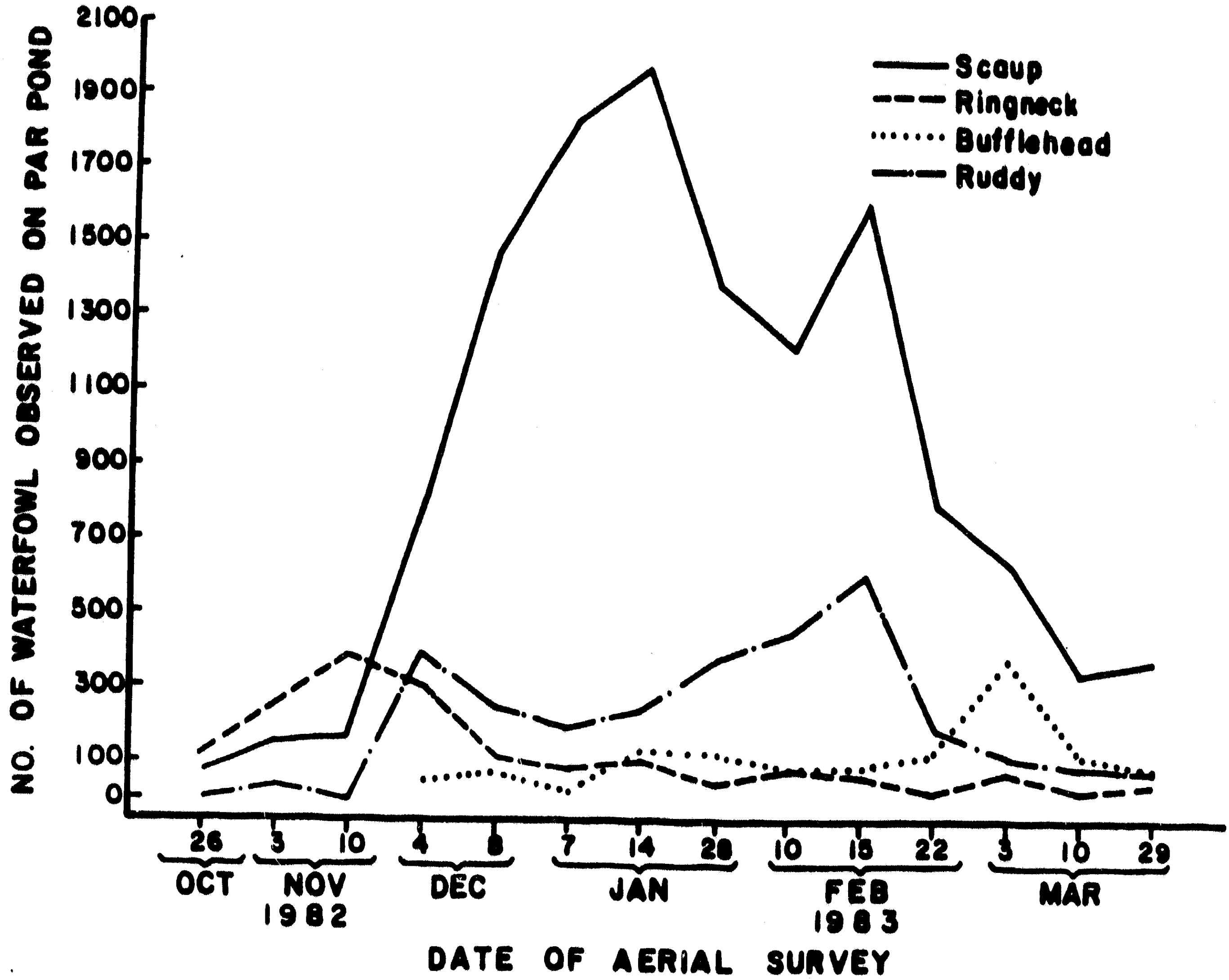

FIGURE 33. Waterfowl numbers on Par Pond in the 1982-1983 wintering period.

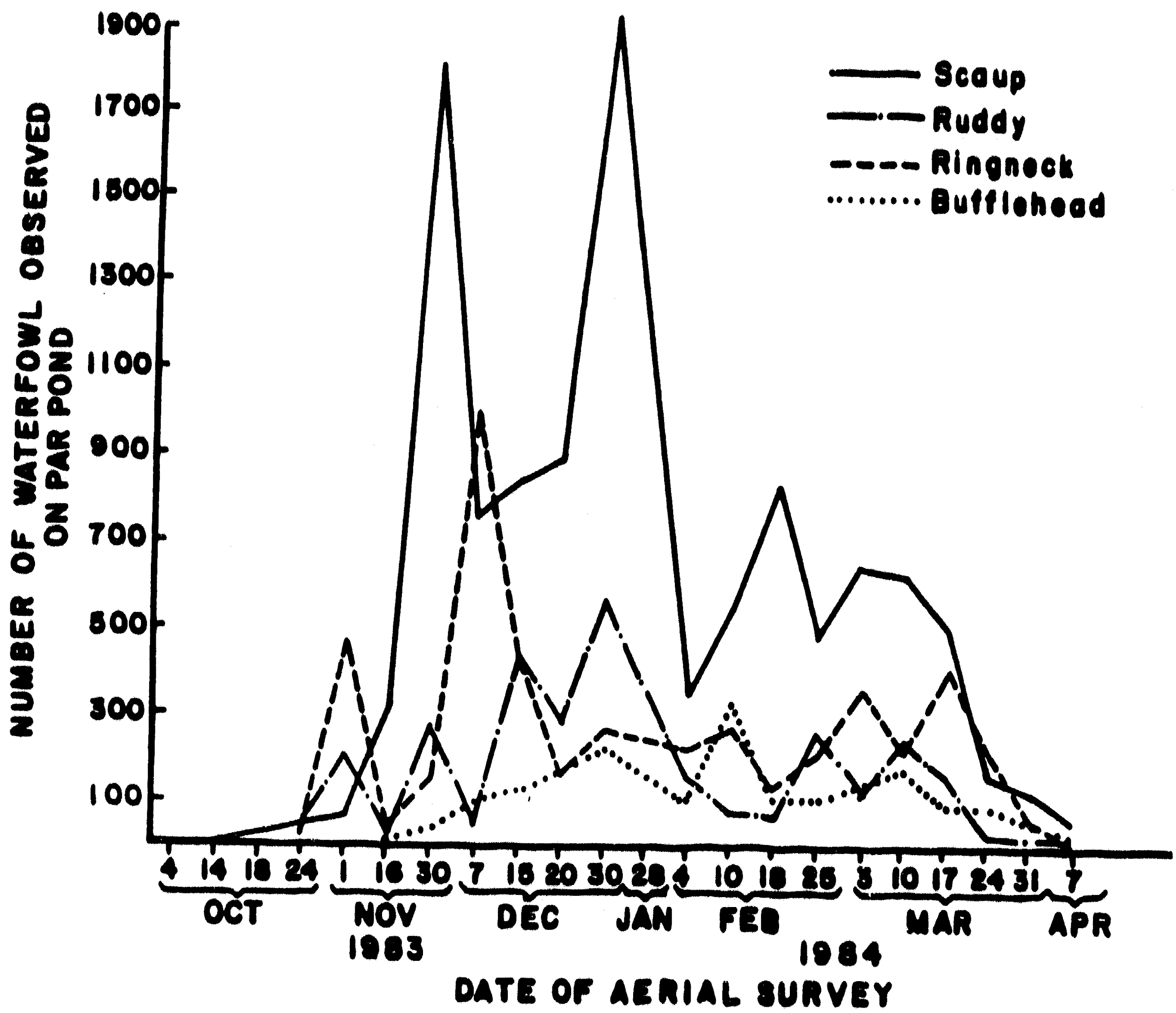

FIGURE 34. Waterfowl numbers on Par Pond in the 1983-1984 wintering season.

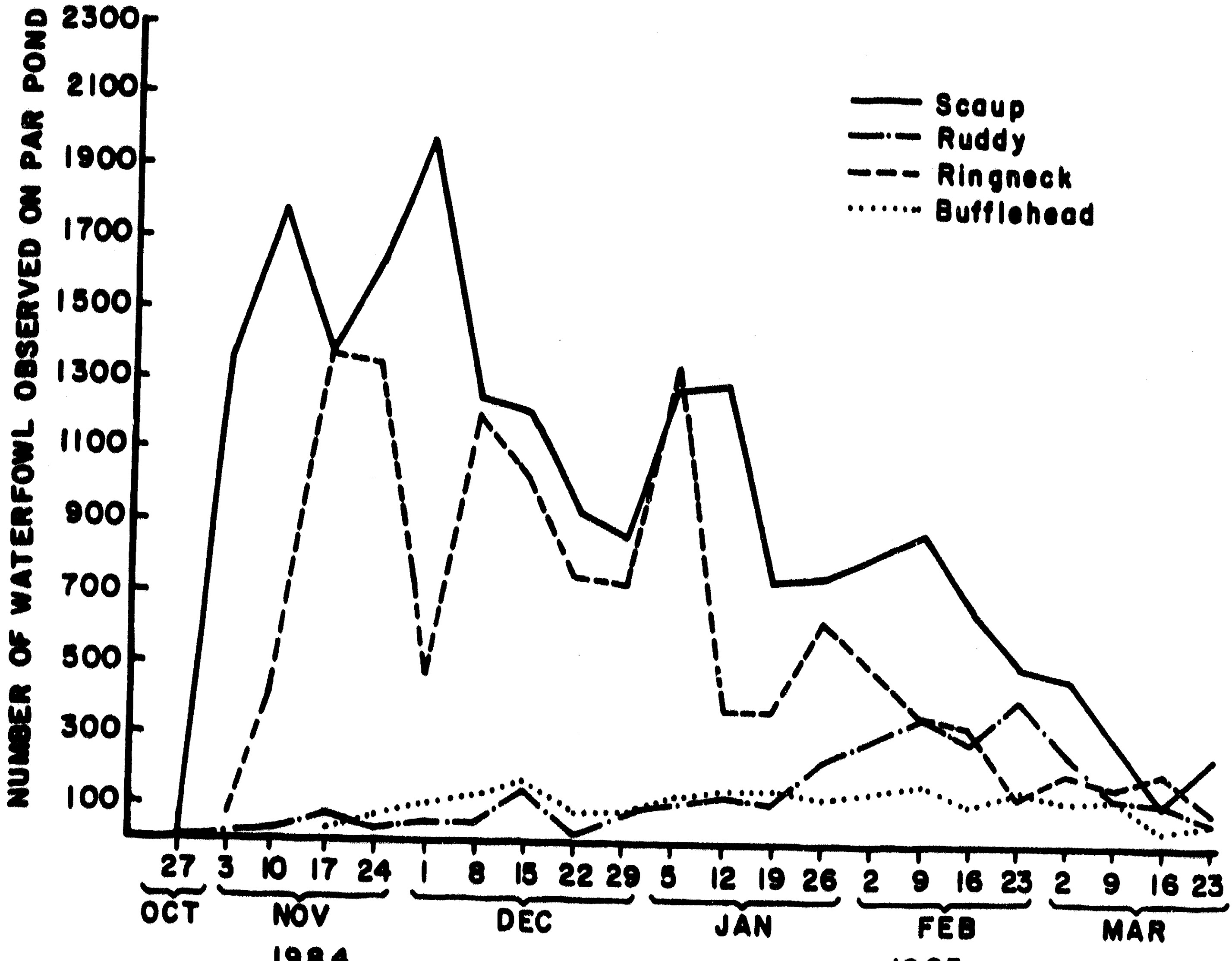

FIGURE 35. Waterfowl numbers on Par Pond during the 1984-1985 winter.

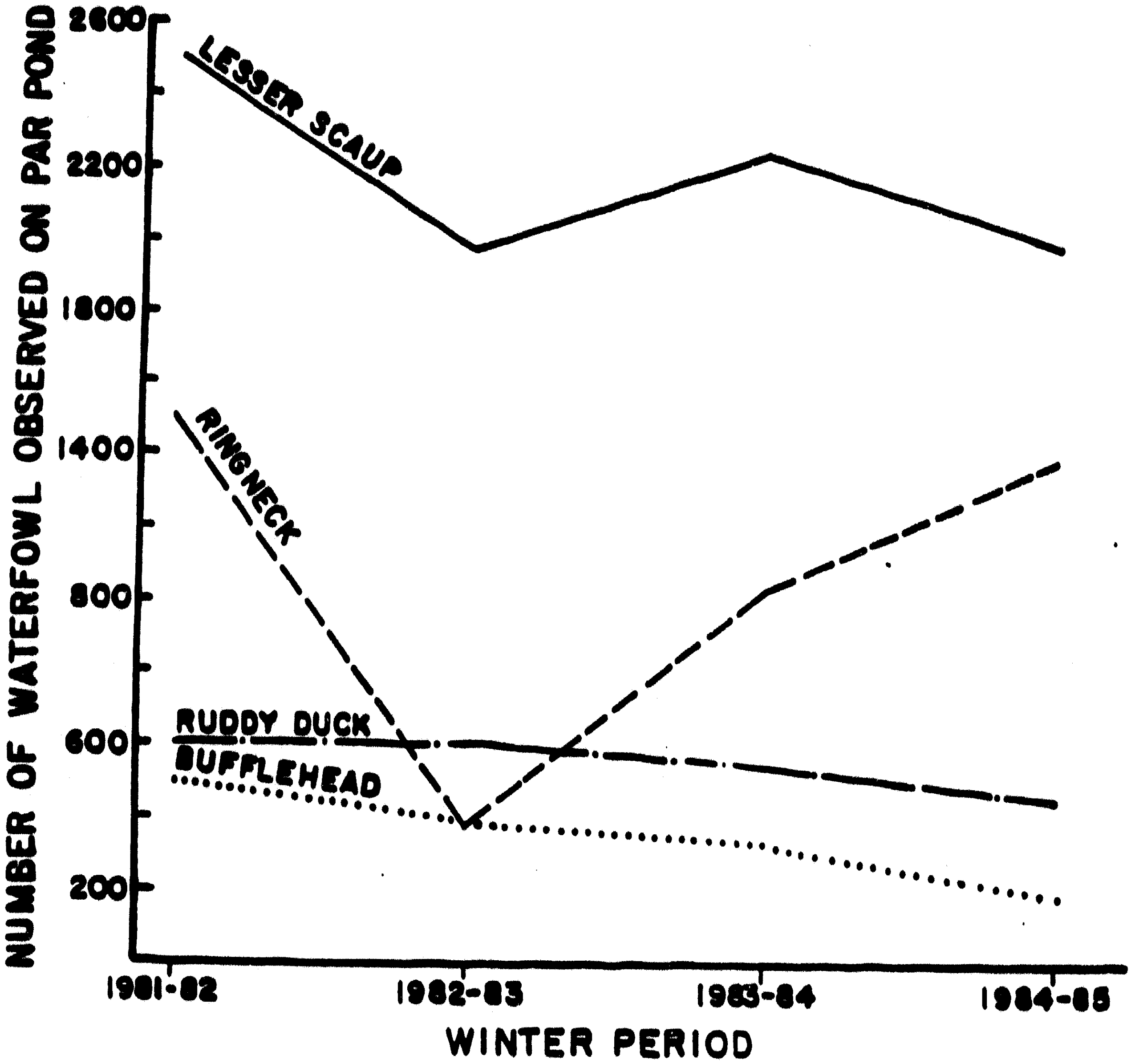

FIGURE 36. Maximum numbers of the four main species observed on Par Pond during any single aerial survey each winter from 1981 to 1985.

winter of 1981-1982 to the winter of 1984-1985. Ring-necked ducks were the second most abundant waterfowl species observed during the aerial surveys. Although the net decline from the winter of 1981-1982 to the winter of 1984-1985 was lower for ring-necked ducks (8.0 percent) than for the lesser scaup (21.2 percent), much greater fluctuations in ring-necked duck numbers were observed between years. Bellrose (1980) noted that winter inventory data for ring-necked ducks showed large ocillations in abundance, but found no significant trends over a 20-year period. Ruddy ducks were the third most numerous waterfowl species present on Par Pond and a net decline of 25.0 percent was observed from the winter of 1981-1982 to the winter of 1984-1985. The least abundant of the four major diving species occurring on Par Pond was the bufflehead. This species experienced the most severe decline of any of the four major species on the reservoir over the study period (62.0 percent). Erskine (1972) suggested that overhunting and the loss of breeding habitat were the primary causes of reduced bufflehead numbers. Unlike the other three diving duck species discussed here, the bufflehead are a cavity nesting species similar to the SRP's resident wood ducks. Buffleheads wintering on the Chesapeake Bay were found to have an well-developed ability to return to specific wintering sites (Limpert, 1980), and other species are known to have similar, though varying, abilities. Perhaps the Par Pond winter population of bufflehead are experiencing severely limited success on the breeding grounds and subsequent population recruitment, thus explaining our annual decline in numbers.

Each year, since the early 1950s, during the first week of January, the U. S. Fish and Wildlife Service has conducted mid-winter waterfowl surveys across the United States. Major wintering areas are surveyed during this "stable" part of the winter period to estimate continental and flyway waterfowl numbers. This information is used by the USFWS to delineate species distributions during the winter and along with breeding ground surveys is used to regulate the hunting seasons, thereby maintaining population levels in acceptable ranges.

From mid-winter surveys of 1964 to 1985, the Atlantic Flyway experienced a net decline in the overall duck population of 44.5 percent (2,792,700 to 1,550,401). During the same period, the state of South Carolina experienced a severe net decline in the duck population of 86.0 percent (525,800 to 73,812). If we consider only the years for which data are available on the Par Pond reservoir (January 1982 - January 1985), and limit the analyses to only the four major species found on Par Pond, the numbers on Par Pond do not reflect either the Atlantic Flyway or South Carolina results (Figure 37). Again, only one flight over Par Pond during the first week of January of each year is under consideration here. Since no such survey was available from the first week of January 1984, we chose to use the closest survey available (30 December 1983). During the four-year period examined the Atlantic Flyway had a net decline of 19.0 percent in numbers of lesser scaup, ring-necked ducks, bufflehead, and ruddy ducks. The state of South Carolina had a decline of 24.5 percent in numbers of these same four species. However, the Par Pond reservoir experienced an increase of 74.7 percent. Such a gross difference between the Atlantic Flyway, South Carolina surveys and the Par Pond surveys would seem to demonstrate an increasing importance role that the Par Pond reservoir is having on wintering waterfowl.

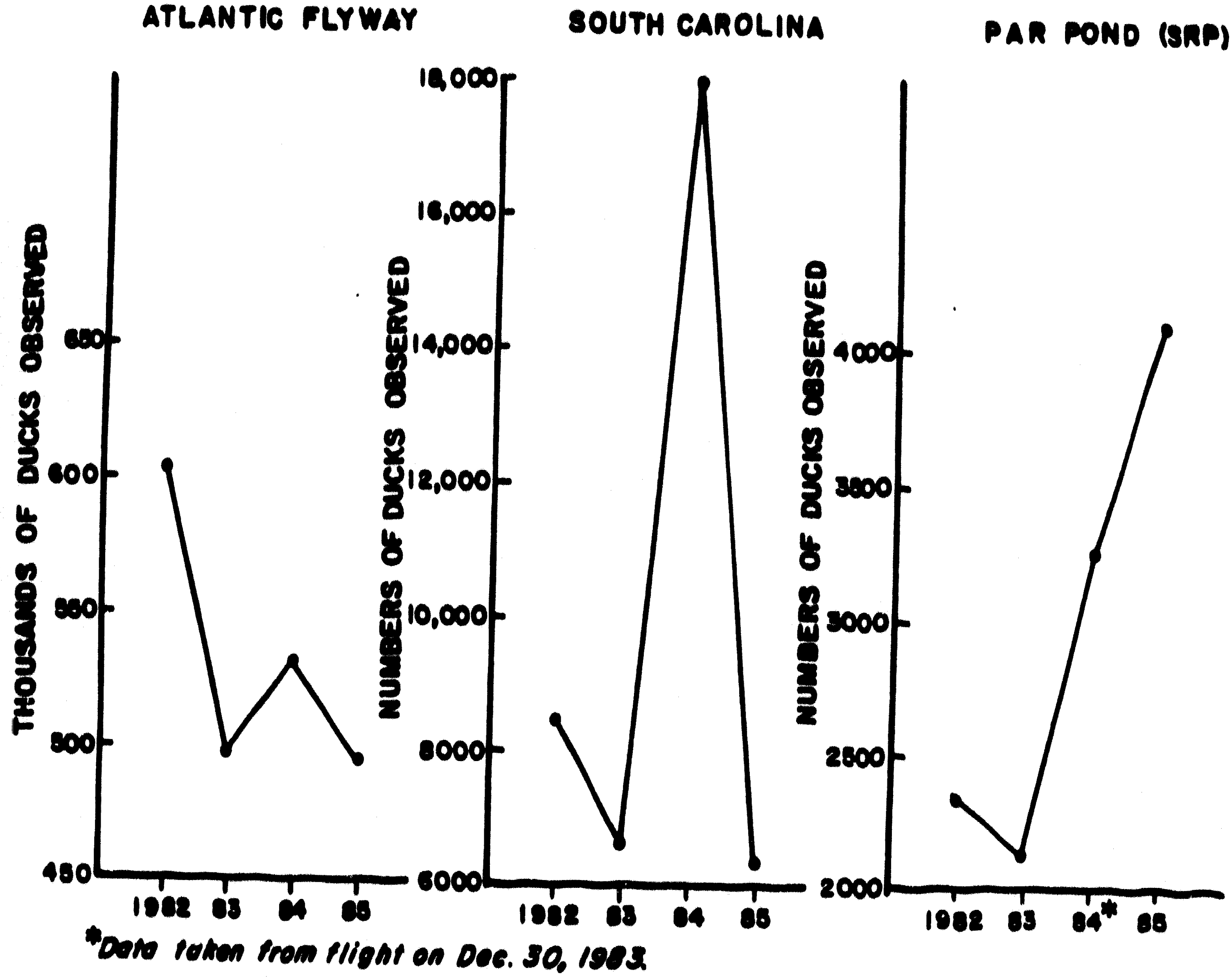

FIGURE 37. Comparison of duck numbers in the Atlantic Flyway, in South Carolina, and on Par Pond from 1982 to 1985.

Fredrickson and Drobney (1979) stated that declines in natural wetlands along migration corridors have resulted in greater concentrations of waterfowl on many stopover areas. Currently, counts of waterfowl on Par Pond are not included in either the South Carolina surveys or the Atlantic Flyway totals. The South Carolina waterfowl surveys are divided into two zones (Figure 38). Zone one includes the inland survey areas of Clark Hill Lake, Richard B. Russell Lake, Lake Greenwood, Wateree Lake, Santee National Wildlife Refuge, Santee Cooper Game Management Area, Hatchery Game Management Area, Carolina Sandhills National Wildlife Refuge, Webb Wildlife Center, Monticello Lake, Broad River, and Enoree River. The Par Pond reservoir is also located within the zone one region of South Carolina. During the four-year study period, there was as a mean of 1,940 more individuals of the four major diving duck species observed on Par Pond than in all combined survey areas within zone one of South Carolina (Figure 39). Zone two, the South Carolina coastal region, includes the Cooper River and its branches, Cape Romain National Wildlife Refuge, Santee Coastal Reserve, Tom Yawkey Wildlife Center, Kinloch Plantation, Santee Delta Game Management Area, Winyah Bay, Brookgreen Gardens, Arcadia Plantation, Samworth Game Management Area, Bear Island Game Management Area, Savannah National Wildlife Refuge, Combahee River, Ashepoo River, and Edisto River. During the four-year study period, there was a mean of 5,895 more individuals of the four main diving duck species observed in the zone two coastal region of South Carolina than on the Par Pond reservoir (Figure 39). Therefore, the Par Pond reservoir can be considered to be a critical wintering area for diving ducks in the inland region of South Carolina, and is at least as important as some of the survey areas along the coastal region of South Carolina.

