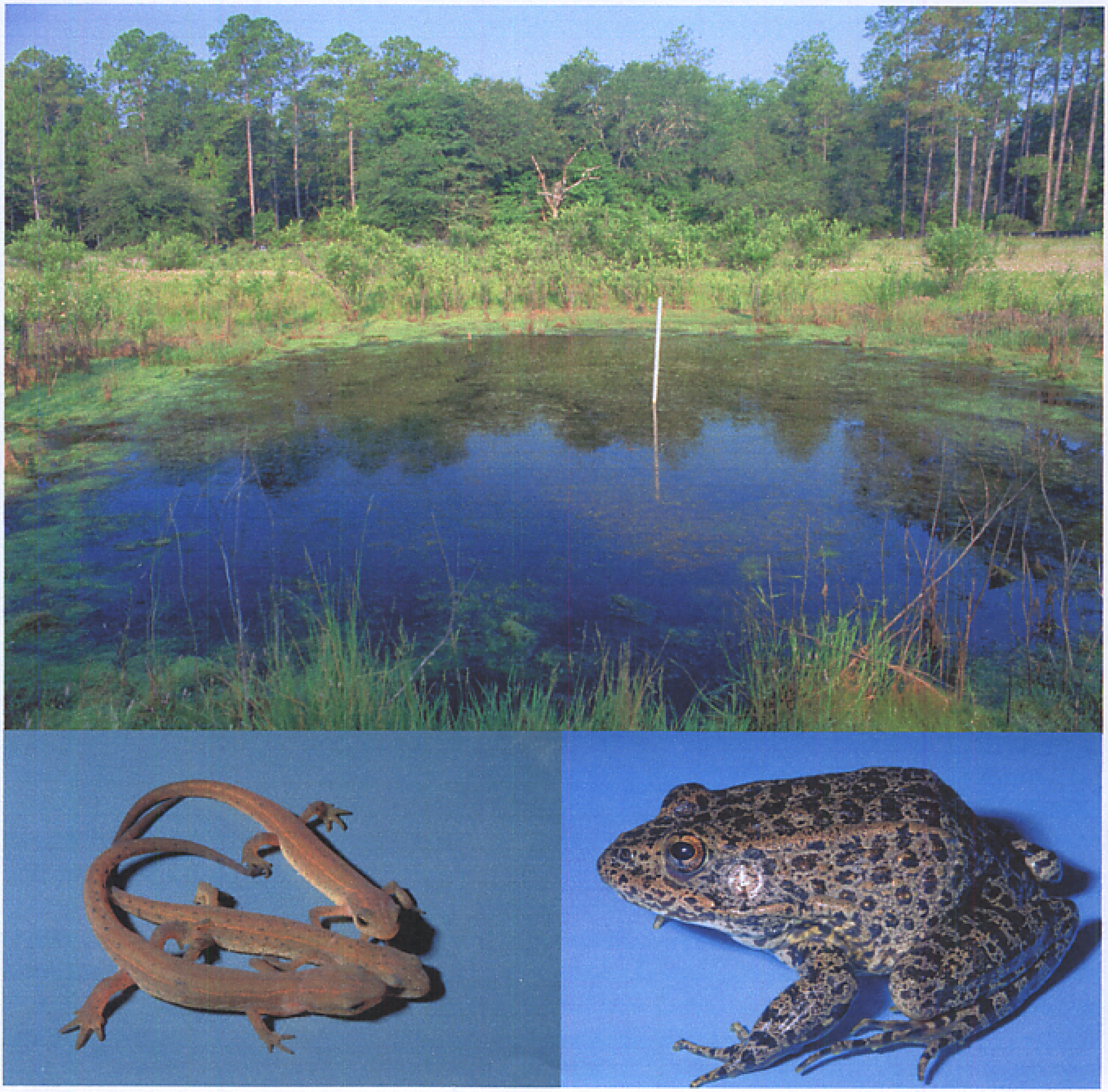
Reducing Impacts on Rare Vertebrates that Require Small Isolated Water Bodies along U. S. Highway 319

FINAL REPORT

to the Florida Department of Transportation for Contract No. BB-278
by D. Bruce Means, Ph. D., Department of Biological Science, Florida State University
and Coastal Plains Institute and Land Conservancy, 1313 N. Duval Street, Tallahassee, FL 32303

September 2001



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Executive Summary

A long-term, multi-faceted study was conducted on the life history and ecology of two candidate species for federal threatened status, the striped newt (*Notophthamus perstriatus*) and gopher frog (*Rana capito*), in southern Leon County, Florida from 1993-2001. This report presents the overall findings of that research, with special emphasis on the period 1997-2001 when the project was funded by the Florida Department of Transportation. The bulk of the research was apportioned among three separate field studies: 1) dipnetting and seining 265 ponds for the presence of the striped newt, gopher frog, and other species in the small natural area (Woodville Karst Plain) that serves as an important refuge in the global ranges of the species; 2) studying the hydrology and biology of a sample of 25 ponds representing the full range of ecological conditions of the ponds in the region; and 3) monitoring for both species the seasonal and long-term use of an important breeding pond (Study Pond #1) that lies adjacent to U. S. Highway 319.

Results from all these efforts have provided the following information and conclusions. A total of 265 ponds in the Woodville Karst Plain were sampled over the six-year period of this overall study, from September 1995 - September 2001. Altogether this study has recorded either adults or larvae of the striped newt from 20 (7.5%) ponds and adults or tadpoles of the gopher frog from 40 (15.1%) ponds. The presence of adults is not certain evidence that a pond is used for breeding by a species, so only 9 ponds were proven as breeding ponds for the striped newt (presence of larvae), but all 40 ponds in which the gopher frog was found contained gopher frog tadpoles.

Over a three-year period (1994-1997) during favorable breeding conditions, a special survey of 245 ponds was conducted throughout the Woodville Karst Plain. The survey found adults and/or larvae of the striped newt in only 17 of 160 (10.6%) ponds on the Apalachicola National Forest whereas no striped newts were found in 85 ponds (0.0%) on private paper company lands, also in the Woodville Karst Plain. Adults and/or tadpoles of the gopher frog were discovered in 26 of 160 (16.3%) ponds on the Apalachicola National Forest but in only 1 of 85 (1.2%) ponds on private paper company lands. Historical records indicate that both species had been more abundant in ponds on paper company lands in the past. The ecological quality of the upland habitat surrounding breeding ponds is as important in the survival of local populations as is the breeding pond, itself. Certain types of silvicultural practices are harmful to these species.

A three-year (1998 - 2001) study of 25 ponds selected to represent a range of different hydrological and biological types in the Woodville Karst Plain revealed four basic types of ponds. Type 1 had such short hydroperiods (water for only a few months once per five years) that no striped newt breeding was recorded in them, and very little other breeding of amphibians. Type 2 was the set of solution collapse ponds that connected to the permanent waters of the Floridin Aquifer and also were unsuitable for most amphibians. Type 3 ponds were more-or-less permanent, had robust stocks of different species of fish, and were not striped newt breeding ponds, although a few were found to have produced gopher frog metamorphs in some years. Type 4 is the set of ponds with modest hydroperiods of a few months to a few years, going dry often enough to eliminate fish that might periodically colonize them. It is the type 4 ponds in which all the breeding activity of the striped newt was recorded, and most of the breeding activity of the gopher frog.

An 1100-foot long drift fence completely surrounding Study Pond #1 was checked three times a week for six years, and the pond was dipnetted regularly to record the presence of life history stages and measure the growth of larvae. Twenty-seven species of vertebrates (4 salamanders, 15 frogs, 5 turtles, 3 snakes) were recorded using Study Pond #1 for breeding, feeding, or habitat. Pond #1 contained water continuously during years 1 - 4 but went dry for 16 months in 1999 - 2000, and again during newt breeding season in the winter of 2001. Successful breeding (emergence of metamorphs) by the striped newt occurred in years 1, 3, and 4 and by the gopher frog only once, in year 4, following heavy rains in October.

Adults of the striped newt migrated into Pond #1 from September to April, with the main movements in December and January. Eggs are laid in December through February and hatchlings first appear in early April. Growth of larvae was reported for six years, 1973 and 1993-1997. Two out-migrations of striped newt metamorphs took place in years 1 and 3, the first in the autumn from September to February and the second in midsummer from June to August. Following the breeding activity in year one, no efts emerged from the pond in year two although there was water in the pond, indicating that something killed off that year's reproductive effort. One huge emigration of metamorphs occurred in year 4 from September to April. No efts were caught in our drift fence drop buckets in years 5 and 6, during the long-term drought. Altogether over a six-year period, there were five emergences of striped newt metamorphs, in three of the six years.