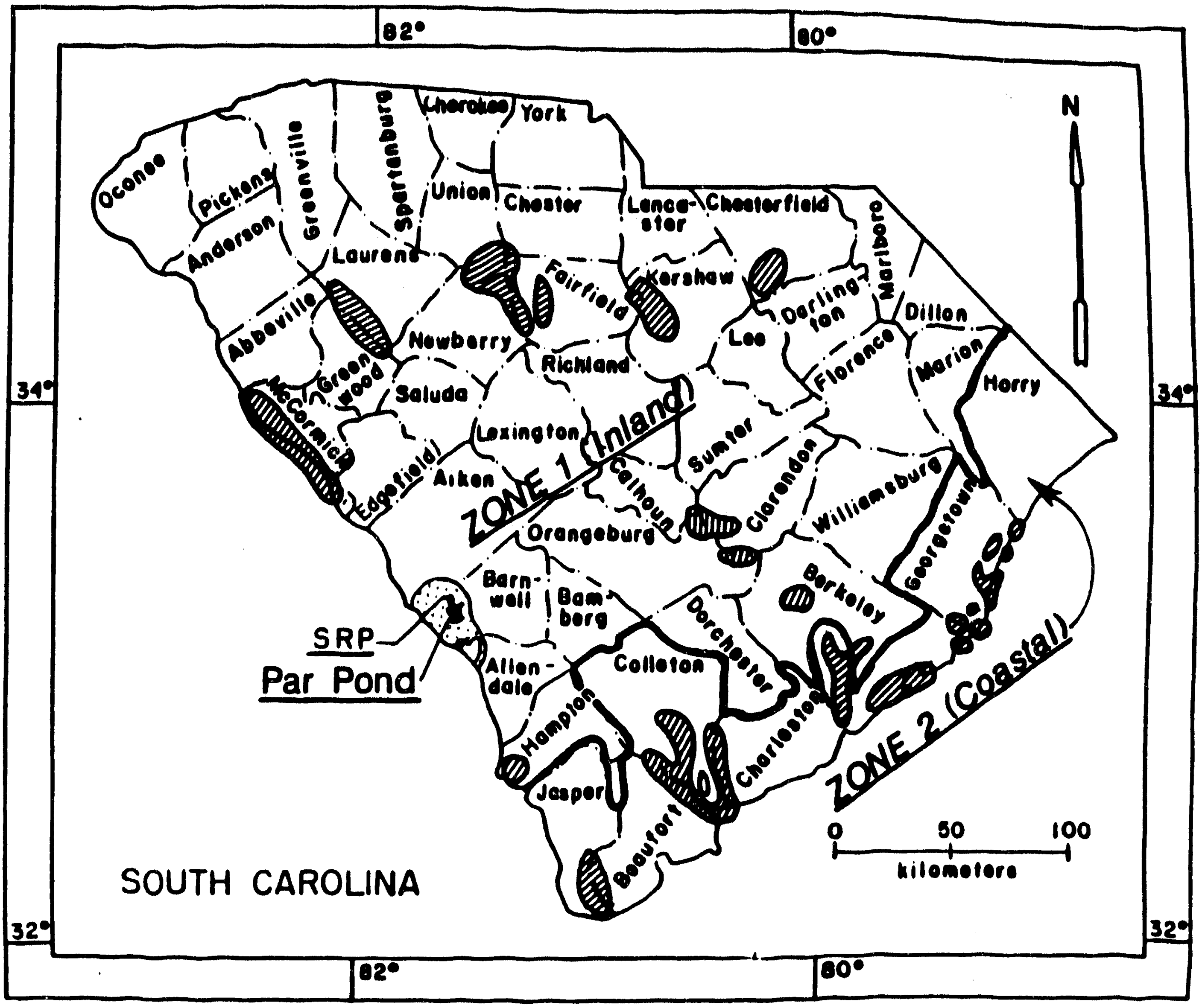

FIGURE 38. Areas in South Carolina surveyed in mid-winter by the U. S. Fish and Wildlife Service for waterfowl.

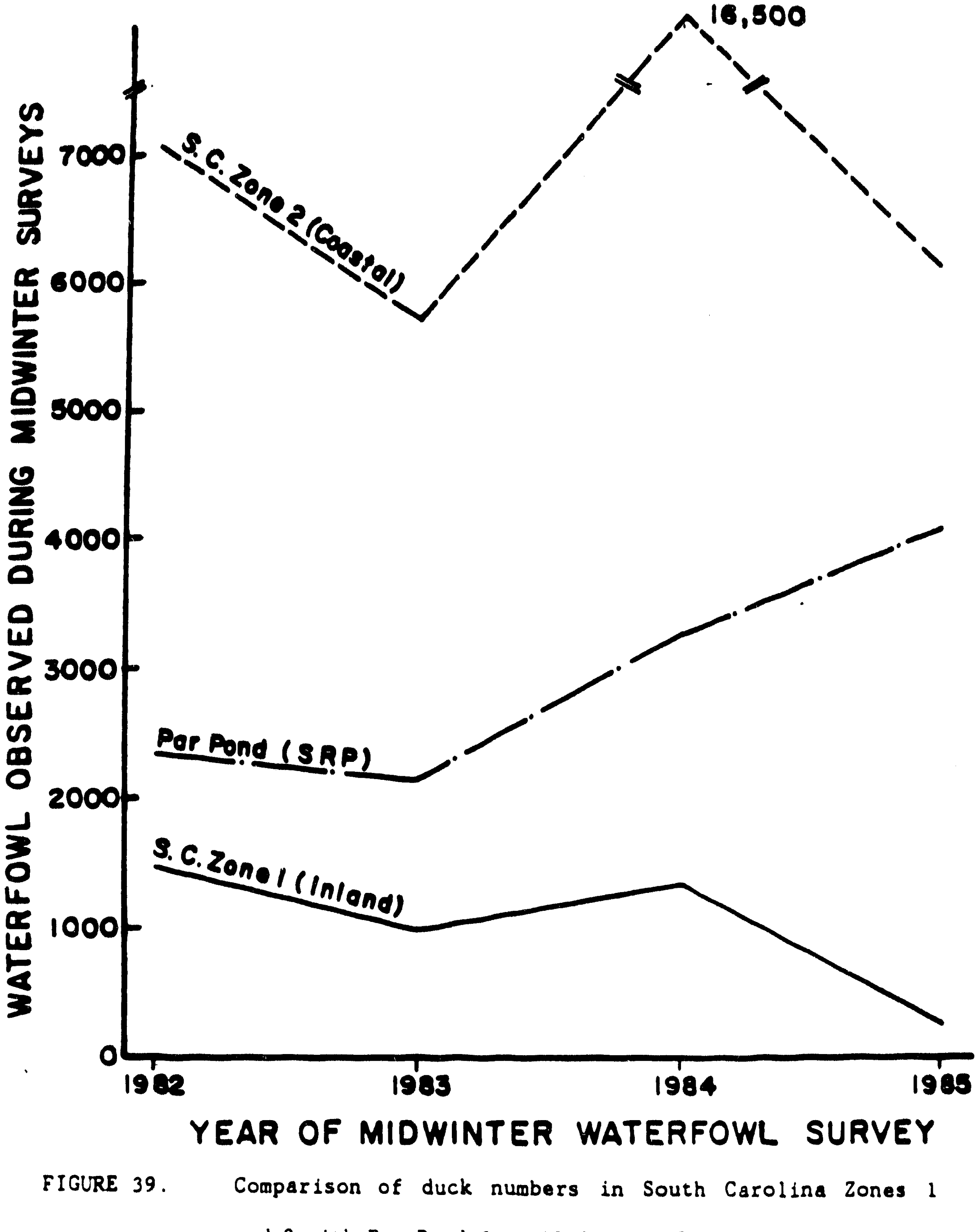

FIGURE 39. Comparison of duck numbers in South Carolina Zones 1 and 2 with Par Pond from 1982 to 1985.

2.3.3.1) Waterfowl Utilization of Sites Within the PPRS

Waterfowl observed using Par Pond during aerial surveys were assigned to the 36 specific sites designated in Figure 40. Flocks of waterfowl observed during the aerial surveys were often of mixed species, with lesser scaup and ring-necked ducks dominating the larger flocks. During the winter of 1984-1985, a mean of greater than 100 individuals of the four main species were found at four of the 36 specific sites at Par Pond. These sites included Loyal's Lair, Parrot Point, Peggy's Point, and the Cold Dam. The largest flock of lesser scaup (800 individuals) was located at the Cold Dam on 3 November, 1984. The largest flock of ring-necked ducks (358 individuals) was located at Loyal's Lair on 17 November, 1984. The largest flock of ruddy ducks (100 individuals) was located at Susan's Swamp on 23 February, 1985. The largest flock of bufflehead (37 individuals) was located at Jim's Junt on 16 February, 1985.

Further grouping of waterfowl using the 36 specific sites into five distinct larger sections of Par Pond allowed an analysis of variance to be performed. No attempt was made to estimate waterfowl densities based on shoreline distances of specific sites or the larger areas. The waterfowl counts for all 21 surveys were square-root transformed before performing the analysis of variance in order to normally distribute the data. Significant differences ($\underline{P} < 0.05$) were found between the five areas of Par Pond being utilized by the four main species of diving ducks wintering on the reservoir (Table 8). Lesser scaup counts for each of the five major areas of Par Pond during the winter of 1984-1985 (21 total surveys) are shown in Figure 41.

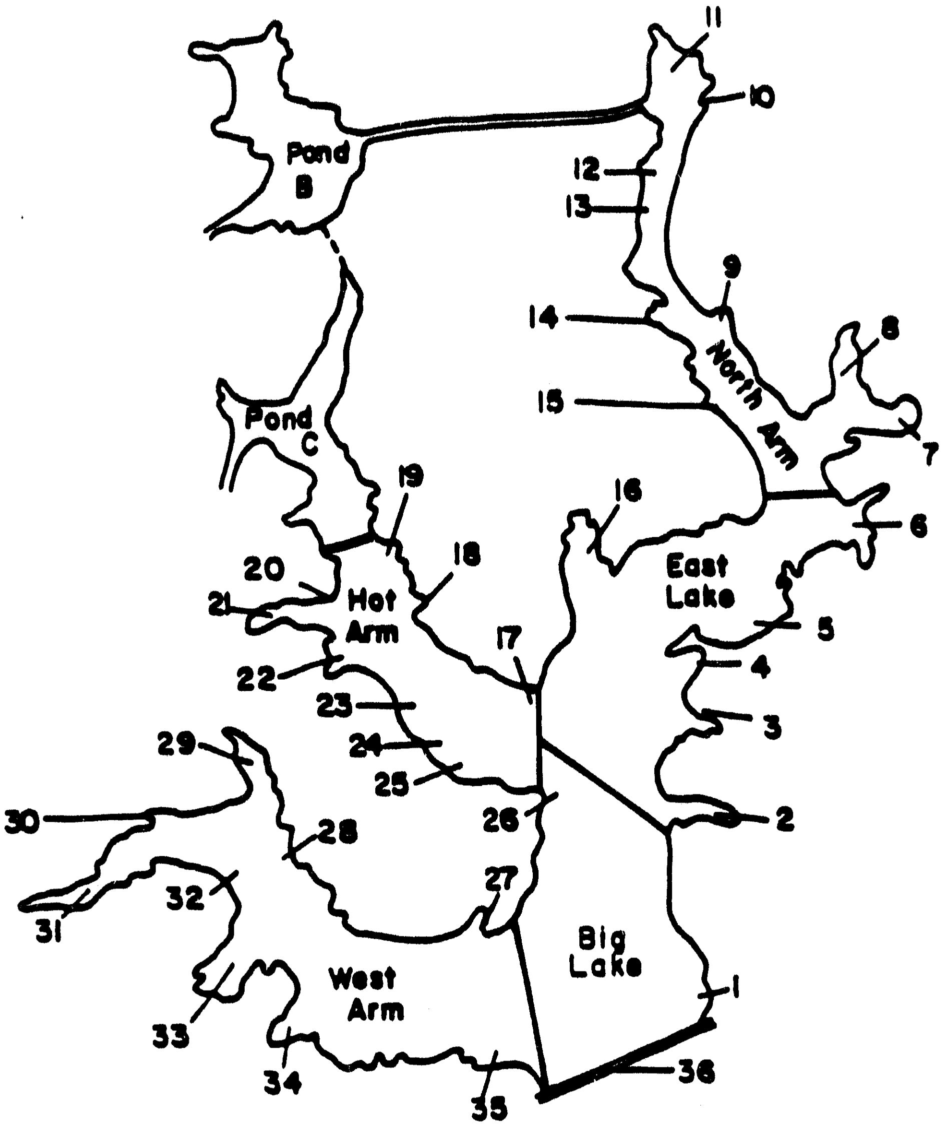

FIGURE 40. Par Pond site locations for waterfowl surveys. These are: 1 - Sarah's Beach; 2 - Susan's Swamp; 3 - Fairman's Landing; 4 - Fred's Bay; 5 - Nancy's Nook; 6 - Gus's Swamp; 7 - South Dave's Lake; 8 - North Dave's Lake; 9 - Callahan Slough; 10 - Kim's Cove; 11 - Little Lake; 12 - Nell's Nook; 13 - Erin's Elbow; 14 - Chris's Cove; 15 - Herde's Inlet; 16 - Loyal's Lair; 17 - Parrot Point; 18 - Jim's Joint; 19 - Coleman's Cove; 20 - Larry's Landing; 21 - Beyers' Bay; 22 - Carol's Bay; 23 - Patsy's Cove; 24 - Golley Bay; 25 - Rosemary's Bay; 26 - Peggy's Point; 27 - Hehr's Inlet; 28 - Barbara's Landing; 29 - Mike's Marsh; 30 - Pumphouse Cove; 31 - Kenyon Bay; 32 - Dayton's Landing; 33 - Gentry's Gulf; 34 - Fran's Inlet; 35 - Jack's Bay; and 36 - Cold Dam.

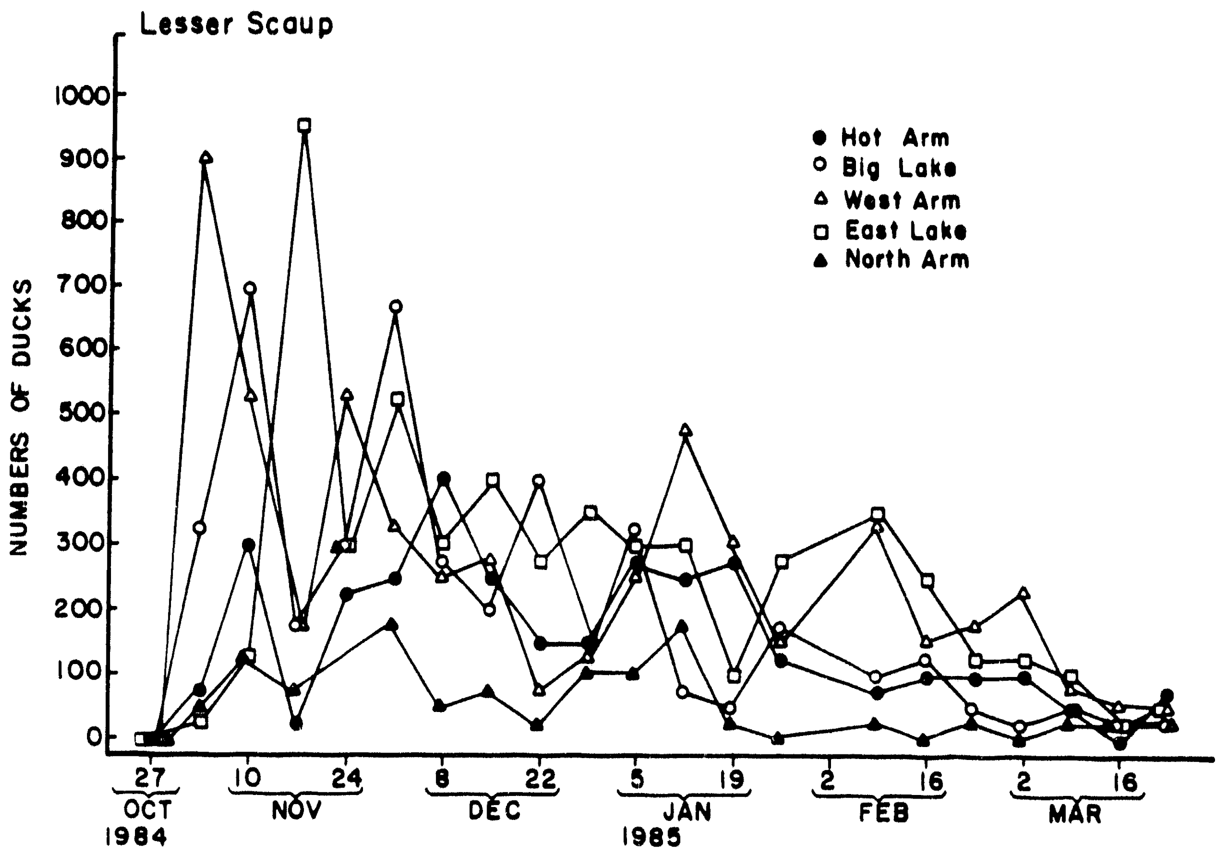

FIGURE 41. Comparison of lesser scaup numbers in the five general areas of Par Pond in 1984-1985.

Table 8. Results of the comparisons of waterfowl use of the five areas of Par Pond using analyses of variance of square-root transformed counts of the four main species during the 1984-1985 winter using a 0.05 level of significance.

Areas being compared	Waterfowl Species			
	Lesser Scaup	Ring-necked Ducks	Buffelhead	Ruddy Ducks
Hot Arm vs Big Lake	NS	NS	NS	NS
Hot Arm vs West Arm	.0069 HA < WA	.0182 HA < WA	.0001 HA < WA	.0452 HA < WA
West Arm vs Big Lake	NS	.0027 WA > BL	.0001 WA > BL	NS
Hot Arm vs East Lake	NS	NS	NS	NS
East Lake vs Big Lake	NS	.0209 EL > BL	NS	NS
East Lake vs West Arm	NS	NS	.0001 EL < WA	NS
Hot Arm vs North Arm	.0004 HA > NA	NS	.0352 HA > NA	.0001 HA > NA
North Arm vs Big Lake	.0003 NA < BL	NS	.0118 NA < BL	.0001 NA < BL
North Arm vs West Arm	.0001 NA < WA	.0160 NA < WA	.0001 NA < WA	.0002 NA < WA
North Arm vs East Lake	.0001 NA < EL	NS	.0016 NA < EL	.0018 NA < EL

NS - not significant

Lesser scaup counts were significantly lower in the North Arm than in all four other areas. Also, the Hot Arm had significantly fewer lesser scaup than the West Arm (P=0.0069). No significant differences in lesser scaup counts were observed between any other combinations of the five areas. Ring-necked duck counts for each of five major areas of Par Pond during the winter of 1984-1985 (21 total surveys) are shown in Figure 42. Significantly more ring-necked ducks were observed in the West Arm than in the Hot Arm (P=0.0182), the Big Lake (P=0.0027), or the North Arm (P=0.0160). Also, significantly more ring-necked ducks were observed in East Lake than in the Big Lake (P=0.0209). No other significant differences in ring-necked duck numbers were observed between areas. Bufflehead counts for each of the five major areas of Par Pond from the winter of 1984-1985 (21 total surveys) are shown in Figure 43. No significant differences in bufflehead counts were observed between the Hot Arm and Big Lake, Hot Arm and East Lake, or Big Lake and East Lake. All major areas of Par Pond had significantly more bufflehead than the North Arm. Bufflehead were observed in the West Arm in significantly higher numbers than in the Hot Arm (P=0.0001), Big Lake (P=0.0001), or the East Lake (P= 0.0001). Ruddy duck counts for each of the five major areas of Par Pond (21 total surveys) are shown in Figure 44. Ruddy duck counts were significantly lower in the North Arm than in any other areas of the reservoir. The only other significant location interaction was found between the Hot Arm and the West Arm (P=0.0452), as higher numbers of ruddy ducks were observed in the Hot Arm than in the West Arm.

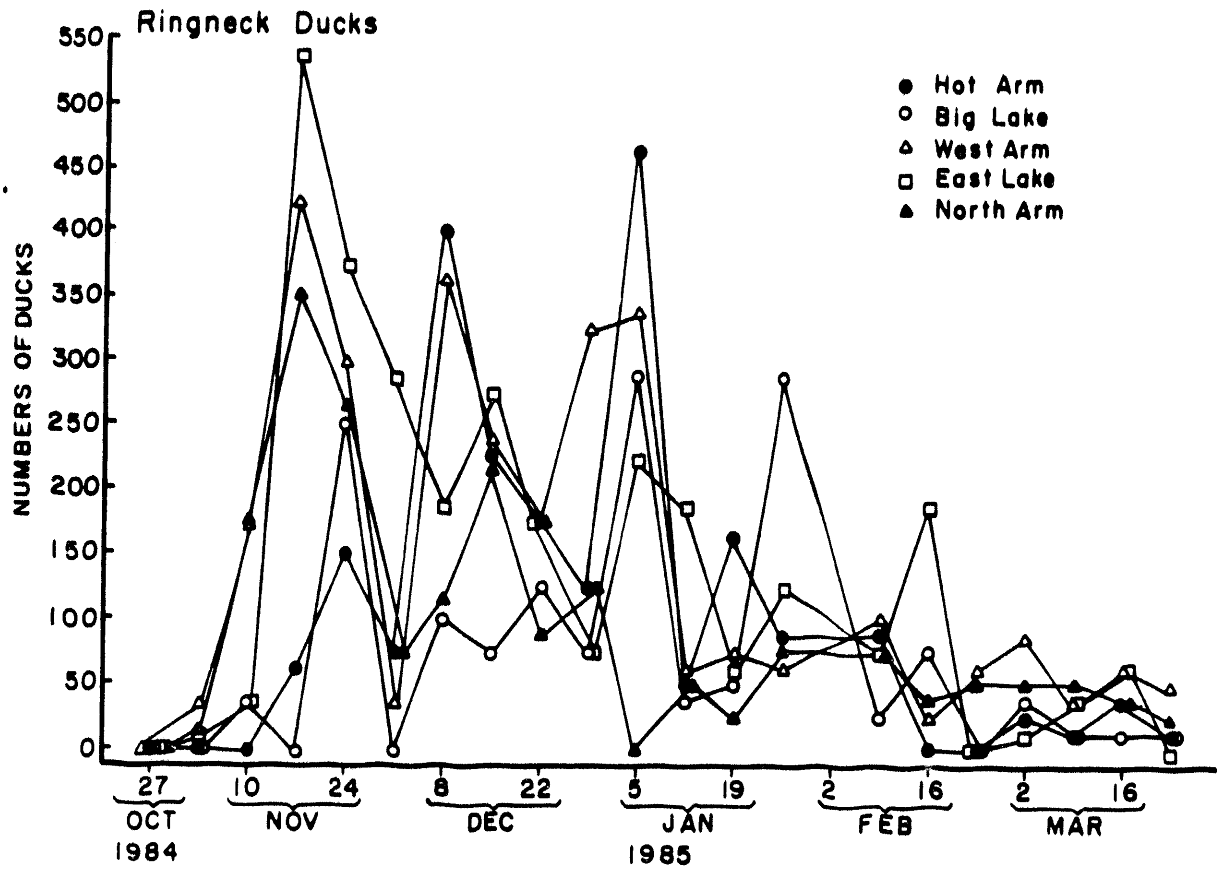

FIGURE 42. Comparison of ring-necked duck numbers in the five general areas of Par Pond in 1984-1985.