Management recommendations are to maintain the ecological quality of all breeding ponds in the small Munson Sandhills area, especially to keep out fishes that are often introduced into ponds deliberately by fishermen, and to avoid pollution, infilling, and other disturbances to water quality and the physical pond integrity. The upland habitats surrounding ponds in the Munson Sandhills should also be maintained in the native longleaf pine-wiregrass ecosystem, and a proper fire regime that benefits the animals that live in longleaf pine forests should be determined and instituted. Because breeding ponds are highly ephemeral and local extinction is more probable than for most animals, dispersal among breeding ponds is a critical component of the survival of local populations. Management for the striped newt and its associates, therefore, should be directed at the metapopulational level. In other words, the whole region with all its ponds should be managed in such a way that animals can easily disperse among the ponds through the longleaf forests. The survival of the striped newt, for example, cannot be accomplished by a strict management focus on several ponds but on the entire suite of ponds and intervening habitat.

Any future alterations of US Highway 319 that can facilitate the migration and dispersal of the striped newt, gopher frog, and their associates across the right-of-way and reduce highway mortality on these species will be very helpful in the long-term survival of these species.

Introduction

The Munson Sandhills and Woodville Karst Plain are adjacent small physiographic regions in the Gulf Coastal Lowlands of Leon and Wakulla counties, Florida (Hendry and Sproul 1966, Swanson et al. 1992). Characterized by deep sands of varying depth (0-15 m) overlying St. Marks Formation limestones (Puri and Vernon 1955), both regions are densely pocked with sinkholes and limesink depressions (Fig. 1). Water stands in most sinkholes and limesink depressions for varying periods of time from dozens of years to less than a few weeks every five years. Permanent water usually supports high biotic diversity including invertebrates and fish. On the other hand, small isolated water bodies with hydroperiods less than one year long, called temporary or ephemeral ponds, are critical habitat for an amazingly rich fauna including hundreds of species of invertebrates and dozens of vertebrate animals (Moler and Franz 1987, Means 1990, Means 1996b). Temporary ponds are highly rich in species in spite of their short hydroperiods and lack of fish. Many of the vertebrates using temporary ponds are extremely vulnerable to fish predation and have become specially adapted for ponds without fish.

Sporadic monitoring of the biology and hydrology of temporary ponds in the Munson Sandhills began about 1967 (Means 1996b). In 1993 the U. S. Forest Service and U. S. Fish and Wildlife Service funded a survey of rare vertebrates utilizing 100 ponds in Leon and Wakulla counties (Means et al. 1994a, b). This was followed by a one-year Cooperative Agreement between the U. S. Forest Service and Coastal Plains Institute to begin a study of the use of a temporary pond (Study Pond #1; see Fig . 1) by two candidate species for federal listing, the striped newt (*Notophthalmus perstriatus*) and the gopher frog (*Rana capito*).

Results of these preliminary studies indicated that 1) about half (17 of 32) of the known breeding ponds in the global distribution of the striped newt are found in the Munson Sandhills (Franz and Smith 1999), and Study Pond #1 supports one of the more robust populations (Means et al. 1994a, b); 2) the Munson Sandhills is one of the few areas in panhandle Florida known to support the gopher frog, and Study Pond #1 is a breeding pond of this species (Means 1999); 3) altogether 27 species of amphibians and reptiles have been documented to use and be dependent upon Study Pond #1 in their life cycles, out of a total of about 46 species that are associated with temporary ponds throughout the southeastern U. S. Coastal Plain (Table 1).

The rare striped newt (Christman and Means 1992), which has one of the most complex life cycles of any amphibian, breeds in Study Pond #1. Sexually mature adults migrate from the surrounding uplands to the pond for breeding purposes in mid-winter, November-February. Courtship, copulation, and egg- laying take place from January to April and eggs hatch beginning about mid-April. Externally gilled larvae grow in the temporary pond environment for several months until the pond dries in mid-summer. There is evidence that small larvae can metamorphose by at least three months of age, at which time they lose their external gills, develop lungs

Figure 1. Map of Study Area in Munson Sandhills of the Woodville Karst Plain. Ponds on the west side of Florida Road #363 are on the Apalachicola National Forest; those on the east side are on private timber company lands. Star = Study Pond #1; + = Drift Fence D.