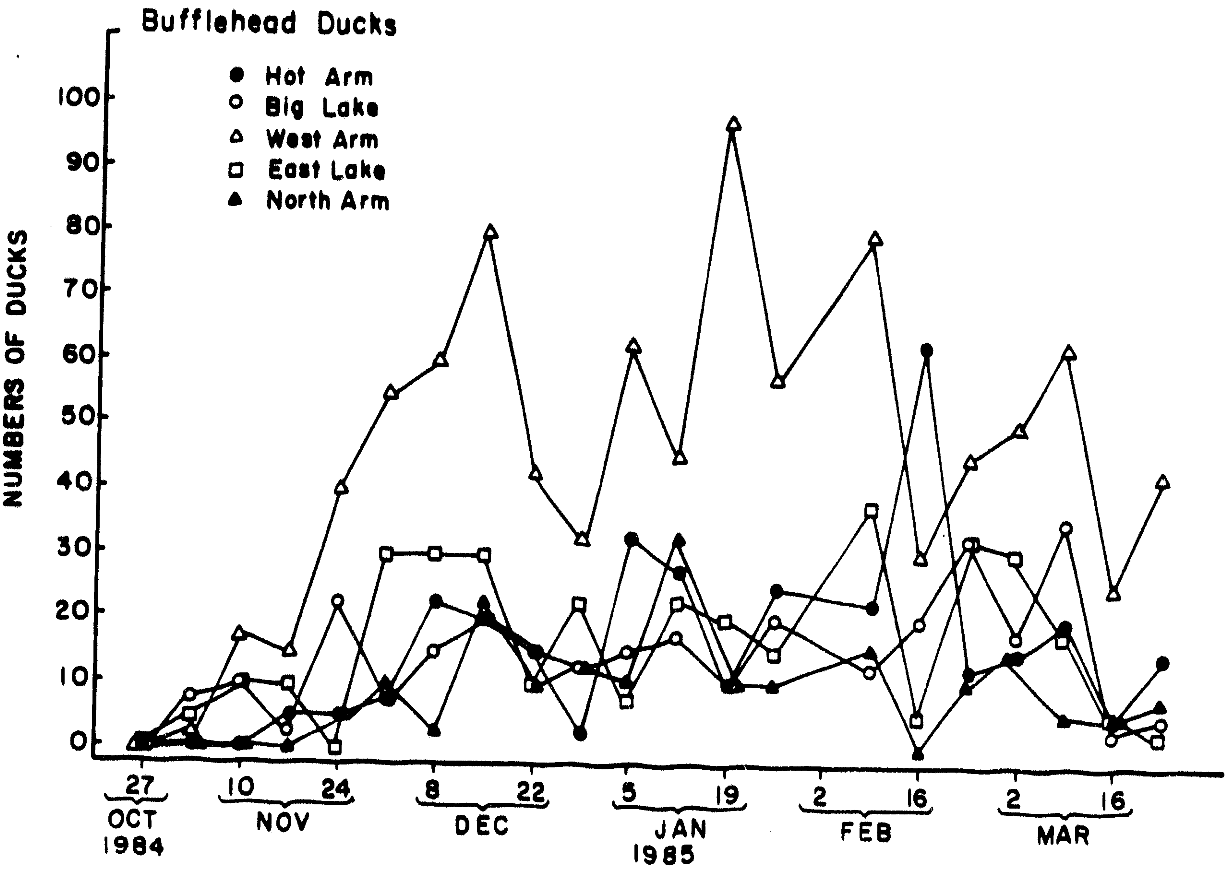

FIGURE 43. Comparison of bufflehead numbers in the five general areas of Par Pond in 1984-1985.

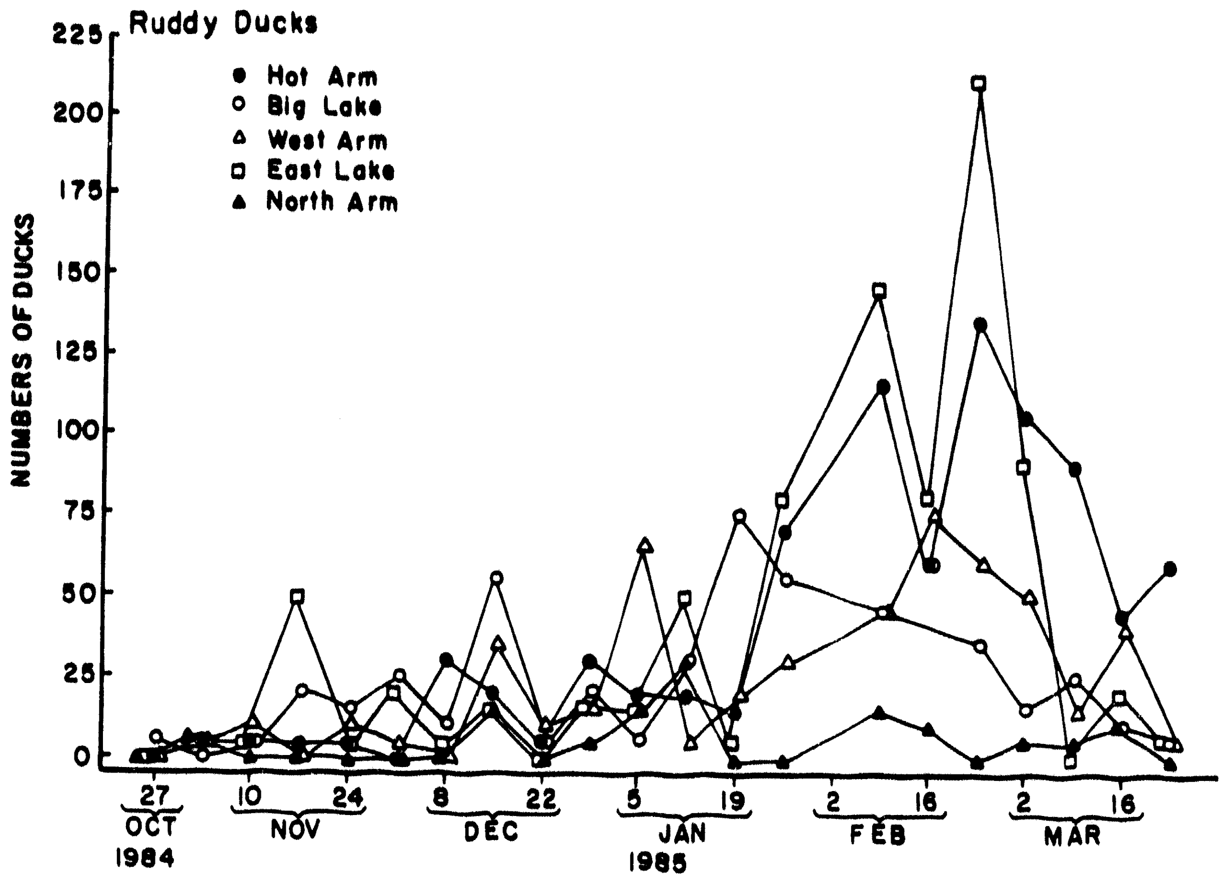

FIGURE 44. Comparison of ruddy duck numbers in the five general areas of Par Pond in 1984-1985.

Perhaps one of the most notable results of these analyses was that lesser scaup, bufflehead, and ruddy ducks were found in significantly fewer numbers in the North Arm than in all four other areas of Par Pond. Ring-necked ducks in the North Arm were only significantly different from counts in the West Arm where they were more frequently seen. Undetected differences between the North Arm and the remaining areas were due primarily to one popular ring-necked duck location in the North Arm; South Dave's Lake, the largest shallow cove found in the North Arm. Significant differences in counts of all four tested species were observed between the Hot Arm and the West Arm (lesser scaup ($\underline{P}$=0.0069), ring-necked duck ($\underline{P}$=0.0182), bufflehead ($\underline{P}$=0.0001), ruddy duck ($\underline{P}$=0.0001), ruddy duck ($\underline{P}$=0.0452)). Only the ruddy ducks, however, were more frequently seen in the Hot Arm than in the West Arm. The other three species were more abundant in the West Arm. Another interesting observation was the highly signific nt preferred use of the West Arm by bufflehead over all other areas of the Par Pond reservoir.

2.3.3.2) Characterization of PPRS Waterfowl Usage

2.3.3.2.1) Time-Budget Studies of Diving Ducks on the PPRS

Recently, studies have been initiated to investigate the activities of waterfowl utilizing the Par Pond reservoir system (Vangilder, 1983). During the winte rof 1982-1983, the diurnal time-activities of wintering lesser scaup, ring-necked ducks, and ruddy ducks in the Big Lake portion of Par Pond were studied. Behavior data collected were grouped into five major behaviors including feeding, swimming, comfort movements, resting, and sleeping. These behaviors were analyzed for the main effects of species, sex, time of day, week, and their interactions. These main effects all significantly influenced the feeding behavior, however, no significance was found for the interactions of the main effects. Lesser scaup, ruddy ducks, and ring-necked ducks spent, on average, 26.3, 29.8, and 43.0 percent (SE = 1.8) of their time feeding, respectively. Females, of all species spent, on average, 4.4 percent more time feeding than did males. During the mid-day, all species spent less time feeding. There was a general increase in percent of time spent feeding by all species from late November through March. Swimming behavior was significantly affected by species and week. Lesser scaup, ruddy ducks, and ring-necked ducks spent, on average, 35.4, 20.6, and 23.3 percent (SE = 1.4) of their time swimming. For all species, the percent of time spent swimming increased from November to mid-winter and declined through March. The percent of time spent resting and sleeping exhibited significant interactions between week and species.

In general, ruddy ducks spent less time resting (x = 10.1 percent) and more time sleeping (x = 31.7 percent) than did either lesser scaup (rest, x = 25.6 percent; sleep, x = 4.1 percent) or ring-necked ducks (rest, x = 23.1 percent; sleep, x = 4.8 percent). Comfort movements were not influenced by any main effect or interaction and averaged 6.6 percent. These results suggest that lesser scaup, ring-necked ducks, and ruddy ducks are capable of using different behavioral strategies to exploit available wintering ground resources.

Another study of the time-activities of lesser scaup, ring-necked ducks, and ruddy ducks on Par Pond was initiated during the winter of 1984-1985. This study includes both diurnal as well as nocturnal observation of waterfowl behaviors. Nighttime observations were made possible by the use of an infra-red night-vision scope. Observation blinds were constructed in three areas of Par Pond including Kenyon Bay-West Arm, Cold Dam-West Arm, and Loyal's Lair-East Lake. These sites are all located within ambient water temperature regions of the reservoir. This study will continue during the winter of 1985-1986 and no results are yet available (J. Bergan, pers. comm.).

2.3.3.2.2) Food Habits of Diving Ducks on the PPRS

An analysis of the foods consumed by lesser scaup, ring-necked ducks, and ruddy ducks on Par Pond was initiated during the winter of 1983-1984 (Hoppe et al., in press). Waterfowl specimens were collected weekly, by shooting, from October 1983 through March, 1984. Esophageal and proventriculus contents were preserved from each carcass and were sorted, identified, and volumetrically measured in the laboratory. The collection technique did not allow individual areas within the reservoir to be sampled, thus, all samples were grouped according to species, sex, and season only. Sample sizes included 13 ruddy ducks, 14 lesser scaup, and 60 ring-necked ducks. Small sample sizes of ruddy ducks and lesser scaup prevented extensive statistical analyses as were performed on ring-neck duck food habit data. The results were summarized by aggregate percent volume, percent occurrence (Swanson et al., 1974), and aggregate percent dry weight

(Prevett et al., 1979). Potential diet differences (P < 0.01) among species were examined with Kruskal-Wallis tests. Significant differences (P < 0.05) in food item selection were found among the three co-occurring species with the exception of dragonfly nymphs (Odonata). Ring-necked ducks were generalists in the selection of food items, with > 55 percent of the total aggregate volume consisting of plant material (Table 9). The major plant items consumed were water lily (Nymphaea odorata) seeds, spike rush (Eleocharis sp.), and unknown vegetative parts. The major animal foods were snails (Gastropoda), comprising approximately 50 percent of the animal foods consumed. The ruddy duck diet (Table 10) consisted of 59 percent animal foods with midges (Chironomidae) comprising 97 percent of animal volume. Spike rush and unknown vegetation were the most important plant foods. Animal foods comprised 89 percent of the lesser scaup diet (Table 11), of which 72 percent were clams (Pelecypoda). These findings are in general agreement with food habit studies conducted elsewhere (Bartonek and Hickey, 1969; Harmon, 1962; Cronan, 1957; Thompson, 1973; and McMahan, 1970). Differences by sex and season (October - December 1983 vs. January - March 1984) were examined with Wilcoxon rank sum tests for ring-necked ducks and by season for lesser scaup. Female ring-necked ducks consumed more (P < 0.05) snails than did males. Ring-necked ducks consumed fewer (P < 0.10) clams (Corbicula fluminea) during late winter (January - March). Lesser scaup consumed more (P < 0.10) animal matter during early winter than late.

The ramifications of these food habits results are more clearly understood if we also consider the work on Par Pond by Brisbin et al. (1973) and Clay et al. (1979). Between October 1971 and May 1972,

Table 9. Food items from Ring-necked Ducks (N=60) collected during fall and winter 1983-84 on Par Pond.

Food Items	Fall				Winter				Total		
	Male (N=14)		Female (N=10)		Male (N=12)		Female (N=24)				
	Agg.%	% Dry Wt.	Agg.%	% Dry Wt.	Agg.%	% Dry Wt.	Aggr.%	% Dry Wt.	Agg.%[a]	% Dry Wt.[b]	% occurrence[a]
Nymphaea odorata	21.8	25.0	45.0	34.4	10.0	16.0	15.0	14.3	21.8	23.5	50.0
Eleocharis spp.	0	0	10.2	24.9	27.9	25.5	11.1	15.2	11.7	15.3	38.3
Eleocharis equisetoides	0	0	Tr.[c]	Tr.	0	0	0.3	0.2	0.1	Tr.	5.0
Hypericum spp.	3.03	3.9	0	0	0	0	0	0	0.5	0.7	1.7
Boehmeria cylindrica	3.03	1.9	0	0	0	0	0	0	0.5	0.3	1.7
Polygonum spp.	3.03	3.3	0	0	0	0	1.4	1.1	1.1	1.1	5.0
Erianthus giganteus	0	0	Tr.	Tr.	0	0	0	0	Tr.	Tr.	1.7
Brasenia schreberi	0.1	0.1	Tr.	1.4	0.3	0.8	0	0	0.1	0.4	8.3
Pinus taeda	0	0	5.0	7.6	0	0	0	0	0.8	1.3	1.7
Pinus spp.	0	0	0	0	0	0	0.5	0.8	0.2	0.3	1.7
Potamogeton spp.	0	0	Tr.	0.5	0	0	Tr.	Tr.	Tr.	0.1	3.3
Myrica cerifera	0	0	0	0	0	0	1.4	0.6	0.5	0.3	1.7
Cyperus spp.	8.7	9.0	0	0	0	0	0	0	1.6	1.6	1.7
Unknown seeds	0	0	5.0	2.4	11.2	11.1	8.3	11.1	6.4	7.0	21.7
Unknown vegetation	31.8	29.3	Tr.	0.1	18.1	14.6	4.2	5.2	11.6	10.5	28.3
Total Plant Food	71.5	72.5	65.2	71.3	67.5	68.0	42.2	48.5	56.9	62.4	
Diptera											
unknown	0	0	Tr.	Tr.	0	0	0	0	Tr.	Tr.	3.3
Chironomidae	0.6	Tr.	Tr.	Tr.	11.7	10.6	1.4	0.1	2.9	2.2	15.0
Tabanidae	0	0	0	0	0	0	0	0	0.1	0.1	3.3
Lepidoptera											
Pyralidae	0	0	0	0	0	0	0	0	Tr.	Tr.	1.7

Table 9 . Continued.

Food Items	Fall				Winter				Total		
	Male (N=14)		Female (N=10)		Male (N=12)		Female (N=24)				
	Agg.%	% Dry Wt.	Agg.%	% Dry Wt.	Agg.%	% Dry Wt.	Agg.%	% Dry Wt.	Agg.%	% Dry Wt.	% occurrence
Gastropoda											
Physella heterostropha	9.1	9.1	12.2	11.4	2.1	2.9	6.9	6.2	7.2	6.7	30.0
Helisoma spp.	0.4	0.1	7.3	5.6	6.2	9.0	32.8	34.1	16.0	16.4	35.0
Pelecypoda											
Corbicula fluminea	18.2	18.2	12.2	10.5	0	0	10.1	36.1	9.4	7.5	18.3
Odonata											
Anisoptera (Nymphs)	0.2	Tr.	3.0	1.0	10.4	8.0	5.1	3.7	6.2	3.7	21.7
Coeagriidae	0	0	0	0	0	0	0	0	1.0	Tr.	1.7
Coleoptera											
unknown	0	0	0	0	2.1	1.6	1.4	1.0	Tr.	0.7	3.3
Dytiscidae	0	0	Tr.	0.1	0	0	Tr.	Tr.	Tr.	Tr.	5.0
Trichoptera											
Phryganeidae	0	0	0	0	0	0	0.3	0.1	0.1	Tr.	1.7
Unknown insect case	0	0	Tr.	Tr.	0	0	0	0	0.1	Tr.	3.3
Unknown insecta	0	0	0	0	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	3.3
Total Animal Food	28.5	27.4	34.7	28.6	32.5	32.1	58.0	51.3	43.0	37.3	

a. (Swanson et al. 1974) - aggregate.

b. (Prevett et al. 1979) - aggregate.

c. 0.1%

Table 10. Food items from Ruddy Ducks ($\underline{N}$=13) collected during fall and winter 1983-84 on Par Pond.

Food Items	Aggregate % Vol. [(a)]	Aggregate % Dry Wt. [(b)]	% Occurrence [(a)]
Nymphaea odorata	6.1	7.2	7.7
Eleocharis sp.	15.4	15.4	15.4
Unknown vegetation	11.9	7.9	23.1
Unknown Seeds	7.7	7.7	15.4
Total Plant Food	41.1	38.2	
Diptera			
Chironomidae	57.0	60.8	69.2
Culicidae	0.7	0.7	7.7
Gastropoda			
Helisoma spp.	0.4	0.2	7.7
Odonata			
Anisoptera (Nymphs)	0.8	0.1	7.7
Coleoptera			
Dytiscidae	Tr.[(c)]	Tr.	7.7
Total Animal Food	58.9	61.8	

a. (Swanson et al. 1974)

b. (Prevett et al. 1979)

c. 0.1%

Table 11. Food items from Lesser Scaup (N=14) collected during fall and winter 1983-84 on Par Pond.

Food Items	Aggregate Percent[(a)]	% Dry Wt.[(b)]	% Occurrence [(a)]
Eleocharis sp.	Tr.[(c)]	0.1	7.1
Unknown vegetation	10.7	11.9	25.5
Total Plant Food	10.7	12.0	
Diptera			
Chironomidae	3.6	2.7	21.4
Gastropoda			
Physella heterostropha	6.6	8.0	28.5
Helisoma spp.	13.3	16.8	28.5
Pelecypoda			
Corbicula fluminea	50.3	45.8	57.1
Anodonta umbecillis	14.0	14.2	14.2
Odonata			
Anisoptera (Nymphs)	1.5	0.5	0.5
Total Animal Food	89.3	88.0	

a. (Swanson et al. 1974)

b. (Prevett et al. 1979)

c. 0.1%

waterfowl were collected by Brisbin et al. (1973) on the reservoir to examine radiocesium body burdens. Waterfowl collected included coots (215), common moorhens (3), pied-billed grebes (9), horned grebes (6), ruddy ducks (7), ring-necked ducks (3), bufflehead (5), lesser scaup (6), black terns (1), and common terns (6). The coots showed relatively higher levels of radiocesium accumulation than any of the nine other species studied. Feeding habit studies of the coot have shown that they consume a high proportion of algae and other aquatic vegetation. Brisbin et al. (1973) suggested that such dietary habits may help to explain the higher body burdens of the coot relative to other species, most of which tend to utilize a higher proportion of animal matter in their diets. With this in mind, ring-necked ducks, noted by Hoppe et al. (in press) to consume greater proportions of plant matter than lesser scaup and ruddy ducks, would be expected to exhibit the highest radiocesium body burdens of the diving duck species found on Par Pond.

Clay et al. (1979) collected waterfowl on Par Pond during the winter of 1977-1978 to examine the patterns of mercury contamination. Waterfowl collected included coots (180), horned grebes (7), lesser scaup (3), bufflehead (6), and ruddy ducks (3). Levels of mercury in the largely vegetarian coots were found to be considerably lower than levels in other, more carnivorus, waterfowl species from Par Pond. From these results, the lesser scaup, whose diet consisted of 89 percent animal matter on Par Pond, could be considered a potential carrier of the highest mercury levels among the diving species wintering on Par Pond. Food habits studies on Par Pond and elsewhere have been instrumental in the explanation of observed contaminant levels in the mobile waterfowl species.

2.3.3.2.3) Habitat Attributes of the PPRS

Par Pond is a 1,120 ha nuclear reactor cooling impoundment with an associated watershed comprising 9,324 ha. Average depths in the reservoir are 6.2 meters with the greatest depth found near the Cold Dam (16.8 meters). The complete shoreline length of Par Pond is 53 km. Three major arms extend from the main body of the reservoir (Figure 40), and include, from north to south, the North Arm, the Hot Arm, and the West Arm. The North Arm received heated effluent from R-Reactor until mid-1964. The Hot Arm presently receives heated effluent from P-Reactor via the 57 ha precooling Pond C and the Hot Dam. The Par Pond pumphouse, with a rated pumping capacity of 275,000 gpm, is located at the shallow end of the West Arm. The Cold Dam is located at the south end of the impoundment across Lower Three Runs Creek. Excess water leaving Par Pond by way of the Cold Dam surface skimmer takes a 29 km flow path to the Savannah River (Neill and Babcock, 1971; Lewis, 1974).