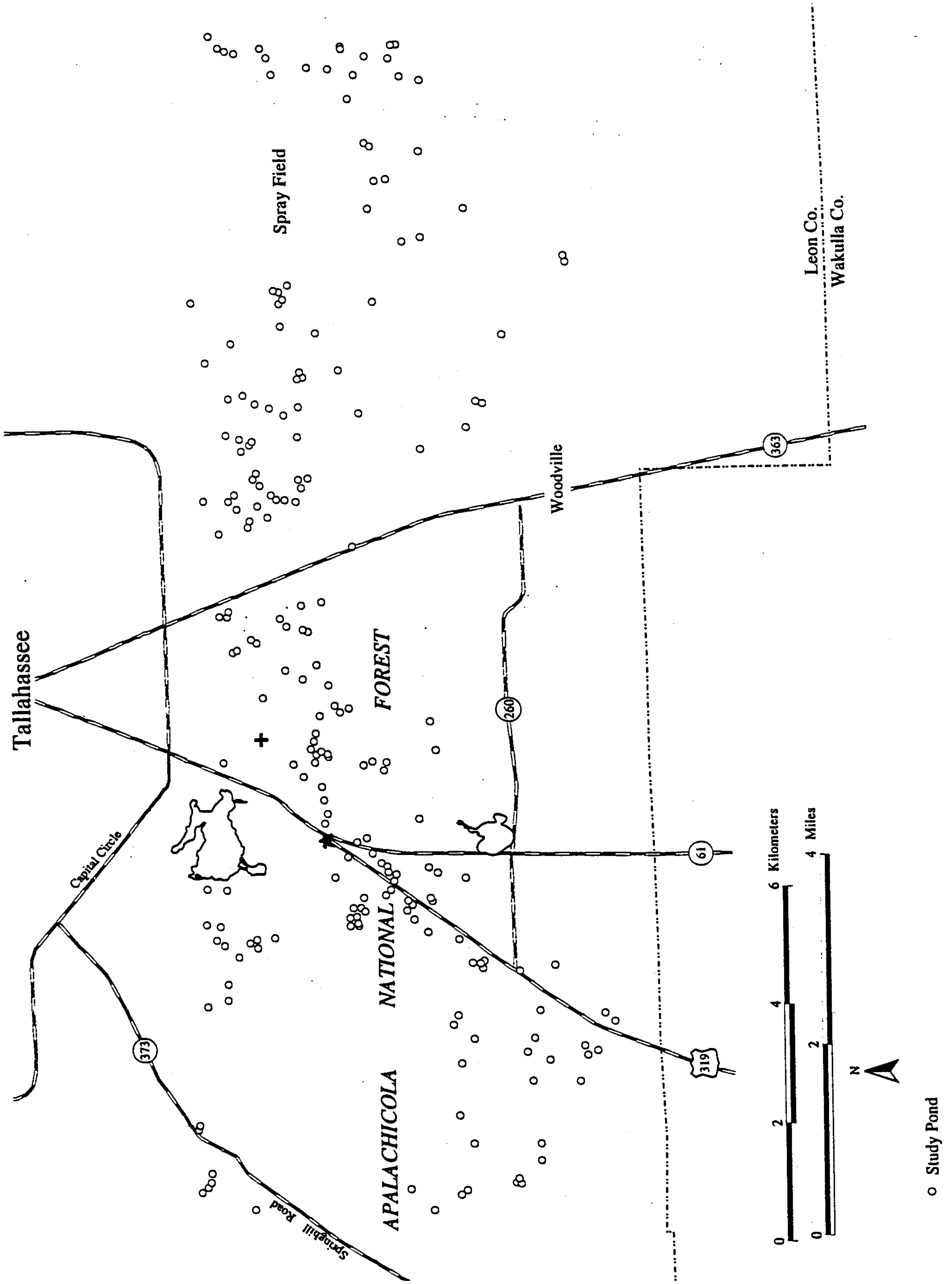

Table 1. Temporary pond-inhabiting amphibians and reptiles in the Southeastern U. S. Coastal Plain. x = uses temporary ponds exclusively; + = uses temporary ponds but also other types of wetlands; o = using Study Pond #1 along US Hwy 319.