The major concentration areas of wintering diving ducks on Par Pond are located in waters known to be 6 meters or less in depth. This does not mean that deeper waters are not utilized by these species, but rather that their occurrence in deeper zones are less frequent. Figures 45 and 46 show the depth contours of Par Pond and the waterfowl concentration sites for 1984-1985 respectively. Bellrose (1980) noted that lesser scaup were normally seen diving in areas less than 7.6 meters in depth, while ruddy ducks were noted to dive in waters 3.0 meters or less. On Par Pond, ruddy ducks have been observed diving in waters known to be as deep as 7-8 meters, however.

FIGURE 45. Depth contours of Par Pond. Areas of six meters or less in depth are shaded in black.

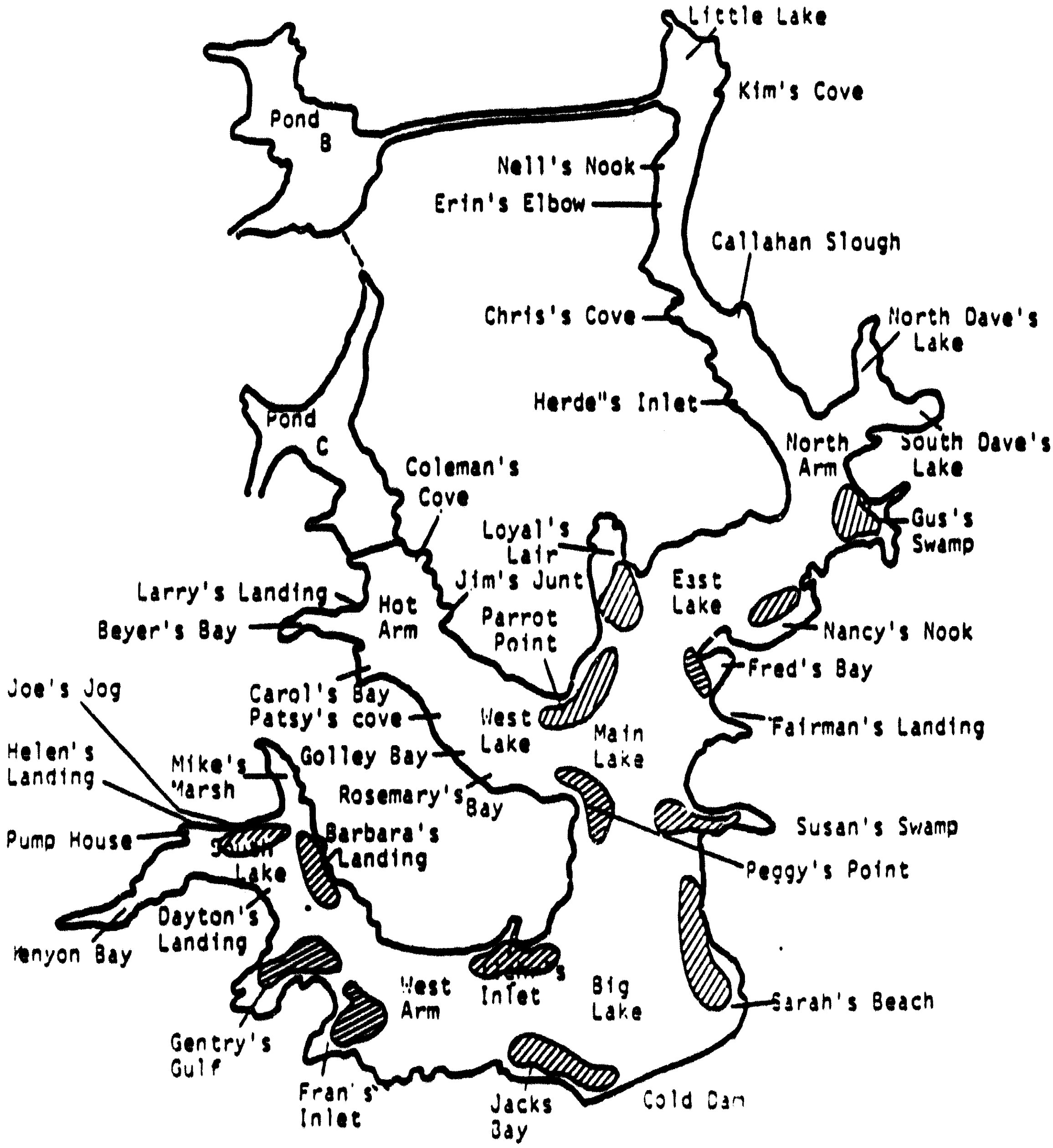

FIGURE 46. Waterfowl concentrations on Par Pond.

Ring-necked ducks are generally users of shallower waters (2.0 meters) occupied by emergent or floating-leaved vegetation.

A study initiated in 1984 (Grace, 1984) provided a partial characterization of the distribution and composition of the vegetation types of Par Pond. Fifteen sites (Figure 47) were examined in detail and the results suggest that Par Pond wetland communities are middle-to-late successional with fairly low species diversity and with a high amount of dominance. Grace (1984) concluded that these developments at the community level were probably attributed to the maintenance of stable water levels in the reservoir. Comparisons of "hot," "warm" and "cold" areas of Par Pond showed that the primary differences between areas in wetland vegetation were the absence of certain species from the "hot" and "warm" areas although very little of the variation in species distributions seemed to be correlated with the thermal regime of the reservoir. The depth distributions of the aquatic species shown by Hoppe et al. (in press) to be of dietary value to Par Pond diving ducks are given in Table 12. These depth ranges by no means would reflect the complete distribution of all plant parts, especially seeds dropped by these species, which are the primary component utilized as food by these waterfowl. Various seed dispersal mechanisms contribute to the much greater range of water depths at which the seeds may be found.

In 1974 and 1975, Grace (1977) studied the distribution and abundance of submerged aquatic macrophytes in Par Pond. Grace concluded that the presence of such species did not vary greatly among the heated and unheated areas, although the relative compositions of the macrophyte communities did vary among areas. Myriophyllum spicatum

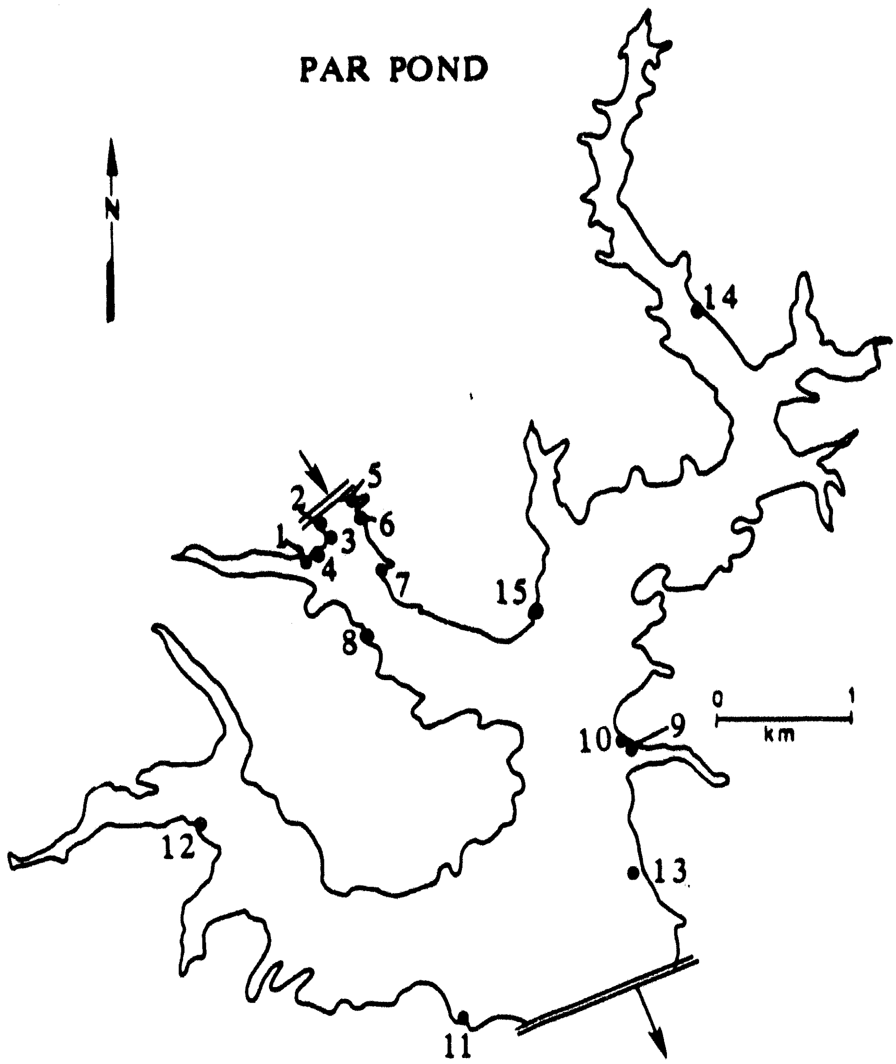

FIGURE 47. Locations of sampling sites used by Grace (1984) on Par Pond to determine the distribution and characterization of vegetation types.

Table 12. Depth distributions of Par Pond emergent vegetative species. Taken from Grace (1984). Waterfowl food species are marked with an asterisk.

Species	Site	Min. Depth, cm	Max Depth, cm
	7	10	60
Nymphaea odorata*,	7	50	--
white-waterlily	8	10	25
	9	95	--
	14	55	210
	14	85	--
Eleocharis quadrangu-*	1	10	75
lata, square-stem spike	1	15	75
spike rush	1	30	70
	15	35	73
Brasenia schreberi*,	9	95	--
water shield	14	55	150
Polygonum spp.,*	4	0	20
smartweed	7	20	30
Boehmeria cylindrica,*	3	0	20
false nettle			
Erianthus giganteus,*	3	0	20
giant plume grass	4	0	20
	6	5	10
	7	5	10
	7	0	15
	8	above water	15
	14	5	10

and Eleocharis acicularis comprised 92 percent of the total biomass in the unheated portions of the reservoir while the same species comprised only 64 percent in areas elevated by five degrees Centigrade or more. Najas guadalupensis and Potamogeton susillus had greater biomass at heated than unheated areas. Table 13 shows the relative occurrence values of Par Pond macrophytes classified as either emergent, floating-leaved, submerged, or free-floating submerged. Hoppe et al. (in press) noted that diving ducks on Par Pond made use of submerged aquatic plants including Eleocharis spp. and Potamogeton spp. Other plant species noted to be of dietary value to diving ducks are shown in Table 14.

Polisini and Boyd (1972) collected Par Pond aquatic plants to determine the nutritive values based on cell-wall fractions. Interspecific differences in protein content of the plants examined were termed as important in food-web considerations. Protein content has been shown to be more closely associated with noncell-wall material (cytoplasm) than with cell walls. Emergent macrophytes have a more rigid supportive structure and correspondingly more cell-wall (fiborous) components than submerged and floating-leaved plants. Although the greatest majority of identifiable plant food items consumed by diving ducks on Par Pond were seeds. Hoppe et al. (in press) noted percent occurrences of unknown vegetative parts as high as 28.3 percent of all foods consumed by ring-necked ducks. These aquatic vegetative parts were probably submerged aquatic macrophytes whose low cell-wall fraction values, with consequently faster digestion, and high protein content prompted selection of these desirable species.

Table 13. Macrophytes of Par Pond. Occurrence values include four subjective categories: 0 - insufficient information; 1 - infrequent; 2 - common; and 3 - frequent. From Grace (1977). Waterfowl food species are marked with an asterisk.

Species	Occurrence
EMERGENT	
Eleocharis equisetoides (Ell.) Torrey*	2
Eleocharis quadrangulata (Michx) R. & S*	2
Juncus effusus L.	0
Ludwigia leptocarpa (Nuttall) Hara.	0
Pontederia cordata L.	1
Sagittaria latifolia Willd.*	0
Scirpus L. spp.*	2
Sparganium americanum Nuttall	2
Typha L. spp.	3
FLOATING-LEAVED	
Brasenia schreberi Gmel.*	2
Hydrocotyle umbellata L.	2
Nelumbo lutea (Willd.) Pers.	3
Nuphar advena Aiton	1
Nymphaea odorata Aiton*	2
Nymphoides aquatica (Walt.) Ktze.	1
SUBMERGED	
Bacopa caroliniana (Walt.) Robinson	2
Chara zeylanica Kl. ex Willd.*	1
Elatine L. sp.	1
Eleocharis acicularis (L.) R. & S.*	3
Myriophyllum heterophyllum Michx.*	1
Myriophyllum spicatum L.*	3
Najas gracillima (A. Br.) Morong.*	1
Najas guadalupensis (Spreng.) Morong.*	3
Nitella acuminata A. Br. ex Wallm.	2
Potamogeton diversifolius Raf.*	2
Potamogeton nodosus Poiret*	2
Potamogeton pusillus L.*	3
Sagittaria graminea Michx.*	1
Sagittaria teres Wats.*	1
Vallisneria americana Michx.*	1
FREE-FLOATING: SUBMERGED	
Ceratophyllum demersum L.*	1
Utricularia inflata Walt.	2

Table 14. Plant species known to be of dietary value to diving ducks. The number designation of each food species indicates the percent volume composition in the diet of each waterfowl species 4-10 to 25%; 3 - 5 to 10%; 2 - 2 to 5%; 1 - 0.5 to 2%. Data taken from Martin et al. (1951), Bellrose (1980), and Cottam (1939).

PLANT FOOD SPECIES	Ring-necked Duck	Lesser Scaup	Bufflehead	Ruddy Duck
Polygonum spp., Smartweed		2		
Scirpus spp., Bulrush	2	1	1	4
Lemnaceae, Duckweed	3			
Eleocharis spp., Spikerush	3	1		
Potamogeton spp., Pondweed	2	2	3	4
Zizania spp., Rice	1			
Najas spp., Naiad	1	1	1	
Ruppia sp., Widgeon Grass	1	4	1	2
Sagittaria spp., Arrowhead	2	1		

Table 14. Continued

PLANT FOOD SPECIES	Ringnecked-Duck	Lesser Scaup	Bufflehead	Ruddy Duck
Ceratophyllum spp., Coontail	3	1		4
Cephalanthus sp. Button Bush	1			
Cyperus esculentus Chufa	1			
Zizania spp., Wild rice		3		
Brasenia sp. Watershield	4	1		
Zannichellia spp., Horned Pondweed		3		
Vallisneria spp Wild Celery		2		
Chara zeylanica Musk Grass	1	2		2
Nymphaea spp., Waterlily	2	2		
Myriophyllum spp., Watermilfoil		1		

Table 14. Continued.

PLANT FOOD SPECIES	Ringnecked-Duck	Lesser Scaup	Bufflehead	Ruddy Duck
Cyperus spp.,				
Sedge		3		
Diplanthera wrigthii				
Shoalgrass	1			
Jussiaea spp.,				
Water Prim Rose	1			
Algae	1			

Benthic invertebrates have been shown in numerous studies to be of varying importance in the diets of waterfowl (Cottam, 1939; Harmon, 1962; Krull, 1970; Thompson, 1973). Studies conducted on Par Pond have shown that benthic invertebrate species richness is generally lower in the vicinity of the Hot Dam than elsewhere in the reservoir (Bowen, 1976; Oden, 1977). No differences in densities of the ramshorn snail (Helisoma trivolvis) between the Hot Dam site and pumphouse site were revealed by Johnson's (1975) dip net sampling. However, Helisoma anceps was virtually absent at the Hot Dam although abundant at the pumphouse site. Johnson (1975) also found the thermal tolerances of these two species to be significantly different, thus explaining the observed differences in abundance between sampling sites.

From December 1983, through May 1984, macroinvertebrates were sampled from nine locations in Par Pond (Figure 48). The percent composition of major macroinvertebrate taxa at each of the sampling locations is presented in Table 15. Dipterans (true flies) were the most abundant macroinvertebrate group collected, accouting for 55.9 percent of the organisms in the macroinvertebrate samples. Chironomidae (midges) and Chaoborus punctipennis (phantom midge) comprised 99.5 percent of the dipterans that were collected. Hoppe et al. (in press) found that ruddy ducks on Par Pond consumed 59 percent animal foods with Chironomidae comprising 97 percent of this animal volume. Macroinvertebrate samples collected near the bottom of Par Pond consistently contained more taxa and higher densities than surface samples (Table 16). No apparent differences in the vertical distribution of macroinvertebrates were observed between the Hot Arm and the other

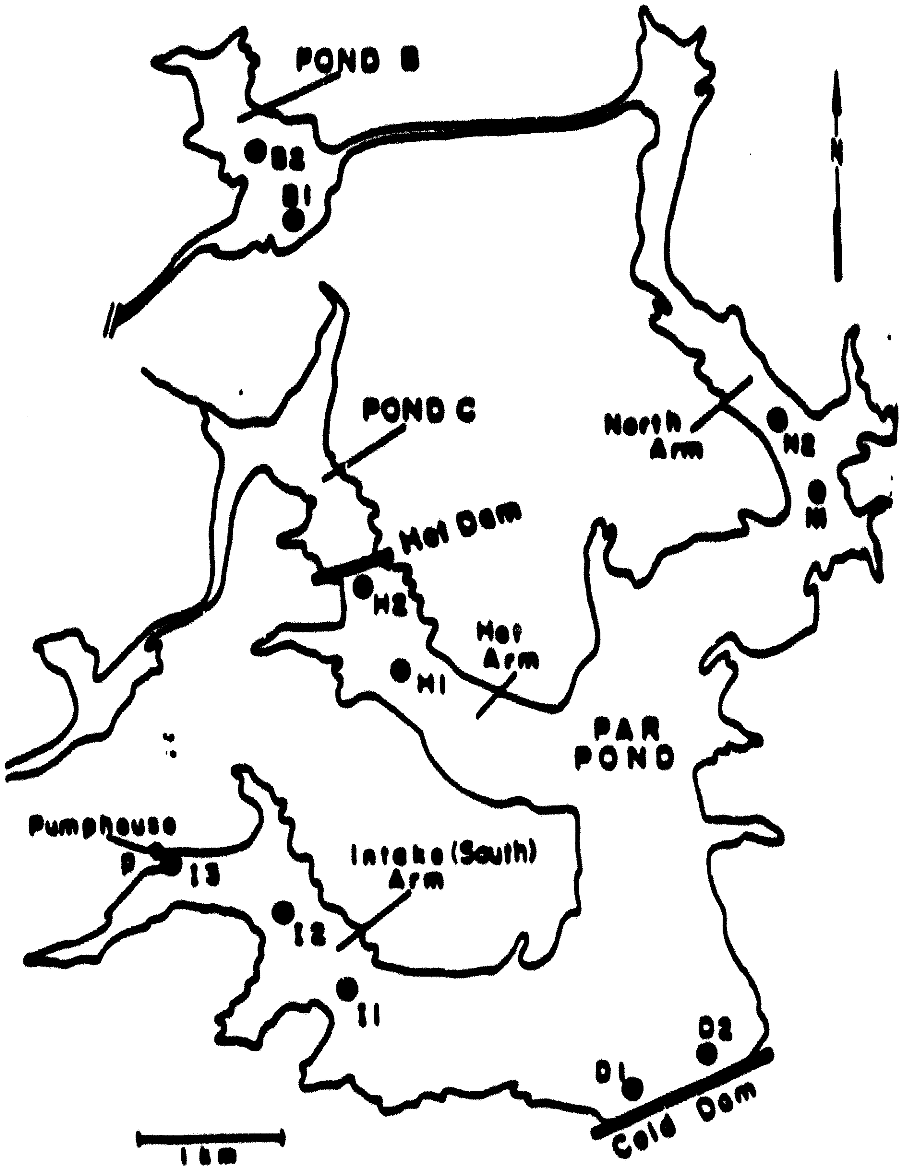

FIGURE 48. Sampling locations of benthic macroinvertebrate studies of the Par Pond system.

Table 15. Percent Composition of Major Macroinvertebrate Taxa Collected in Par Pond and Pond B. December 1982 - May 1984.

	Sampling Location										
Taxa	H1	H2	N1	N2	D1	D2	I1	I2	P	B1	B2*
Diptera	61.5	65.6	80.4	67.6	85.1	87.9	35.7	53.7	64.5	38.7	40.0
Trichoptera	4.8	1.2	3.6	2.3	0.9	1.1	1.2	2.6	8.7	15.0	6.8
Odonata	0.5	0.0	0.6	0.5	0.0	0.0	0.0	0.9	0.2	0.8	0.0
Emphemeroptera	0.0	0.0	0.0	0,8	0.9	0.0	0.0	1.1	0.8	0.4	0.0
Amphipoda	0.0	0.0	3.3	9.0	0.0	0.2	1.6	4.5	1.2	19.3	5.3
Gastopoda	0.5	3.5	0.6	0.0	0.9	0.8	0.8	8.6	0.4	0.4	0.0
Pelecypoda	3.0	2.3	0.0	0.0	4.3	1.1	52.2	1.0	0.2	0.0	0.0
Oligochaeta	27.4	26.4	3.6	10.5	3.4	1.7	2.0	21.4	5.9	1.9	17.1
Turbellaria	0.9	0.1	0.9	2.3	0.0	0.0	0.0	0.5	0.6	5.9	1.4
Nematoda	0.4	0.0	0.3	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.3
Hydracarina	0.7	0.8	5.9	6.4	2.9	1.7	3.6	1.7	16.4	9.4	0.2
Ostracoda	0.2	0.0	0.3	0.5	0.3	0.4	0.8	2.9	0.1	7.4	29.0
Other	0.0	0.0	0.5	0.0	1.3	5.1	2.1	1.0	0.9	0.8	0.0

* B2 includes only data from December 1983 to January 1984.

Table 16. Vertical distribution of macroinvertebrates in Par Pond and Pond B. December 1983 - May 1984. Taken from Gladden et al. (1985b).

Sampling Location	Mean Number of Taxa Top	Mean Number of Taxa Bottom	Mean Density (Organisms/1000m^3) Top	Mean Density (Organisms/1000m^3) Bottom
Par Pond				
H1	2.6	3.7	191	755
H2	1.8	3.0	145	1053
N1	3.2	3.7	185	376
N2	1.5	3.8	104	572
D1	3.1	3.9	214	330
D2	3.7	3.4	310	437
I1	2.6	3.1	100	374
I2	4.1	6.4	294	1108
Par Pond (overall)	2.8	3.9	193	626
Pond B				
B1	3.7	8.4	246	4167
B2*	3.2	8.0	425	3213
Pond B (overall	3.4	8.2	386	3690

*B2 includes only data from December and January.

sampling sites on the reservoir. Diel (24-hour) variations in macroinvertebrate taxa present and densities were assessed by sample collections at four-hour intervals during 24-hour periods in February and in May 1984. Distinct diel patterns were observed, with most species exhibiting higher nocturnal densities (Table 17). Nighttime densities were generally an order of magnitude higher than daytime densities. The phantom midge Chaobrus punctipennis, exhibited the most dramatic nocturnal increases in density and generally accounted for 98 percent of the macroinvertebrates collected at night. J. Bergan (pers. comm.) noted increases in the feeding behavior of ruddy ducks on Par Pond during nocturnal observations. If ruddy ducks on Par Pond are indeed using this food resource at night, it would be a previously unreported phenomenon for this species and represents a clear demonstration of the ruddy duck's ability to alter behavior strategies to exploit available wintering grounds resources.

The Asiatic clam (Corbicula fluminea) is an introduced species which is found in most major river systems of the United States. During May, June, and July 1977, Britton and Fuller (1979) surveyed various aquatic habitats of the SRP and found no evidence that the Asiatic clam had then reached the Par Pond reservoir. In recent years, however, the Asiatic clam has become well established and may even dominate the bivalve mollusks in the reservoir. Hoppe et al. (in press) found that animal foods comprised 89 percent of the lesser scaup diet, of which 72 percent were clams. These clams were dominated by a single species, the Asiatic clam. The greatest concentrations of the Asiatic clam in Par Pond occur in areas adjacent to the Hot Arm and to the West (Intake) Arm (Table 18), which indicates

Table 17. Diel differences in the number of taxa (per 50 m^3), and densities of macroinvertebrates (per 1000 m^3) in Meroplakton samples. February and May 1984. Taken from Gladden et al. (1985*b*).

Time		February		May	
Time Period	Time	No. Taxa	Density	No. Taxa	Density
1	6 a.m. - 10 a.m.	6.2	696	6.9	1,841
2	10 a.m. - 2 p.m.	6.1	689	6.5	1,123
3	2 p.m. - 6 p.m.	5.0	360	4.2	700
4	6 p.m. - 10 p.m.	7.0	85,243	6.9	59,342
5	10 p.m. - 2 a.m.	9.7	103,825	11.2	471,959
6	2 a.m. - 6 a.m.	7.9	84,985	8.4	253,863

Table 18. Number of Specimens, Size, and Density/m^2 of Corbicula fluminea Collected from Ponar Dredge Samples in Par Pond and Pond B. February and May 1984. Taken from Gladden et al. (1985b).

Location	No. of Specimens	Shell Length Range (mm)	Shell Length Mean (mm)	Mean Density/m^2
		February 1984		
Par Pond				
Hot Arm	14	4.8 -29.4	14.4	50.2
Intake Arm	12	7.9 - 24.6	15.8	43.1
Cold Dam	1	10.3	10.3	3.6
North Arm	0	-	-	0
Pond B	0	-	-	0
		May 1984		
Par Pond				
Hot Arm	406	1.0 - 27.8	5.2	1456.7
Intake Arm	109	1.2 - 24.8	3.1	391.1
Cold Arm	1	9.5	9.5	3.6
North Arm	0	-	-	0
Pond B	0	-	-	0

that its distribution is influenced by flow patterns resulting from reactor operations.

The effects of diving duck (Aythyini) predation on macroinvertebrate numbers and biomass, as well as the relationship of food quality with increasing water depth, was investigated with the use of exclosures during the winter of 1983-1984 on the Par Pond reservoir (Smith et al., submitted). Thirty exclosures (1 by 2 meters) were established along depth contours on the north and south sides of the Cold Dam. Benthic invertebrates were sampled three times during the winter period; November 1, 1983, January 1, 1984, and March 1, 1984. Core samples were taken inside and outside of each exclosure on each sampling date. Chironomids were the most numerous organisms found in the benthic samples, while Corbiculidae made up the major portion of the biomass. Results of these studies indicate that there was no significant ($\underline{P}$ = 0.10) impact of wintering diving ducks on Par Pond marcoinvertebrate taxa in terms of numbers or biomass. Total biomass of all invertebrates tended to be greater ($\underline{P}$ = 0.0347) in shallow water zones than in deep water. Corbiculidae density was found to be independent of depth. The total biomass of all Chironomids was greater in deep water zones than in shallow water zones.

2.3.3.3) Effects of Thermal Effluent on PPRS Wintering Waterfowl

Since the Par Pond reservoir serves as a production nuclear reactor cooling reservoir, portions of Par Pond are significantly elevated in temperature during the reactor "up" cycles. Currently, only the SRP's P-reactor discharges thermal effluent into the PPRS.

Detailed evaluations of the heat distribution and dissipation within the Par Pond reservoir are given by Lewis (1974) and Neill and Babcock (1971). During the period from 1 October, 1984, to 31 March, 1985, P-reactor was "up" for 81.3 percent of 182 days. All aerial surveys of Par Pond were conducted during "up" periods with the exception of one flight on 17 November, 1984, which was flown during one of five routine refueling or "down" periods of P-Reactor which generally required five to six days to complete. Counts of waterfowl observed in the Hot Arm of Par Pond during the winter of 1984-1985 are shown in Figure 49. Aerial survey counts were grouped together within reactor cycles to note any possible trends in Par Pond usage. Lesser scaup and ring-necked duck counts were found to fluctuate significantly within reactor cycles $\underline{P} = 0.0302$ and $\underline{P} = 0.0497$, respectively), though no discernable trends could be attributed to thermal influence. No significant differences were found in the counts of lesser scaup, ring-necked ducks, or bufflehead between the Hot Arm and all combined ambient areas of Par Pond among the reactor cycles. Only the ruddy duck showed any significant differences in counts between the warm and ambient areas of Par Pond among the reactor cycles. During the last reactor cycle of the winter of 1984-1985 study period, two of the last four surveys indicated significantly more ruddy ducks using the Hot Arm. Had this difference been found during a mid-winter reactor cycle when no waterfowl on Par Pond were in transient migration, this could have been meaningful, however, it is our feeling that this significant difference only reflects the probable random distribution of waterfowl resting briefly on Par Pond as they migrate through the area. These birds probably had no prior experience in selecting preferred sites on

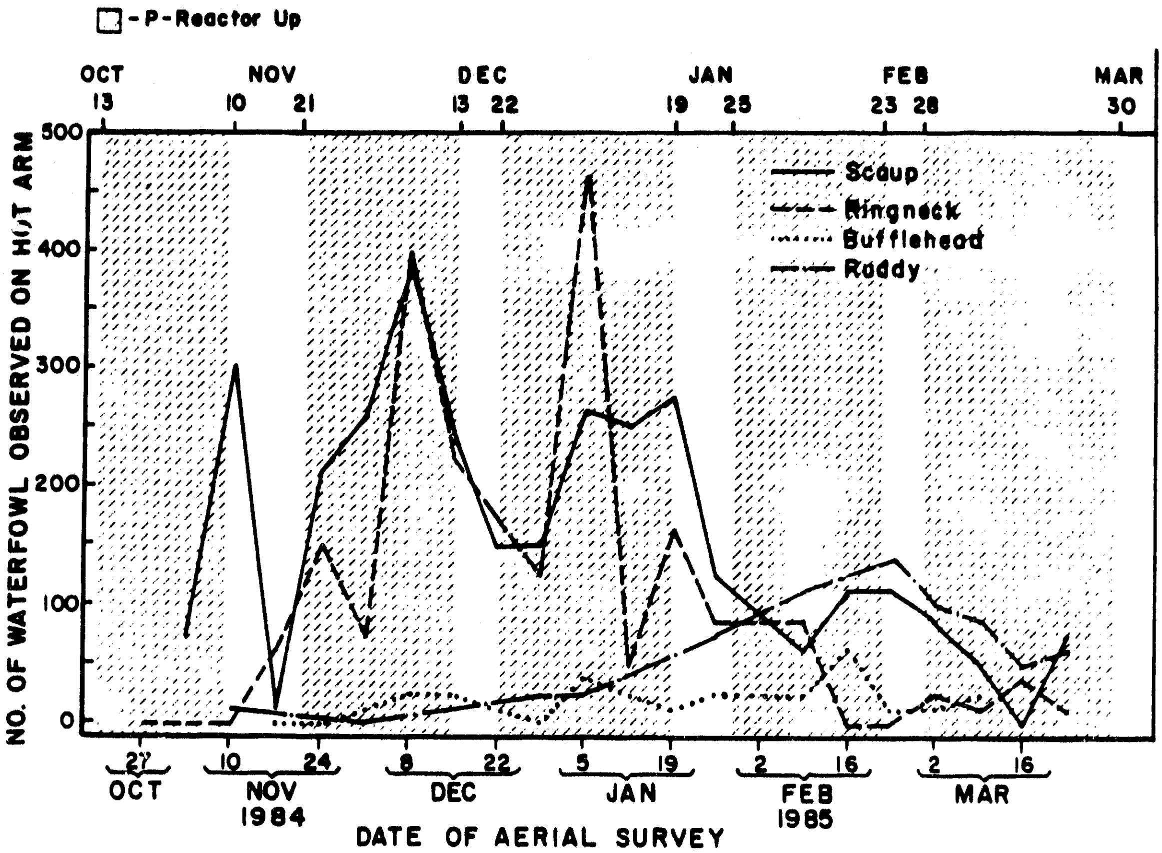

FIGURE 49. Waterfowl numbers in the Hot Arm during the 1984-1985 wintering period compared to the reactor cycles.

the reservoir. Analyses were also performed to test if waterfowl would seek the warmer regions of Par Pond during the coldest ambient air periods of the winter. Mean 48-hour air temperatures including the day before and day of the aerial survey were associated with each flight count. As mean air temperatures dropped below 7.2 degrees centigrade, counts of bufflehead and ruddy ducks increased significantly on Par Pond ($P = 0.0023$ and $P = 0.0447$, respectively). No such effects were found for either lesser scaup or ring-necked ducks, however. Also, no significant movement of Par Pond waterfowl toward warmer areas of the reservoir occurred as mean ambient air temperatures dropped below 7.2 degrees centigrade ($P > 0.30$).

2.3.3.3.1) Effects of Thermal Effluent on Common Moorhen Nesting Behavior

Data collected on nesting common moorhens (Gallinula chloropus) during the 1985 breeding season suggest that moorhens may utilize the thermal water within the Hot Arm of Par Pond as a source of incubation heat (i.e., when the nest is left unattended by the incubating adults, the eggs may have a lower rate of heat loss).

Data were collected on 14 common moorhen nests in thermal areas and 9 nests in ambient areas of the Par Pond reservoir between 1 May and 3 July, 1985. Several nest-site parameters were measured: 1) height of nest above water, 2) outside diameter, 3) inside diameter, 4) depth of nest bowl, 5) distance to nearest shore, 6) water depth at nest, and 7) plant species in which each nest was constructed. Mean nest heights from thermal and ambient areas were 5.79 cm, SE = $\pm$ 2.64

and 21.41 cm, SE= $\pm$ 5.88, respectively. Outside diameters from thermal and ambient areas were 23.46 cm, SE = $\pm$ 0.73 and 26.04 c,m SE = $\pm$ 0.65, respectively. A simple t-test applied to each of the dependent variables revealed that nest heights as well as outside diameters were significantly different between thermal and non-thermal areas of the reservoir (N=23, t = 3.17, $P < 0.005$; and N = 23, t = 2.45, $P < 0.03$). No other parameters were found to vary significantly between locations. All nests in the sample were constructed of cattails (Typha spp.). One moorhen nest located nearest to the source of thermal water entering the Hot Arm (less than 100 meters) also had the highest height above the water. This nest was deleted from the data set because it was felt that an upper threshhold heat limit had been exceeded and the moorhens had increased the distance between the water and nest in order to compensate for nearness to the heat source.

Nocturnal micro-climate parameters were measured at each nest site on 22 August, 1985. P-Reactor was "up" during the sample period and thermal effluent entered Par Pond at the west end of the Hot Arm. Parameters measured include wind speed, surface air temperature, nest air temperature, surface water temperature, surface percent relative humidity, and nest percent relative humidity. Nest air termperatures and percent relative humidities of all nests were recorded immediately adjacent to the actual nest site because nest structures had been destroyed as the nesting season progressed. Thus, no insulative properties of the nest structure are incorporated into these values. Temperature of nest air (Hot Arm: x=25.33, SE=+0.14; West Arm: x=23.21, SE=$\pm$0.24), surface air (Hot Arm: x=26.11, SE=$\pm$0.27; West Arm: x=24.46, SE=$\pm$0.27) and surface water Hot Arm: x=$\pm$33.29, SE=±0.25; West Arm: $\bar{x}$=29.87, SE=±0.12) varied significantly (P < 0.001) between sites.

Adult common moorhens nesting in thermal portions of the Par Pond reservoir may exhibit behavioral and physiological adaptations to an altered environment. Common moorhens are known to be territorial on the breeding grounds (Petrie, 1984; Wood, 1974) and considerable time and energy are spent defending resources vital to reproduction. Time spent incubating may be less for birds in thermal areas. If this is correct, other aspects of reproductive effort (i.e., size of territory, clutch size, chick survival, chick growth, adult lipid reserves, renesting) may be affected. In addition, if adults spend less energy for incubation, females may allocate some of these savings toward production of higher quality eggs. Egg quality may be related to fledgling success and survival of young common moorhens.

2.3.4) Waterfowl Utilization of Pond C

As stated earlier, waterfowl aerial surveys of Pond C did not begin until January 1984. Waterfowl use of Pond C is minimal compared to the rest of the PPRS. This reduced usage of Pond C is due to the elevated water temperatures (> 36 degrees Centigrade) of the thermal effluent in that impoundment, which restricts the area's availability for waterfowl to narrow littoral zones or "down" periods of the reactor cycle. A total of eight species of waterfowl have been known to use Pond C (Table 1). In the first winter it was surveyed (January 28 to April 7, 1984), Pond C was used by only five species represented by 23 individuals. These included ring-necked ducks, lesser scaup, buffleheads, ruddy ducks, and pied-billed grebes. The majority of the use (56.6 percent) of this precooling impoundment was in February of that year. Of the 11 days on which Pond C was sampled, P-Reactor was "down" for only four of these days. However, 69.6 percent of the birds were observed on those days surveyed during the reactor "down" cycle. During the 1984-1985 wintering period, waterfowl use of Pond C was reduced from the previous year. Only four species (lesser scaup, ruddy ducks, gadwalls, and pied-billed grebes) represented by 17 individuals were seen on that impoundment from October 27 to March 23. The majority of the birds (82.4 percent) were seen in November. The remainder of the ducks were present only in December. During this sampling period, P-Reactor was "down" for only 9.5 percent of the days surveyed, but 76.5 percent of the birds were seen on those days. Areas used in Pond C during the "up" period in the reactor cycle include the backs of the major coves (Boatdock, Canal and Sanctuary), the backs of smaller coves along the eastern shore, and the 20 m margin of the impoundment adjacent to and off of the Hot Dam. During reactor "down" periods, the entire pond is available, and this is also the period of maximum use. Waterfowl seen during ground observations on Pond C included 3 American Coots and 12 Buffleheads. These birds were all seen during the reactor "up" periods, were within 1 to 10 m of shore, in 1 to 3 m of water, and in surface water temperatures between 38.5 and 40.0 degrees Centigrade. Wood ducks were also seen during these observations in Sanctuary Cove, but no water parameters were measured. The only waterfowl activity observed on Pond C to date has been loafing. Although not observed, feeding is a potential activity in the back of the major coves on Pond C with the following waterfowl forage species present: arrowhead, bulrush, Cyperus spp. and needle rush (Parker et al., 1973).

2.3.5) Waterfowl Utilization of Pond B

At present, Pond B is unique in the PPRS because it no longer receives thermal effluent. As a result of this, waterfowl use of Pond B is substantial. A total of twelve species of waterfowl are known to use Pond B (Table 1). During the first survey year (1984), nine species were observed on this impoundment represented by 651 individual birds. These included the four main species (Figure 50) seen on Par Pond plus mallards, wood ducks, gadwall, northern shoveler, and pied-billed grebes. Of the four main species, buffleheads were the most abundant (N=224), followed by ruddy ducks (N=201), lesser scaup (N=96), and ring-necked ducks (N=55). The entire winter period (November to April) was surveyed on Pond B during the second season. Eight species represented by 1,152 individuals were observed during this period. The species composition was similar to that of the previous year, excluding mallards. The four main species were again the most common (Figure 51) with ring-necked ducks being most abundant. However, compared to the same sampling period of the previous year, total waterfowl numbers were down (N=269). No waterfowl behavior observations have been made on Pond B. Waterfowl food species found in Pond B include: spikerush, waterlily, pondweed, and bulrush (Parker et al., 1973).

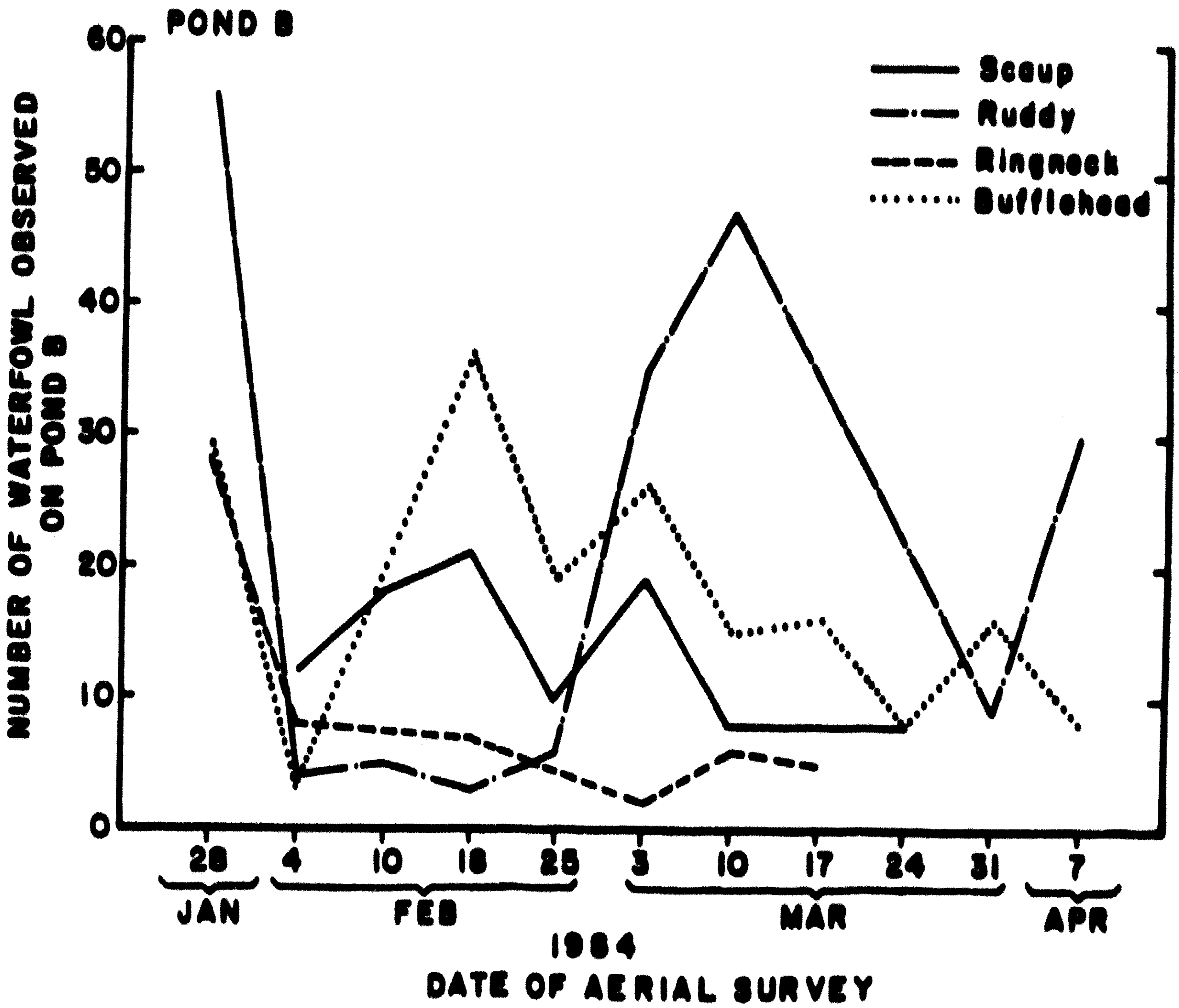

FIGURE 50. Waterfowl numbers on Pond B during 1984. The four most abundant species are included.

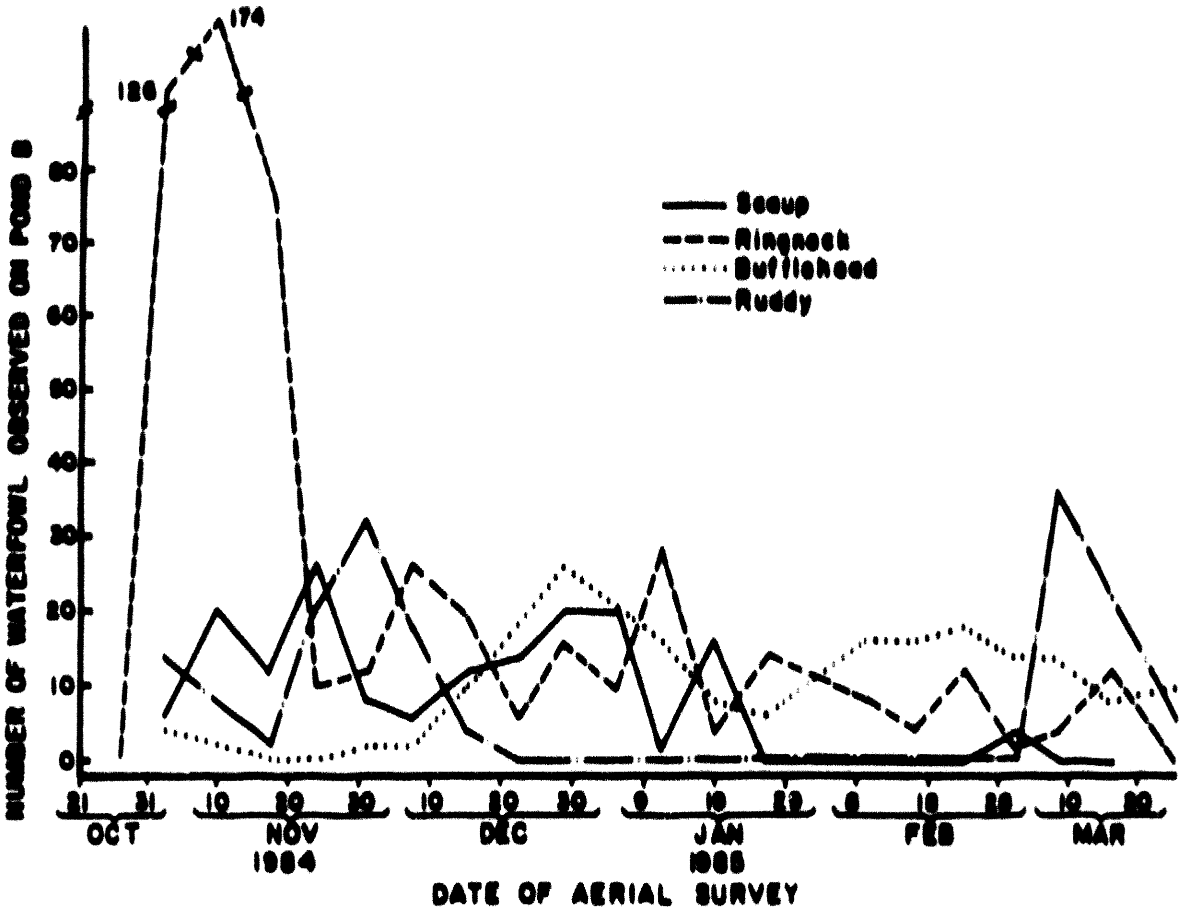

FIGURE 31. Waterfowl numbers on Pond B during the 1984-1985 wintering period. The four most abundant species are included.