Species	Category
SALAMANDERS	
Flatwoods salamander (*Ambystoma cingulatum*)	x
Mabee's salamander (*Ambystoma mabeei*)	x
Small-mouthed salamander (*Ambystoma texanum*)	x
Striped newt (*Notophthalmus perstriatus*)	x, o
Spotted salamander (*Ambystoma maculatum*)	+
Marbled salamander (*Ambystoma opacum*)	+
Mole salamander (*Ambystoma talpoideum*)	+, o
Tiger salamander (*Ambystoma tigrinum*)	+
Eastern newt (*Notophthalmus viridescens*)	+, o
Lesser siren (*Siren intermedia*)	+
Dwarf siren (*Pseudobranchus striatus*)	+
Two-toed amphiuma (*Amphiuma means*)	+
Dwarf salamander (*Eurycea quadridigitata*)	+, o
FROGS	
Eastern spadefoot (*Scaphiopus holbrooki*)	x, o
Oak toad (*Bufo quercicus*)	x, o
Barking tree frog (*Hyla gratiosa*)	x, o
Squirrel tree frog (*Hyla squirella*)	x, o
Pinewoods tree frog (*Hyla femoralis*)	x, o
Little grass frog (*Pseudacris ocularis*)	x, o
Ornate chorus frog (*Pseudacris ornata*)	x, o
Gopher frog (*Rana capito*)	x, o
Southern chorus frog (*Pseudacris nigrita*)	x
Eastern narrowmouth toad (*Gastrophryne carolinensis*)	+, o
Spring peeper (*Hyla crucifer*)	+, o
Southern toad (*Bufo terrestris*)	+, o
Green tree frog (*Hyla cinerea*)	+, o
Southern cricket frog (*Acris gryllus*)	+, o
Bullfrog (*Rana catesbeiana*)	+, o
Southern leopard frog (*Rana utricularia*)	+, o
Gray tree frog (*Hyla chrysoscelis*)	+
Bronze frog (*Rana clamitans*)	+
Pig frog (*Rana grylio*)	+
Carpenter frog (*Rana virgatipes*)	+
Upland chorus frog (*Pseudacris triseriata*)	+
River swamp frog (*Rana heckscheri*)	+
TURTLES	
Chicken turtle (*Dierochelys reticularia*)	x, o
Mud turtle (*Kinosternon subrubrum*)	+, o
Stinkpot (*Sternotherus odoratus*)	+, o
Pond slider (*Trachemys scripta)*	+, o
Cooter (*Pseudemys floridana*)	+, o
Eastern softshell turtle (*Apalone ferox*)	+
Snapping turtle (*Chelydra serpentina*)	+
SNAKES	
Banded water snake (*Nerodia fasciata*)	+, o
Garter snake (*Thamnophis sirtalis*)	+, o
Swamp snake (*Seminatrix pygaea*)	+, o
Cottonmouth (*Agkistrodon piscovorus*)	+

for air-breathing, and become a relatively dry-skinned animal called an eft. The eft stage is adapted for life in the longleaf pine-wiregrass forest of the adjacent hot and dry sandhills.

After living as an eft in the uplands for an unknown period of time, possibly for as long as a decade, individuals return to the pond to breed and undergo a partial second metamorphosis. There they develop fins on their tail and hind limbs to assist in swimming and courtship and take up a life in the water again, but at this time in their life they must come to the water's surface to gulp air into their lungs. The life cycle is completed when they court and produce viable eggs. This is not the complete life story, however. In times when Study Pond #1 has retained water all year long, the larvae bypass the eft stage and remain in the pond until the next breeding season when some individuals become sexually mature as gilled larvae. Retention of larval characteristics when sexually mature in salamanders is known as neoteny. The neotenes, as they are called, complete the life cycle without ever leaving the pond. It is assumed that the post-breeding neotenes and post-breeding lunged adults return to the uplands again to live through additional breeding cycles, but is not known whether they metamorphose back into the eft morphology again. The striped newt has survived in captivity as an aquatic adult for 12-15 years (Grogan and Bystrak 1973), although such a long aquatic life probably rarely, if ever, occurs in nature.

Almost nothing is known about the terrestrial life of the striped newt. In order to effectively assess the population status of this species, important life history and ecology information is needed, such as 1) distances dispersed away from the breeding pond; 2) types of upland habitats preferred; 3) longevity in the terrestrial phase of its life; 4) breeding site fidelity; 5) whether adults metamorphose back into efts and continue the cycle again; 6) sensitivity to human impacts on uplands; 7) vulnerability to habitat fragmentation by roads; and 8) effects of highway mortality on population size, to name but a few.