3) WOOD DUCK REPRODUCTIVE ECOLOGY ON THE SRP

3.1) Introduction

The wood duck is a common year-round resident on the SRP (Norris, 1963; Mayer et al., 1984). These resident birds on the site are a component of the southern portion of the breeding range of this species and are not migratory (Bellrose, 1980). The wood duck is also the only waterfowl species to breed commonly on the site (Gladden et al., 1985a). Limited nesting by hooded mergansers (*Lophoytes cucullatus*) is known to occur on the SRP (Fendley, 1978). In addition, one breeding record for the mallard has been documented for Aiken County adjacent to the Savannah River (Norris, 1963); however, these birds may have been escaped game farm stock (I. L. Brisbin, Jr., pers. comm.).

Wood duck use of Carolina bays and the SRSS on the SRP was noted as early as 1958 (Norris, 1963). Wood ducks were abundant locally as a breeding species prior to the closure of the SRP to the public in 1952 (Murphy, 1937). In the mid-1930s wood ducks were most commonly found in cypress swamps and lagoons in this area (Murphy, 1937). This species is the only one present on the site that is known to use most of the available open water habitat on the SRP (Table 1). Wood ducks nest on the SRP from January through July (Gladden et al., 1985a). Norris (1963) stated that in late summer, many wood ducks tended to leave the SRSS and visit Carolina bays on the SRP, where good forage conditions for this species were found.

Because of the unique breeding status of this species on the SRP, a great deal of emphasis has been directed toward studying their reproductive biology. Research on this topic has included a five-year study on the reproductive biology of this species on the site and a nest box utilization survey. The nest box utilization survey was initiated in 1973 (Fendley, 1978) and has been continued on a site-wide basis up to the present. In addition, the proposed restart of L-Reactor was thought to represent a potential for either the complete destruction or at least a reduction of wood duck nesting habitat in the Steel Creek corridor and delta due to the direct discharge of thermal effluent. In 1983, it was decided to mitigate this possible loss of nesting sites by erecting additional nest boxes in suitable habitat adjacent to the main drainage of Steel Creek that would not be effected by reactor effluents. With the construction of L Lake, the potential loss of nesting habitat may be reduced as a result of the projected lower water temperatures of the reactor effluent. However, the full impact of the L-Reactor restart has yet to be determined.

3.2) Methods

The wood duck nest boxes were inspected, repaired, and prepared for the nesting season by putting fresh wood shavings in every box during the month of January. Nest boxes were then checked weekly from February 1 until June 30 to collect the reproductive biology data. Incubating hens were captured and banded with a U. S. Fish and Wildlife Service leg band. The hen's tarsus length was measured in mm and her total body weight was taken in g. The bird was then released.

Any eggs present in the nest boxes were numbered for later identification, length and breadth were measured, and they were returned to the nest. Each egg was candled to determine the stage of incubation. A mean incubation time of 30 days was assumed. The presence of eggs in a nest box that were in two or more stages of incubation indicated that the nest was dump nest (two or more hens laying eggs in the same nest box). Boxes were then checked daily beginning on the 28th day of incubation until the ducklings were hatched. Ducklings found in the boxes were web-tagged with No. 1 Monel fish-fingerling tags to allow later identification as adults. Similar to the hens, the duckling's tarsus length was measured and the total body weight was taken. The birds were then returned to the nest. Aspects of the wood duck reproductive ecology being studied included: heritability of clutch, egg, and body size; correlations between egg size and initial duckling weight; effects of nest predation and abandonment; movement patterns of nesting hens; effects of dump nesting on the overall nesting success; effects of water level fluctuations on nesting success. A nest was classified as successful if it produced one or more ducklings. An unsuccessful nest occurs for one of two reasons, either nest abandonment by the hen or predation of the nest and/or hen during the incubation period. Predation of nest also frequently causes the hen to abandon the nest. A total of 162 nest boxes have been used on a variable basis throughout the SRP (Figures 52 and 53). Line I, composed of four boxes located in the standing timber around Par Pond, were not checked after 1981 because the only documented use in those sites was by screech owls (*Otus asio*). Line K at Jesse Kennedy Pond was not checked after 1981 because of the lack of use of those nest

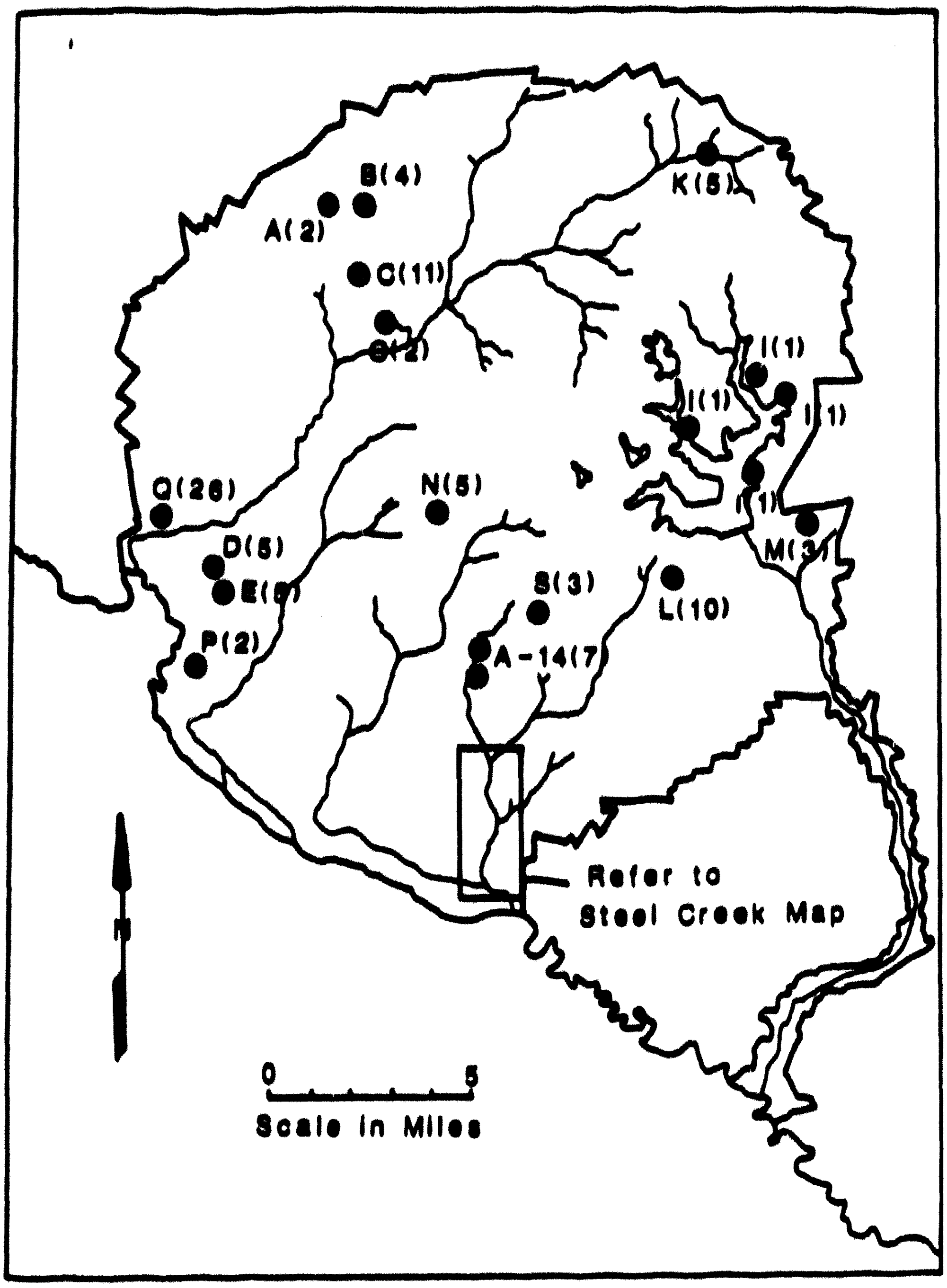

FIGURE 52. Locations of wood duck nest box lines on the SRP.

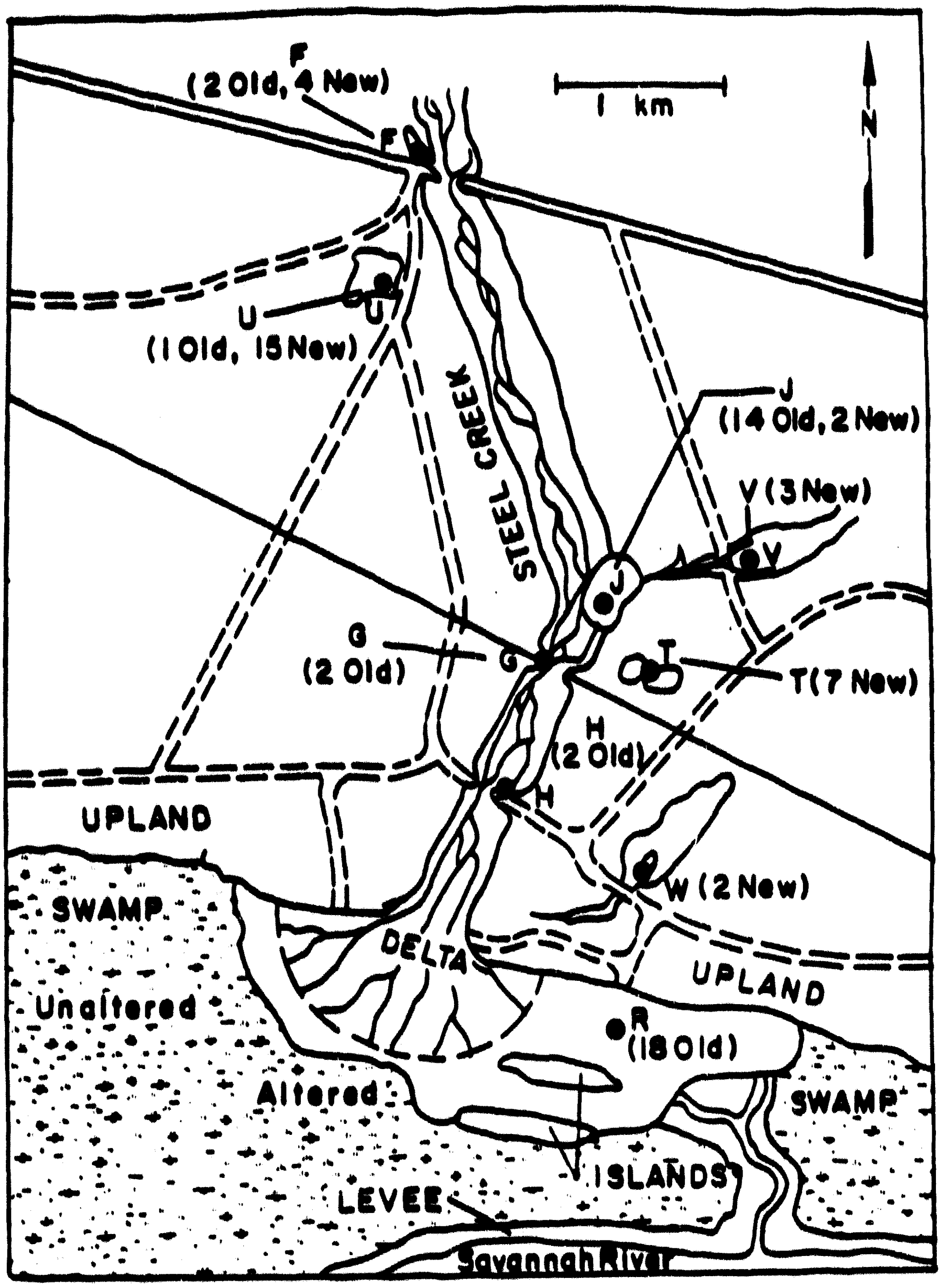

FIGURE 53. Locations of the wood duck nest box lines in the Steel Creek drainage.

boxes and logistical problems with the accessibility in checking them. Lines S and A-14 were destroyed as a result of the construction of L Lake. This left a total of 151 nest boxes site-wide for the 1985 nesting season. Specifically in Steel Creek, 35 old boxes remained from previous years and 33 new boxes remained from the 1983 nest box line expansion.

3.3) Results and Discussion

3.3.1) Site-wide Results

Fifty-seven nests were initiated in the nest boxes site-wide by wood duck hens during the 1985 nesting season. Of these, 38 laying or incubating hens were captured in those boxes. Eight of these were birds which had been web-tagged as ducklings. Four of these hens were one-year old birds which were nesting for the first time. The other four were older birds which had not been previously recaptured since being web-tagged. Eighteen of the remaining birds were banded hens with known prior nesting histories. The last eight hens were unmarked birds which were captured for the first time. Of the 20 recaptured nesting hens, 40 percent were found in the new boxes. First-year returning web-tagged hens accounted for 20 percent of these recaptured birds. Only one of these first-year birds initiated a nest in one of the new nest box lines.

Thirty or 52.6 percent of the nests initiated were successful. A total of 329 ducklings were produced in all of the SRP wood duck nest box lines in 1985.

3.3.2) Steel Creek

Thirty-eight nests were initiated in the 68 available nest boxes in the Steel Creek drainage and adjacent mitigation areas. The majority of the nests initiated (57.9 percent) were in the new boxes (Figure 54). The new nest boxes also had a higher percentage of successful nests, 72.7 percent as compared to 50.0 percent in the old nest boxes. A total of 263 ducklings were produced during the 1985 season in the Steel Creek nest boxes. The majority (174 or 66.2 percent) were produced in the new boxes. Nest initiation and duckling production was down compared to last year because of lower rainfall and water levels before and during the nesting season than in 1984 (Figure 55). The number of ducklings was dramatically lower in some of the mitigation sites established in Carolina bays because these areas dried up to a level that prevented any hens from nesting during the normal second nest initiation peak in May and June. Nest initiation was also reduced in 1985 (Figure 56) in the Steel Creek delta (Line R) because of low water conditions and the advanced stage of succession of the flora in that location. As succession continues in the delta, nest initiation is likely to continue to decrease over time.

3.3.3) Upper Three Runs Creek

Five nests (19.2 percent) were initiated in the nest box line Q in the Upper Three Runs Creek drainage. Eleven ducklings were produced in those nest boxes. Of the five nests, one was successful, one was abandoned, and three were predated. Nest initiation in the Upper

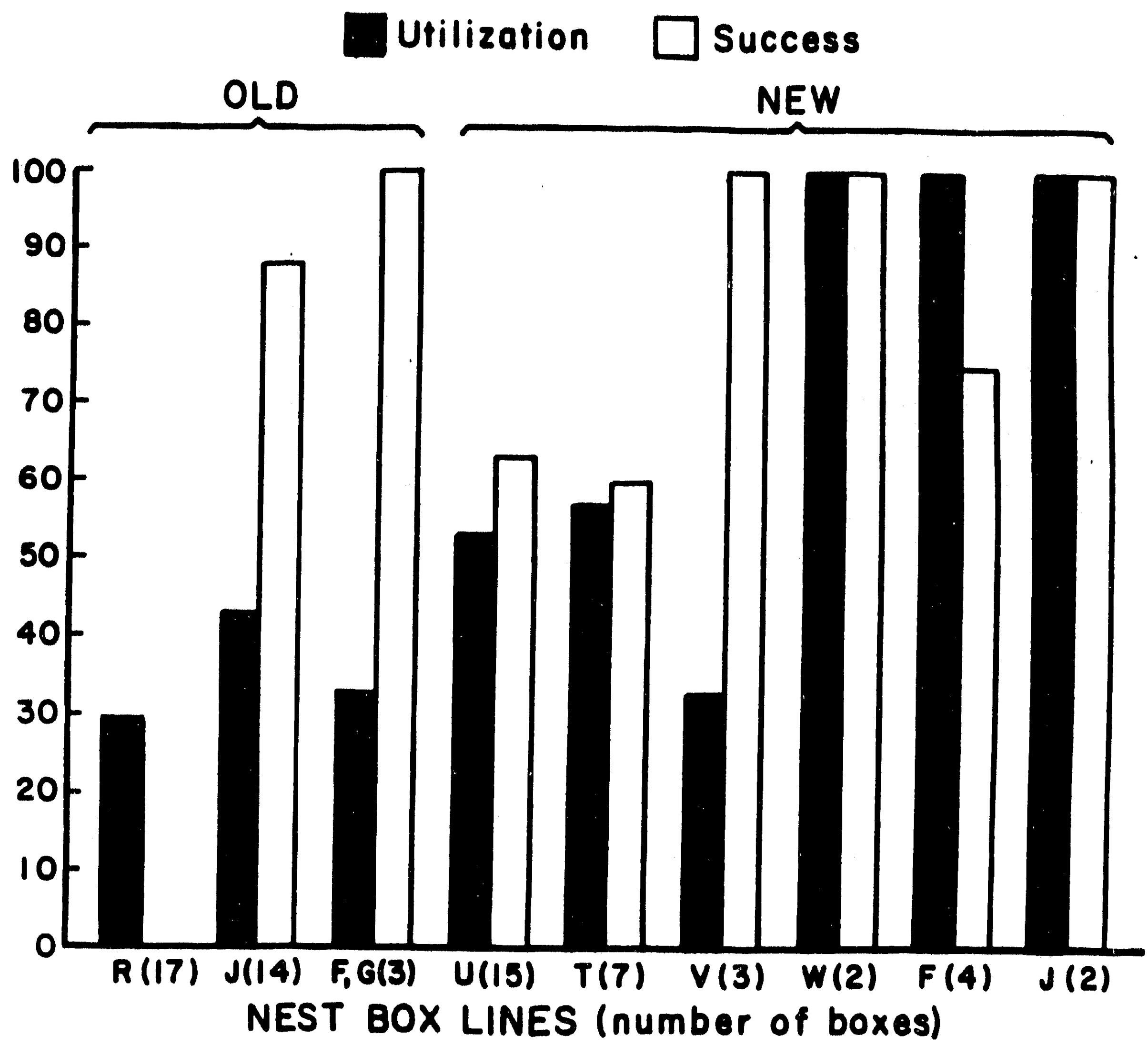

FIGURE 54. Wood duck nest box utilization and success for the Steel Creek nest box lines for 1985.

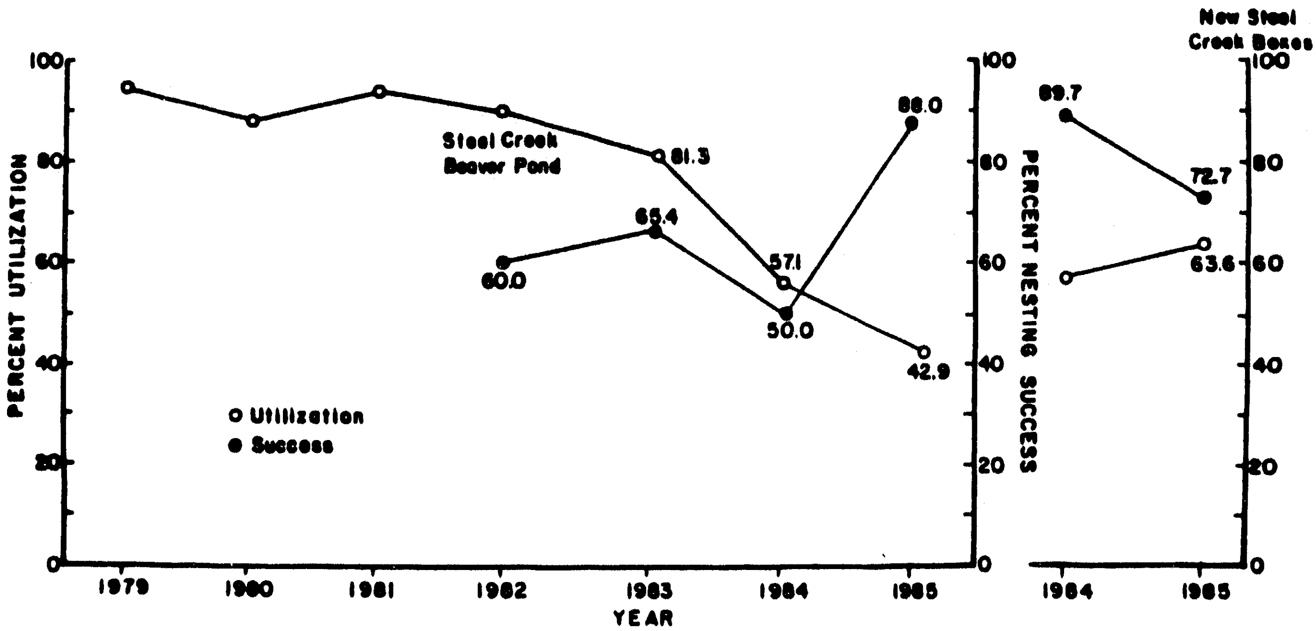

FIGURE 55. Percent utilization and success of wood duck nests in the Steel Creek beaver pond and the new Steel Creek nest boxes from 1979 to 1985.

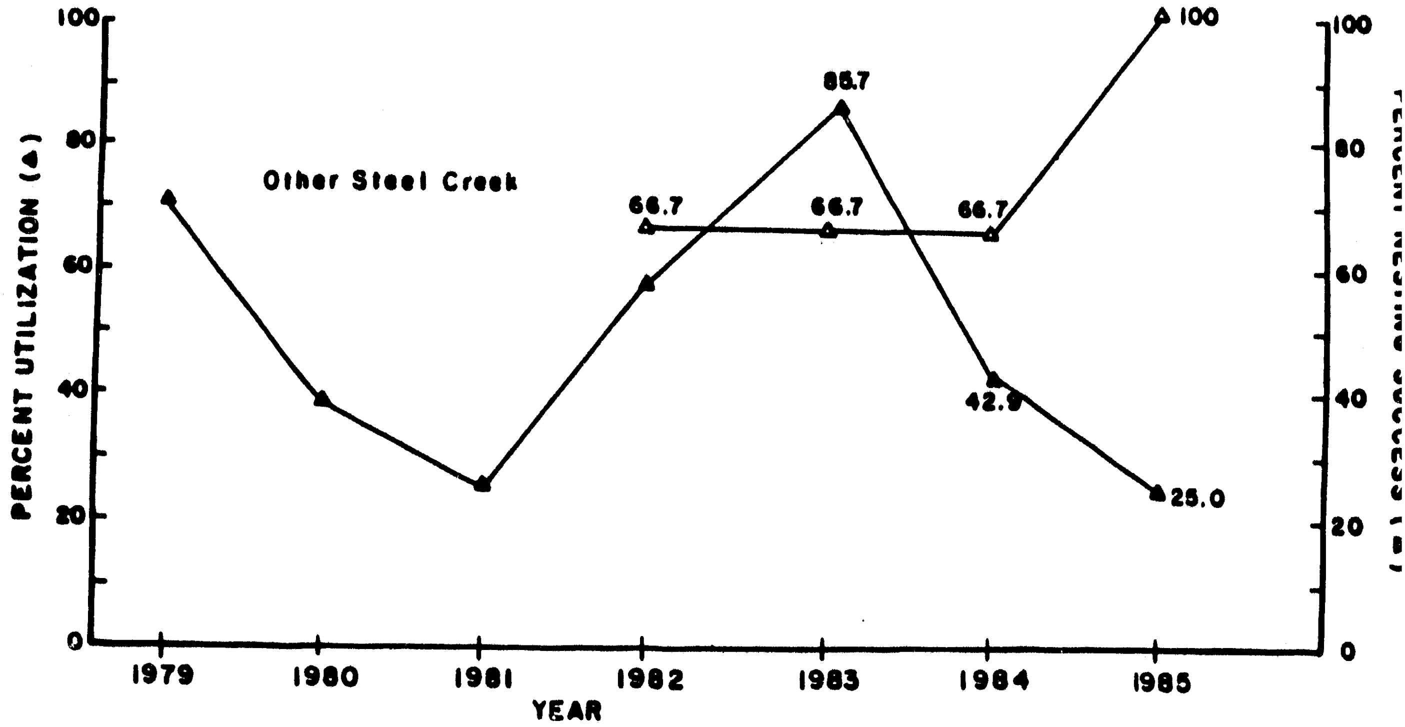

FIGURE 36. Percent utilization and success of the wood duck nest boxes in Steel Creek nest box lines R, F, and G from 1979 to 1985.

Three Runs Creek drainage is related to the water level in the system. During dry years when the Savannah River is low, only the main stream channel contains water. Because the floodplain is not inundated, there is very little suitable brood-rearing or foraging habitat. As a result of this, wood duck hens tend not to initiate nests in the nest boxes along Upper Three Runs Creek. In 1985, water levels were very low. As a result, only five nests were initiated. During wet years (e.g., 1983), the percentage of nest boxes utilized in this drainage can be considerably higher (Figure 57). However, problems can occur during years of high river flooding. If the flooding occurs early in the nesting season, nest boxes can be completely under the surface of the water and, therefore, would not be available to nesting hens. If flooding occurs late in the season, entire clutches of eggs can be covered with water and killed.

3.3.4) Dump Nesting by SRP Wood Duck Hens

Dump nesting is a typical behavior of wood ducks regardless of the geographic locality in which they nest (Clawson et al., 1979). It is also normally found in both cavity and box nesting hens (Clawson et al., 1979). Dump nesting may result from a number of factors. Robinson (1958) related it to a scarcity of nest sites. Jones and Leopold (1967) associated dump nesting with density of wood duck populations. Behavioral causes such as displaced adult hens or inexperienced yearling hens have also been suggested (Grice and Rogers, 1965). In general, dump nesting has been found to be beneficial to most wood duck populations (Heusmann et al., 1980). In 1984 on the

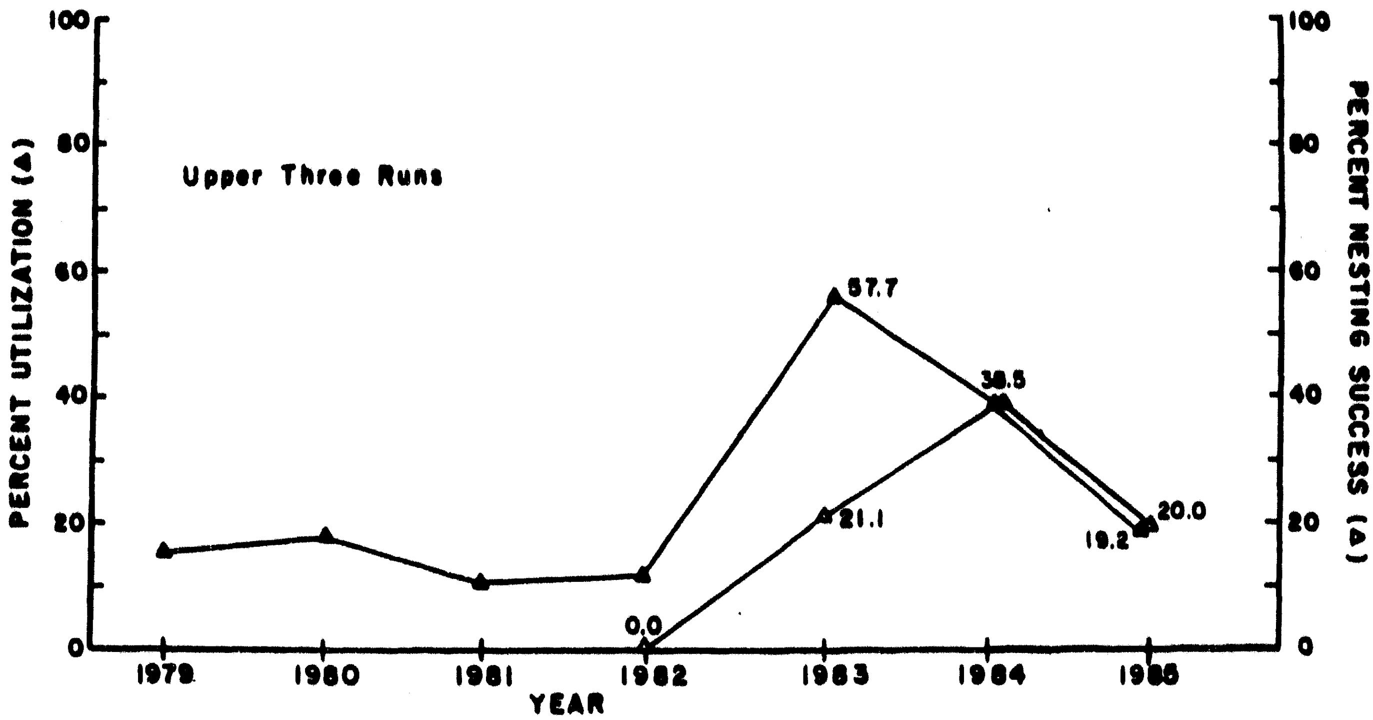

FIGURE 57. Percent utilization and percent success of wood duck nests from Upper Three Runs Creek from 1979 to 1985.

SRP, dump nests made up 32.1 percent of the nests initiated (Figure 58). In 1985, 36.8 percent of all nests initiated were dump nests (Figure 59). Of these, 81.0 percent were successful in producing a total of 211 ducklings. This is 63 percent of the total number of ducklings produced on the site during this past season. This is due in part to the larger clutch sizes (10 to 26) found in dump nests. Normal nests range in size from 7 to 16 eggs on the SRP. In addition, both predation and abandonment rates (both 9.5 percent) are lower in dump nests compared to normal nests on the site. The reasons for this are inexplicable, but the same results have been reached at other locations (Heusmann et al., 1980). Dump nests also tended to be more prevalent in early- rather than late-season nests. This same seasonal frequency has been found elsewhere (Grice and Rogers, 1965).

3.3.5) Unsuccessful Nests

Predation accounted for 29.8 percent of the unsuccessful nests on the SRP during 1985. There are two major predators of wood duck nests/eggs on the site, the red-headed woodpecker (Melanerpes erthrocephalus) and the black rat snake (Elaphe obsoleta). The red-headed woodpecker pecks holes in exposed eggs in the nest boxes. The reason for this behavior is not known. This depredation, however, is the lesser of the two and usually does not destroy the entire clutch. In contrast to this, the black rat snake will consume all of the eggs present in a nest box. In the past, depredation rates resulting from this species have been as high as 50 percent. In the past 4 years, predation by this species has decreased (Figure 60). Data collected

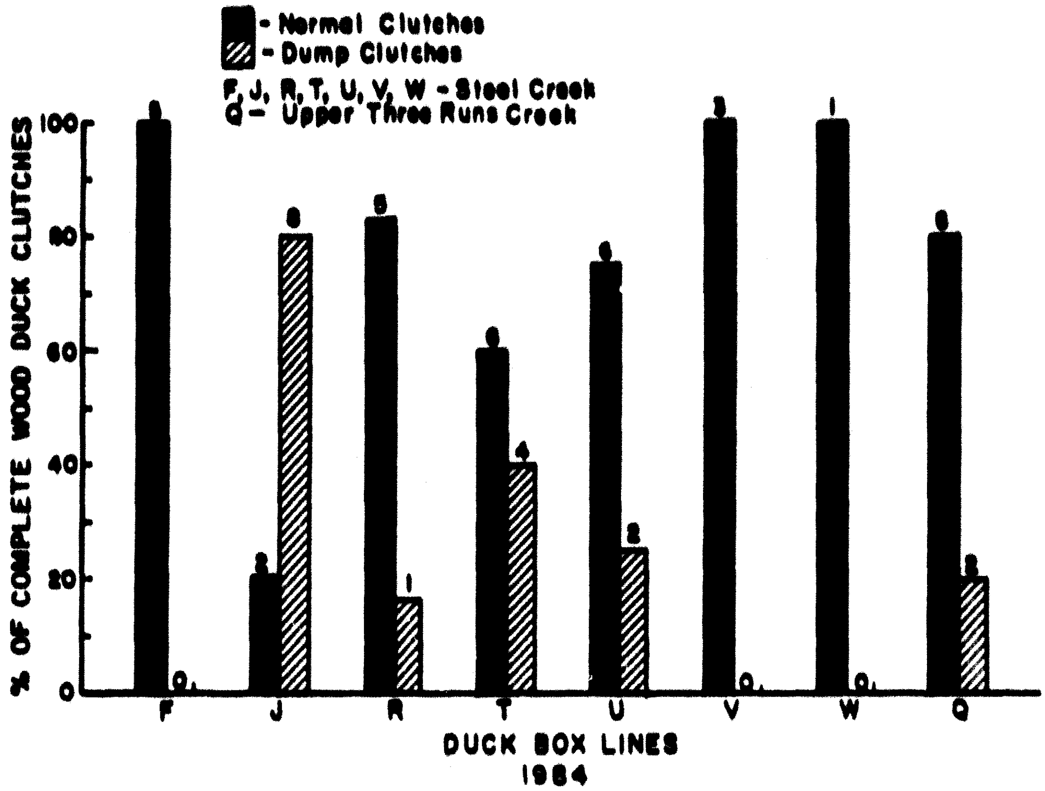

FIGURE 38. Comparison of normal and dump clutches from the 1984 wood duck nest box survey results.

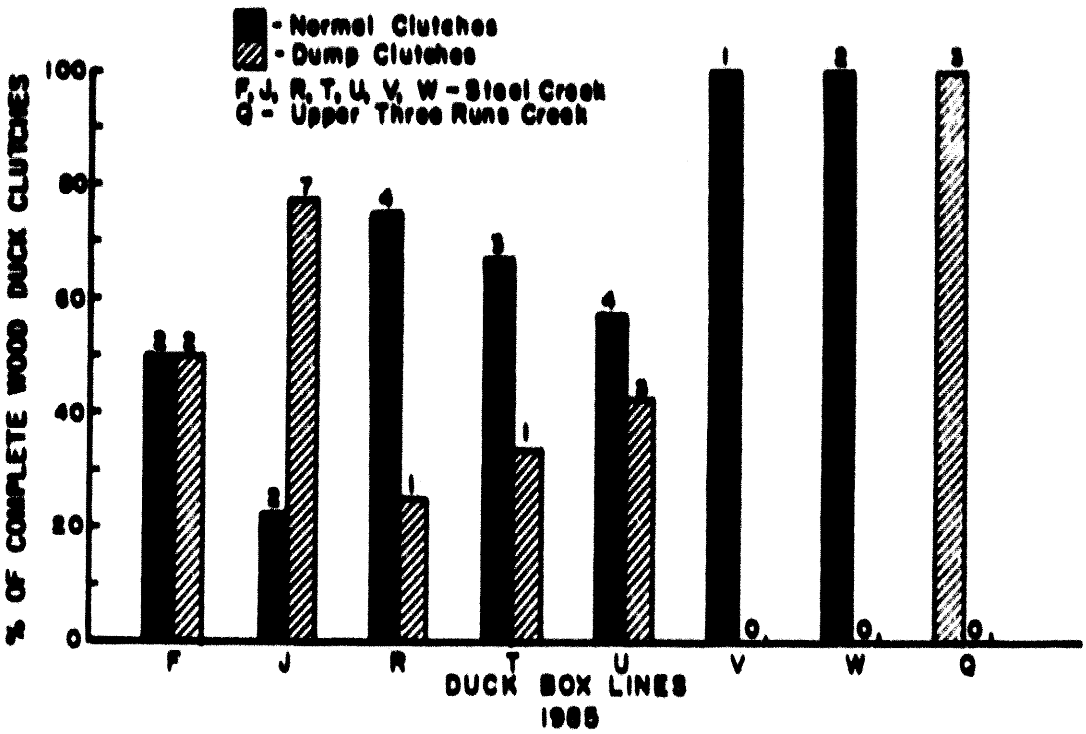

FIGURE 59. Comparison of normal and dump clutches from the 1985 wood duck nest box survey results.

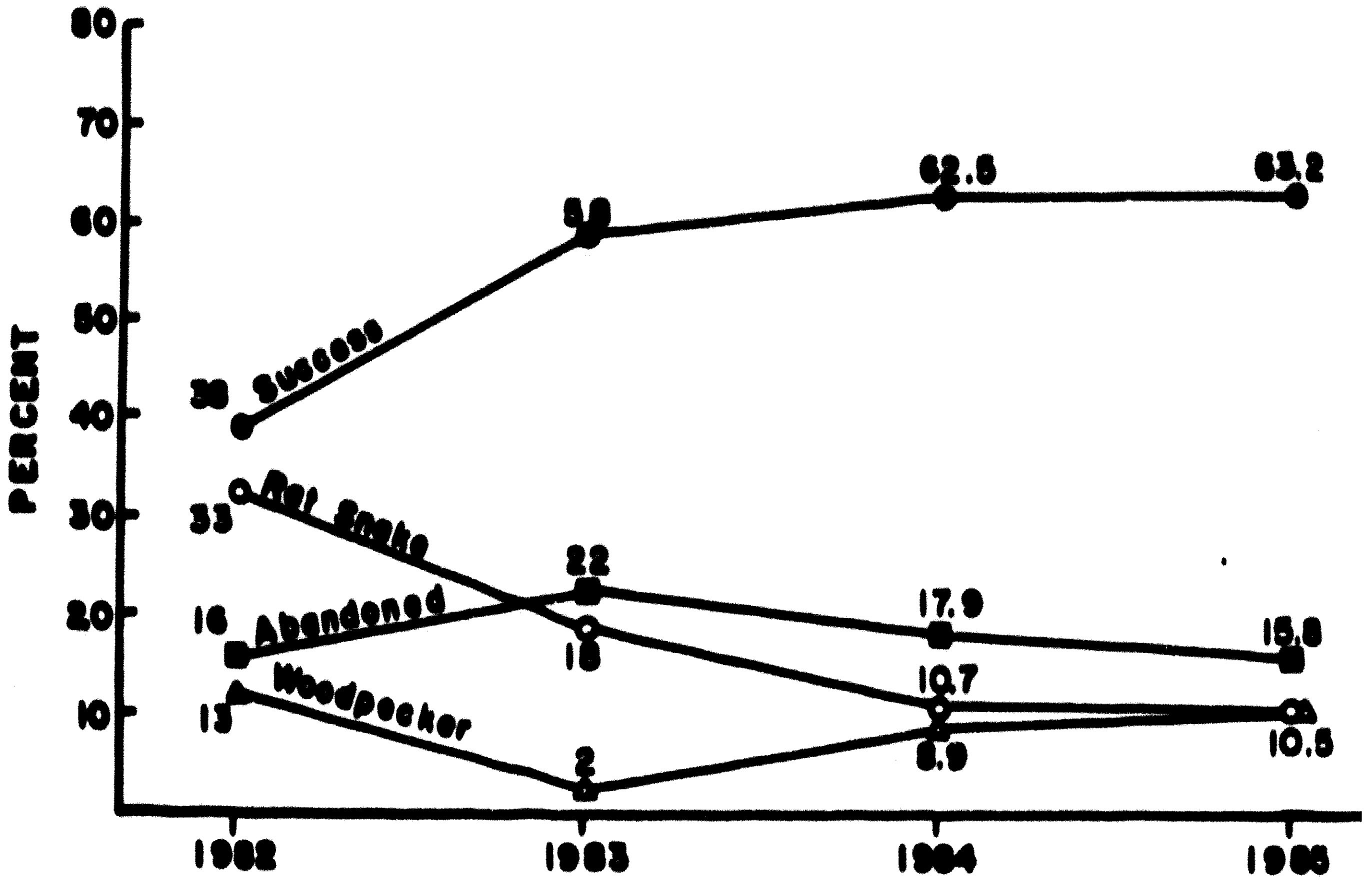

FIGURE 60. Percent outcomes of successful, predated and abandoned wood duck nests in the Steel Creek nest box lines from 1982 to 1985.

on a black rat snake mark-recapture study during the nest box survey indicates that individual snakes will return annually after successfully predating a nest box. Although still higher than the old lines, the percentage of successful nests in the new lines was down from last year. This was due entirely to egg predation by the red-headed woodpecker. In contrast to egg predation by the black rat snake which was virtually eliminated in the new lines by erecting the nest boxes on aluminum poles, predation by the red-headed woodpeckers cannot be prevented. The longer the nest boxes remain available, the greater the chances that red-headed woodpeckers will find and later prey upon any eggs present. Therefore, red-headed woodpecker predation will increase in an existing nest box line with time. Abandonments accounted for 17.6 percent of unsuccessful nests. The number of these nests that were associated with predation attempts is unknown.

3.3.6) Occupation of Nest Boxes by Other Species

One of the factors affecting the numbers of nests initiated during a season is the utilization of these boxes by other cavity nesting or dwelling species. Occupation of nest boxes by these other animals excludes wood duck use of these boxes and therefore reduces nest availability/initiation. Fortunately, this use of the nest boxes is normally low (< 15.0%). Among those species which have been present in wood duck nest boxes on the SRP are: screech owl; hooded merganser; yellow-shafted flicker (Colaptes auratus); Eastern bluebird (Sialia sialis); tufted titmouse (Parus bicolor); great crested flycatcher (Myiarchus crinitus); prothonotary warbler (Prothonotaria citrea); southern flying squirrel (Glaucomys volans); gray squirrel (Sciurus carolinensis); honey bees (Apis Mellifera); and social vespid wasps (Family Vespidae). Wood duck nest box competition was greatest by Eastern bluebirds and then by great crested flycatchers. In 1985, the number of nests occupied by these other species were as follows: screech owl - 5, hooded merganser - 1, honey bees - 7, Eastern bluebirds - 13, great crested flycatcher - 9, tufted titmouse - 3, yellow-shafted flicker - 3, prothonotary warbler - 1, and gray squirrel - 3. In general, the nesting by passerines does not hinder wood duck nest initiation since the smaller birds do not normally nest until the later half of the wood duck nesting season. However, in 1985, one Eastern bluebird did build a nest and lay a clutch of eggs on top of a wood duck nest with a clutch of eggs in it. Fendley (1978) reported an average of 7 percent occupation of his wood duck nest boxes by screech owls. Fendley (1978) also noted a minor occurrence of nests of hooded mergansers and two passerines in nest boxes.

3.3.7) Wood Duck Hen Population Dynamics

Seven years of capture-recapture data from the population of female wood ducks on the SRP were used by Hepp et al. (in prep) to estimate the population size, recruitment and survival, and to ascertain whether these wood duck hens were philopatric. Table 19 summarizes the capture-recapture data in Leslie Method B. table format (Leslie and Chitty, 1951). A total of 144 individuals were captured and banded during 1979-1985. Annual estimates of population parameters, standard errors and arithmetic means are presented in Table 20.

Table 19. Hen wood duck capture-recapture data summarized in Leslie Method B. table form (Leslie and Chitty 1951).

Capture Year							
1979	1980	1981	1982	1983	1984	1985	Year returns were last previously caught
	8	1	0	1	0	0	1979
		7	5	0	0	0	1980
			11	1	0	0	1981
				19	0	0	1982
					21	2	1983
						22	1984
							1985
0	8	8	16	21	21	24	Returns
28	14	13	16	27	32	14	New birds banded
28	22	21	32	48	53	38	Total caught
28	22	21	32	48	53	38	Total released

Table 20. Jolly-Seber estimates of population parameters for breeding female wood ducks.

	Population size		Survival rate		Recruitment		Capture probability	Proportion marked
Yr(t)	$\hat{N}_t$	$\hat{SE}(\hat{N}_t)$	$\hat{\Phi}_t$	$\hat{SE}(\hat{\Phi}_t)$	$\hat{B}_t$	$\hat{SE}(\hat{B}_t)$	($\hat{p}_t$)	($\hat{A}_t$)
1979	-	-	0.41	0.07	-	-	-	-
1980	29.5	5.9	0.71	0.14	23.4	10.4	0.69	0.36
1981	44.4	11.8	0.62	0.08	10.0	6.7	0.44	0.38
1982	37.5	3.8	0.59	0.03	25.7	1.9	0.83	0.50
1983	48.0	0.0	0.53	0.06	37.4	5.8	1.00	0.44
1984	63.1	7.5	-	-	-	-	0.82	0.40
1985	-	-	-	-	-	-	-	0.63
Means	44.5	3.1	0.57	0.02	24.1	2.1	0.76	0.45

Bias-adjusted estimates of Seber (1982) are presented. Goodness-of-fit (Pollock et al., 1985) $\chi^2 = 3.74$, 6 df, $P = 0.71$.

Estimates of population size ranged from 29 to 63 breeding females, and recruitment estimates varied from 10 to 37 individuals (Hepp et al., in prep). Annual survival rate averaged 0.57 and ranged from 0.41 to 0.71. Mean estimated survival of hen wood ducks from this study (Hepp et al., in prep) did not differ significantly ($z=1.82$; $\underline{P}=0.07$) from average survival rate (0.52) of adult female wood ducks in the southeastern United States (1973-1983) calculated from band recovery data. The philopatric nature of the wood duck hens on the SRP was documented, such that surviving hens had a high probability of returning and being captured again in the nest boxes (Hepp et al., in prep).

3.3.8) Results of the Mitigation Program

The success of the program to mitigate the loss of wood duck nesting habitat in the Steel Creek drainage has not been fully evaluated. In general, the expansion in the number of nest box lines in 1983 did dramatically increase the duckling production in this area. From 1981 to 1985, the number of wood duck ducklings hatched out in the Steel Creek nest box lines increased from 90 to 269 birds (Figure 61). A peak of 341 ducklings was observed in 1984. Excluding unforseen factors, e.g., an increase in the predation rate or an extremely low annual rainfall, this increased level of productivity should be maintained within this system. However, the ultimate success of this program should not be measured by the number of ducklings produced each season. Rather, it should be evaluated in terms of the number of

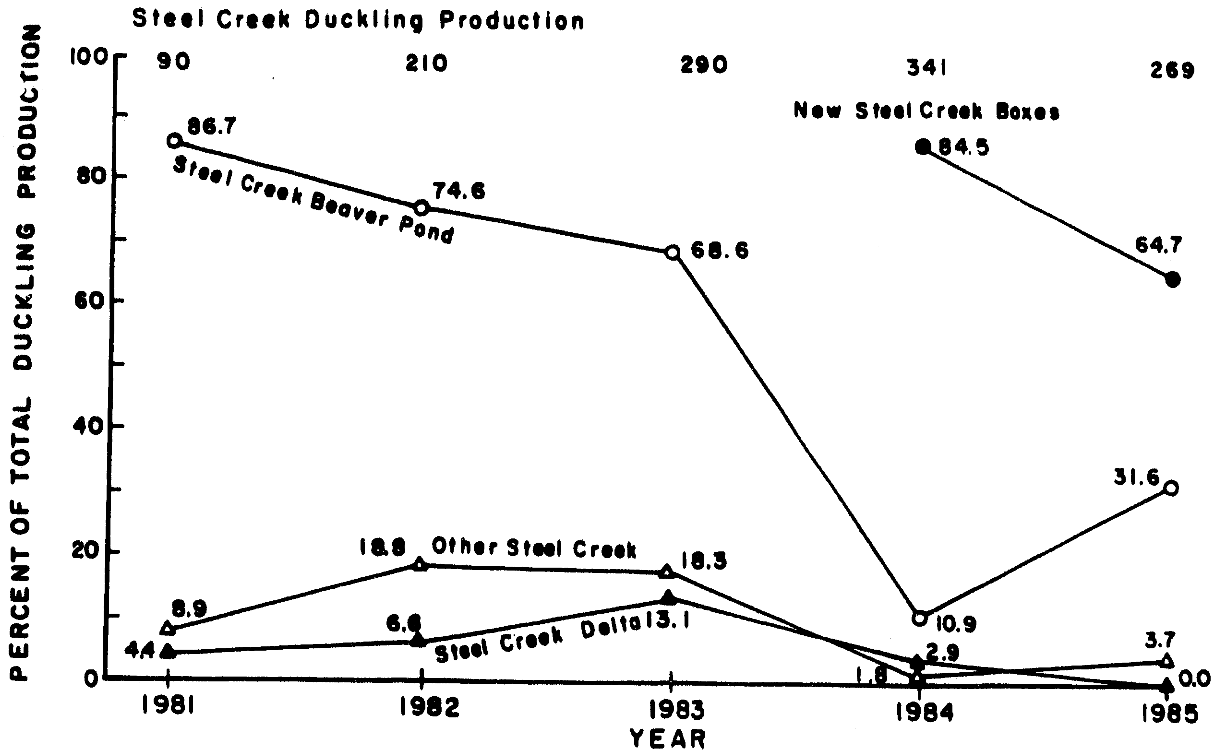

FIGURE 61. Comparison of the percent of total wood duck duckling production in the Steel Creek nest box lines. Percentage is divided among the Steel Creek beaver pond, new Steel Creek boxes, Steel Creek delta, and other Steel Creek lines.

ducklings which survive long enough to be recruited into the reproductive component of the wood duck population in the Steel Creek drainage.

Age specific mortality rates within wood ducks are highest between the time of hatching and about six weeks of age (Bellrose, 1980). Within that time period, mortality rates are highest in the first few days of life and decrease to the flight stage (Bellrose, 1980). Approximately 50 percent of the ducklings survive to reach the flight stage (Grice and Rogers, 1965). This mortality rate ranges from 22 to 66 percent depending upon when in the nesting season the ducklings are hatched (Grice and Rogers, 1965). Brood size apparently has no effect on the survival rate of wood duck ducklings (Heusmann, 1972). Therefore, the period of brood rearing by the hen is the stage of duckling development which has the most impact upon determining how many of these individuals reach maturity. This then would also be the period of development which would have the greatest impact on the overall success of the mitigation program.

Critical brood rearing habitat is essential for wood duck brood prosperity and reduced mortality rates in ducklings less than six weeks of age (Bellrose, 1980). Waterfowl critical brood rearing habitat is generally characterized by having both sufficient cover and abundant food resources. In wood ducks, brood rearing habitat cover consists of aquatic areas which are dominated by overhanging wooded vegetation (Bellrose, 1980). Floral species typically associated with this type of habitat and cover are willows (<u>Salix</u> spp.), buttonbush (<u>Cephalanthus occidentalis</u> and swamp privet (<u>Forestiera acuminata</u>) (Bellrose, 1980). The early diet in wood ducks is composed mostly of animal material. This consists mainly of adult and larval aquatic insect species (Bellrose, 1980). The remainder is made up of larval fish. Foraging for the animal component of the diet normally occurs in water less than one and one-half meters in depth. About 15 percent of the duckling's diet is composed of plant matter. Seeds of pondweed are most frequently cited as making up this portion of the diet (Bellrose, 1980).

Areas of the Steel Creek drainage which would exhibit these characteristics would include stream margins within the drainage corridor, the Steel Creek beaver pond, the shallowly flooded deltaic fan, and the margins of the islands in the deepwater portions of the delta. Several of the mitigation sites adjacent to the Steel Creek corridor do not exhibit these habitat characteristics. Hens nesting in these areas would have to move their broods overland to the corridor or delta to find suitable brood rearing habitat. This is not an uncommon behavior in this species. Wood duck hens have been known to lead their broods up to 11.6 km overland from the nest site to reach habitat suitable for brood rearing (Ball, 1973). Since the Steel Creek corridor and delta are the only suitable brood rearing habitat in this drainage, these areas are critical for the success of the mitigation program. To date, however, the impact of the restart of L Reactor on those habitat characteristics which are necesary for critical brood rearing habitat have not been fully assessed.

4) RADIONUCLIDE AND MERCURY CONTAMINATION OF WATERFOWL

4.1) Introduction

One of the principal concerns with the migratory and locally resident waterfowl of the SRP is the contaminant accumulation by these organisms during the time period in which they are present on the site. Because these species are harvested during the fall waterfowl hunting season and many of these birds are either migrating from or locally leaving the SRP during daily foraging flights in the fall, the possibility exists for an on-site contaminated bird to be collected and eaten by a human. The magnitude of this problem is not well understood at this time. Radiocesium and mercury uptake by waterfowl has been documented on the SRP (Marter, 1970; Brisbin et al., 1973; Fendley et al., 1977; Fendley, 1978; Clay et al., 1979). However, the probability of an individual bird with a high contaminant body burden being harvested and consumed is unknown at present.

4.2) Radionuclide Uptake by Waterfowl

4.2.1) Review of Previous Studies

In a discussion of the radiocesium contamination of the Steel Creek drainage, Marter (1970) reported a few Cs-137 concentrations for SRP waterfowl. A green-winged teal from Par Pond was found to have a body burden of 171 pCi/g body weight. Marter (1970) stated that this was a higher concentration than was normally found at that site, noting that the 1969 Par Pond ring-necked duck sample averaged 6.0 pCi/g Cs-137 and had a maximum concentration of 19.0 pCi/g. Marter (1970) also reported that a wood duck collected approximately 500 yards below SRP Road B on March 16, 1970, had a Cs-137 body burden of 923 pCi/g live weight. This figure remains the highest Cs-137 body burden reported for any waterfowl species from this site. In addition, duck muscle from the 1970 sample also contain detectable levels of Zn-65, Sr-89, Sr-90, tritium, Cs-134, Ru-103, Ru-106, Ce-141, and Ce-144 (Marter, 1970).

Brisbin et al. (1973) studied the accumulation and redistribution of radiocesium by waterfowl inhabiting Par Pond. Changes in whole-body burdens of radiocesium were studied in monthly samples of American coots and nine other species of migratory waterfowl wintering on the PPRS. In October, newly-arrived coots averaged between 4-8 pCi radiocesium/g live weight and approximately a 50-50 sex ratio. Between October and Janaury , the sex ratio of the coots rose steadily to a maximum of 87 percent males as the females moved to more southerly wintering grounds. In the predominately male population remaining on the reservoir, radiocesium body burdens continued to rise at a rate of approximately 2-3 pCi/g per bird per month, to a maximum of between 15-20 pCi/g. From February through April the predominately male population of coots began to leave for northern breeding grounds and were apparently replaced by populations that had wintered further south and consisted of a higher percentage of females. As a result, the sex ratio began to decline until it once again approximated 50-50 in the late spring. Birds not wintering on Par Pond had low radiocesium counts, thus the average body burden of the coot population began to decline to a level approximating that of the first birds to arrive in the fall. In any given month the radiocesium content of the coots was generally higher than that of any of nine other species of waterfowl and aquatic birds sampled. Brisbin et al. (1973) believed the higher body burdens of the coots may be related to their tendency to rely heavily upon submerged aquatic plants as a food resource. Migratory waterfowl may remove up to 3.75 x 10(-5) Ci of radiocesium from Par Pond each year and redistribute it elsewhere along their migratory pathways.

Brisbin and Swinebroad (1975) made reference to the advantages of bird banding studies with regard to evaluating potential environmental impacts resulting from contamination levels of pesticides, heavy metals and radionuclides.

Pinder and Smith (1975) used coots and crows (Corvus brachychynochos) from Par Pond to evaluate frequency distribution of radiocesium to normal, log-normal, exponential, and Weibull distributions. Frequency distributions of radiocesium (primarily 137Cs) concentrations in 33 samples were investigated in soils, plants and animals. The log-normal and Weibull distributions showed close agreement to many of the samples, but the normal and exponential distributions showed close agreement to relatively few of the samples. More of the distributions were highly skewed in plants but tended to be less skewed in animals.

As part of a doctoral dissertation on the ecology of the wood ducks of Steel Creek, Fendley (1978) gathered data on the seasonal radiocesium body burdens, and radiocesium uptake and elimination rates. The objectives of this study were to determine: 1) rates of radiocesium accumulation for free-living uncontaminated wood ducks released into contaminated habitat; and 2) radiocesium elimination rates of naturally contaminated wood ducks under penned conditions. The accumulation rates were studied in hand-reared birds which were released into an enclosed portion of the Steel Creek drainage which had been contaminated with 267 curies of radiocesium (Fendley et al., 1977). The uptake of radiocesium/g live body weight=0.36+0.18 (days). There was no effect of sex on the uptake rate. The average estimated time required to attain practical equilibrium was 17.3 days, with a range from 10.2 to 28.6 days. Ducks which were recaptured after attaining equilibrium concentrations in the field showed single-component elimination-rate curves when confined in a semi-natural pen for elimination studies. Radiocesium elimination under penned conditions was described as: in percent initial body burden = 4.60-0.13 (days). Elimination-rate and body weight showed a negative linear correlation for the penned birds although there was no effect of sex on loss-rate. Radiocesium biological half-times for the penned birds averaged 5.6 days with a range from 3.2 to 9.3 days. Calculations based on biological half-times determined from studies with the penned ducks, were successful in accurately predicting both the levels and rates of radiocesium accumulation by free-living birds in the field (Fendley et al., 1977).

4.2.2) 1985 Results of Waterfowl Sampling for Radiocesium

Between January 23, 1985 and February 24, 1985, 82 waterfowl specimens aquatic birds were collected from wetland sites on the SRP and were analyzed by gama spectroscopy for radiocesium body burdens.

The sites included Par Pond (70 birds), Steel Creek delta (4 birds), and Pond B (8 birds). The collections on Par Pond were made entirely during a four-day period (2/7 to 2/10). Collecting at the remaining two sites was scattered over the 30-day period. The level of contamination in these birds was determined using a sodium iodide crystal counter for 10,000 sec., with a minimum detectable limit of 0.02 pCi/g.

The average and maximum concentrations detected for all samples collected were 1.4 and 16.0 pCi/g respectively. The results by species and location for the Par Pond sample are given in Table 21. As determined earlier by Brisbin et al. (1973), this current sample revealed that American coots had the highest average (1.30 pCi/g) and maximum (2.20 pCi/g) concentrations for this impoundment (Figure 62). This difference was also found to be significant at the 0.001 level ($F=8.81$) using log transformed figures in order to normally distribute the data. In addition, the frequency distribution of Cs-137 concentrations in these birds showed a Weibull distribution (Figure 62) as predicted by Pinder and Smith (1975). Within the coot sample, the birds from North Arm were found to be significantly ($\underline{P} < 0.05$; $F=4.59$) more contaminated than the coots from either West Arm or Hot Arm. Again, the same conclusion was reached by Brisbin et al. (1973) in the early 1970s.

The average species body burdens for birds sampled on Pond B were: ruddy ducks-0.93 pCi/g ($N=6$) and bufflehead-15.05 pCi/g ($N=2$). The maximum concentration (16.0 pCi/g) from this location, and in fact, for the overall sample, was in a bufflehead.

The Steel Creek bird mean concentrations were: wood ducks-0.66 pCi/g ($N=3$) and mallards-1.50 pCi/g ($N=1$). The maximum in this sub-

Table 21. Average radiocesium body burden (in pCi/g body wt.) of waterfowl species collected on Par Pond in 1984-1985. Sample sizes are in parentheses. Waterfowl species abbreviations are: lesser scaup - LS; ring-necked duck - RN; ruddy duck - RD; bufflehead - BH; American coot - CT; horned grebe - HG.

General Area Specific Locality	Waterfowl Species						Locality Mean
	LS	RN	RD	BH	CT	HG	
North Arm							
Little Lake	-	-	-	-	1.65(2)	-	1.65(2)
North Arm	-	-	-	-	1.25(2)	-	1.25(2)
N. Dave's Lake	-	-	0.60(2)	-	1.73(3)	-	1.28(5)
S. Dave's Lake	-	-	-	1.30(1)	-	-	1.30(1)
Erin's Elbow	-	-	-	-	1.65(2)	-	1.65(2)
Calahan Slough	-	-	-	-	1.40(1)	0.97(1)	1.19(2)
East Lake							
Susan's Swamp	-	-	0.21(1)	1.00(1)	-	-	0.61(2)
Gus's Swamp	-	1.20(1)	-	-	-	1.30(1)	1.25(2)
Fairman's Landing	-	0.88(1)	-	-	-	-	0.88(1)
Nancy's Nook	-	-	0.54(1)	-	-	-	0.54(1)
Big Lake							
Cold Dam	0.63(1)	-	0.45(2)	-	-	0.49(1)	0.50(4)
Peggy's Point	-	-	-	-	-	1.10(1)	1.10(1)
West Arm							
Gentry's Gulf	-	-	0.72(3)	0.96(4)	0.92(2)	-	0.87(9)
Jack's Bay	-	-	-	1.30(1)	-	0.71(2)	0.90(3)
Barbara's Landing	-	-	-	1.60(1)	-	-	1.60(1)
Dayton's Landing	-	-	-	-	1.35(8)	-	1.35(8)
Fran's Inlet	0.91(1)	-	-	-	-	-	0.91(1)
Hot Arm							
Carol's Bay	0.92(6)	0.77(2)	-	1.30(1)	-	-	0.93(9)
Jim's Junt	-	-	-	-	1.00(6)	-	1.00(6)
Coleman's Cove	-	-	-	-	1.05(4)	-	1.05(4)
Hot Dam	1.40(1)	-	-	-	1.90(1)	-	1.65(2)
Beyer's Bay	-	0.93(1)	-	-	-	-	0.93(1)
Rosemary's Bay	1.70(1)	-	-	-	-	-	1.70(1)
Species Means	1.02(1)	0.91(5)	0.63(9)	1.15(9)	1.30(31)	0.88(6)	-

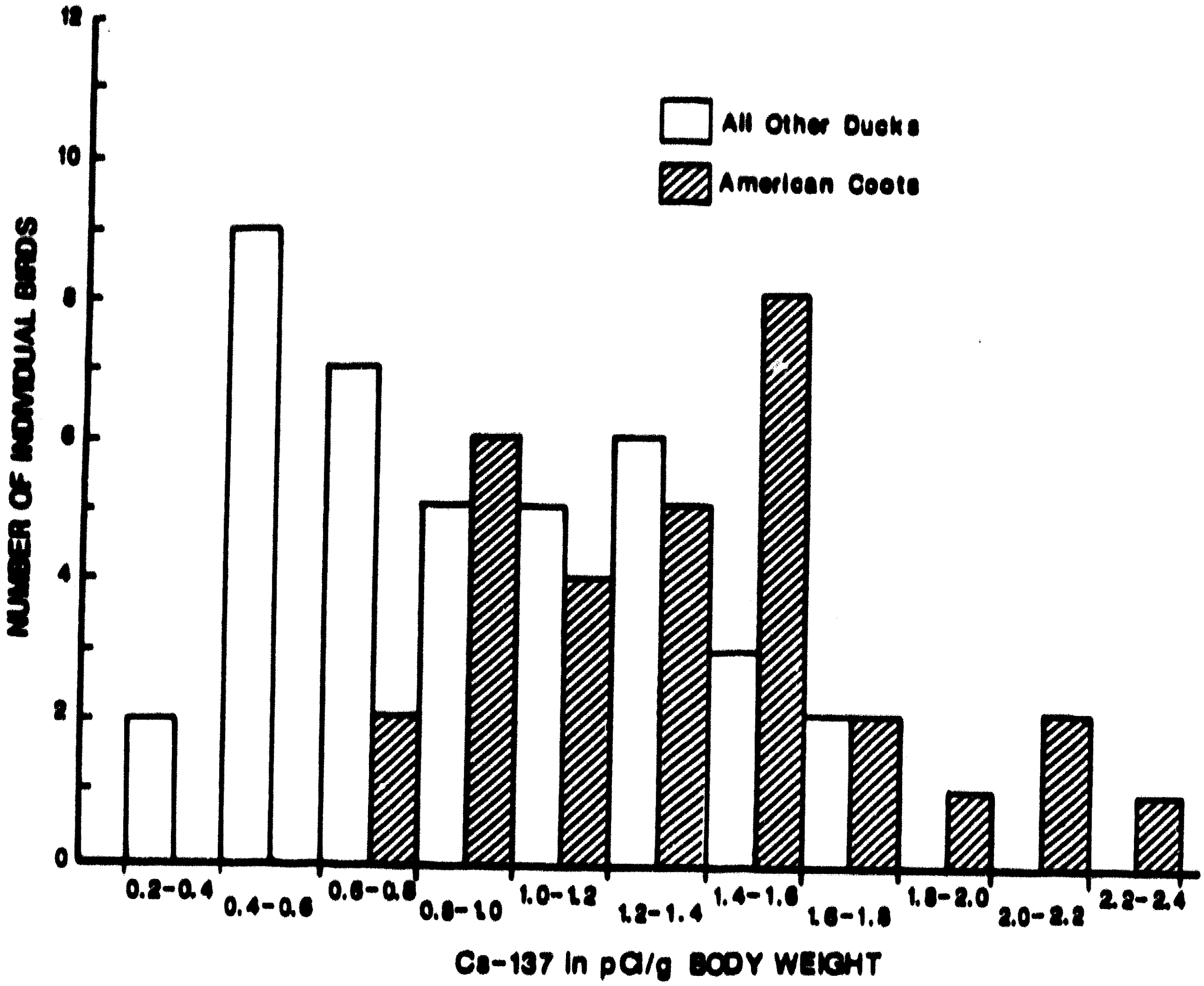

FIGURE 62. Frequency distribution of radiocesium body burdens of American coots compared to all other ducks on Par Pond in the 1985 sample.

sample was a wood duck with a concentration of 1.80 pCi/g.

Concentrations of radiocesium from the 1985 sample were found to be within the range of levels reported for previous years (Marter, 1970; Brisbin et al., 1973). The levels detected in the 1985 sample are well below that which would suggest a health hazard for persons who may shoot and eat these birds as food (Jenkins and Fendley, 1968; Brisbin et al., 1973).

4.3) Mercury Uptake by Waterfowl

Mercury contamination levels were studied by Clay et al. (1979) in several species of waterfowl wintering on Par Pond. Samples from 177 American coots indicated that this species, which is largely vegetarian on its wintering grounds, had significantly lower levels of mercury accumulation than did four other aquatic bird species which are more carnivorous in their food habits. Coot feathers had the highest frequency (88.1 percent) of detectable levels of mercury, while gut contents had the lowest (0.2 percent). Mercury in coot feather samples was not affected by month of collection or location within the reservoir. The highest frequency of mercury in breast muscle occurred in the first birds to arrive in early fall. Frequencies of mercury contaminiation in breast muscle then tended to decline generally throughout the remainder of the fall, winter and spring. Radiocesium cycling patterns were useful in interpreting monthly changes in mercury contamination of Par Pond coots, despite differences in both temporal and spatial cycling patterns of these contaminants in the resident waterfowl community (Clay et al., 1979).

5) FUTURE OF WATERFOWL ON THE SRP

With the continued drainage of wetlands in the plains region of western Canada and the United States, continential waterfowl numbers are likely to continue to decrease because of reduced productivity and recruitment each year. Waterfowl numbers on the SRP will probably reflect these declines, but not to the extent as will be observed in other wintering areas in the Southeast. This is because of the almost nonexistent human disturbance of the wintering waterfowl found on the site. Reduced disturbance allows the wetland areas of the SRP to serve as a refuge for these birds.

The completion of L-Lake has provided yet an additional large impoundment for wintering waterfowl on the SRP. During the first wintering season in which L-Lake was in existence, 12 species of waterfowl have been observed using that cooling reservoir. These included lesser scaup, bufflehead, ring-necked ducks, ruddy ducks, Canada geese, canvasback, blue-winged teal, wood duck, redhead, common moorhen, American coots, and pied-billed grebes. Flocks of ring-necked ducks as large as 300+ have already been counted on L-Lake. American coots and Canada geese are already foraging around L-Lake, the American coots on the vegetation in the littoral zone and both species on the planted areas adjacent to the shore. In addition, the large flocks of ring-necked ducks were observed to be diving extensively (presumably foraging) around the L-Reactor inflow cove of L-Lake. As other aquatic floral species and invertebrate faunas increase in this system, waterfowl use will likely increase and become more diversified. No decrease in the use of the PPRS has been noted in conjunction with the initial use of L-Lake. If this trend continues, the waterfowl use of the SRP will unquestionably increase as a result of the increase in the suitable wintering habitat provided by L-Lake.

The effects of the restart of L-Reactor on the wood duck nesting in the Steel Creek drainage are currently being determined through the nest box survey being conducted post-restart in 1986 and again in 1987. With the reduced temperatures of the reactor effluent created by L-Lake, increased water temperatures in the nesting sites does not appear to be a problem at this time. Increased flow rates and the resulting greater water depths, however, have been realized with the restart. The impacts of these factors have yet to be assessed. Potential negative impacts of increased flow rates on the SRP waterfowl would be in the destruction of plant forage and cover species in the Steel Creek delta and corridor. If the sole result of the restart is only the already observed increased water depths in the delta and corridor, it is possible that there will be no negative impact on the nest initiation by wood duck hens in that drainage. However, this could affect the available brood rearing habitat. In addition, the loss of nesting habitat in the Steel Creek system may be mitigated by the eventual accessibility to new nesting habitat created in the deltas of Pen Branch and Four-Mile Creek as result of reduced temperatures of the thermal effluent from C-Reactor and K-Reactor with mitigation efforts in those drainages. During the interim, additional nest box mitigation sites may have to be erected adjacent to the Steel Creek corridor.

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