Study Pond #1 is also important to the gopher frog, *Rana capito*, a rare species (Franz and Smith 1999) and another candidate for federal listing. Like the striped newt, the gopher frog is a long-lived animal (5-10 years) but has a wider range in the Florida panhandle, although restricted to sandhills habitats. It has a complex amphibian life cycle involving a tadpole larval stage in temporary breeding ponds and a terrestrial stage as a frog in the dry upland habitats of sandhills. Its upland habitat preferences are reasonably well known as longleaf pine/wiregrass/turkey oak forest (Godley 1992). It utilizes burrows of the gopher tortoise for daytime retreat from predators and desiccation, and it also uses the burrows of other animals and especially stumpholes (Means 2001).

The gopher frog breeds in temporary ponds when these fill with heavy rains in winter, usually December-March, but breeding may take place in any month. Tadpoles are found in ponds through late spring when they metamorphose and disperse from ponds in May and June. Individuals are capable of moving over relatively long distances because marked gopher frogs were recovered up to two kilometers away from breeding ponds in north central Florida (Franz et al. 1988), but nothing is known about breeding site fidelity in this species. Habitat quality and fragmentation, and impacts from roads all potentially affect successful dispersal in this species because of the long distances involved.

In addition to the two federally sensitive species, 25 other amphibians and reptiles have been documented to utilize Study Pond #1 (see Table 1). Among them are five species of aquatic turtles, all of which migrate out of the pond during nesting season when the females of each species must lay eggs in the terrestrial environment. Later, hatchlings must make their way overland to the pond. Additionally, when the pond dries, all these species migrate through the adjacent uplands looking for water or taking refuge under leaf litter until rains signal the return of water in the pond (Burke and Gibbons 1995). During out- and in-migrations, aquatic turtles are vulnerable to impacts from highway mortality as they cross roads.

The nineteen other vertebrates using Study Pond #1 in their life include three other salamanders, 14 other frogs, and two snakes. All of these species emigrate from Study Pond #1 when it dries and when juveniles disperse to other ponds as part of their normal life history, yet little information exists on distances these species move, preferred habitats they move through, and their vulnerability to highway mortality.

<u>The Problem</u>.--The location of Study Pond #1 immediately adjacent to the paved, two-lane U. S. Highway 319 south of Tallahassee has been problematic for all 27 species inhabiting the pond over the years. Road-kills of nearly all the species have occurred at all times of the year (Means, personal observation). Data from drift fence monitoring of Pond #1 clearly indicate that a substantial percentage (possibly up to 50%) of the populations of most of the species move in and out of the pond along its eastern side (Means 1999), which lies adjacent to U. S. 319. These animals emigrate toward upland habitat east of U. S. 319 in which to spend their terrestrial life stages, then immigrate back across U. S. 319 to complete their life cycles by breeding in the pond.

Road-kill mortality from traffic using U. S. 319 presently is an impediment to migration in and out of Study Pond #1 influencing the population biology of all 27 species that depend upon the pond, and especially the two amphibians under consideration for federal Threatened status.

<u>Rationale for this Study</u>.--A number of separate study projects were proposed to the Florida Department of Transportation to generate sufficient knowledge to mitigate impacts on the vertebrate species using temporary ponds along U.S. Highway 319 when this highway is four-laned in the future. With a lead time of 5-7 years or more until the four-laning of U. S. 319 takes place, these studies enable interagency cooperation and

involvement in generating important information so that the appropriate environmental issues will have been addressed far in advance of road design and construction.

This report provides the results of three major studies: 1) a survey of a large sample of the ponds in the Woodville Karst Plain (n=245) in order to determine how many are utilized by the striped newt, gopher frog, and other vertebrate species; 2) a three-year study of a moderate sample (n=25) of ponds representing the full spectrum of ecological conditions of ponds in the Woodville Karst Plain (including all 17 ponds in which the striped newt has been found) in order to determine the important ecological and biological parameters associated with striped newt and gopher frog breeding ponds, and to determine where Study Pond #1 fits into the continuum; and 3) the continuation of an important biomonitoring project at a major breeding pond of the striped newt and gopher frog (Study Pond #1) to learn more about the life history and population ecology of these and other species.

Methods and Materials

Study Area.--The study area is the Munson Sandhills of the Woodville Karst Plain in the Coastal Lowlands of Wakulla and Leon counties (Puri and Vernon 1964, Wolfe, et al. 1988). It includes all the lentic habitats found in the region, ranging from relatively large (~20 ha) permanent lakes to small (0.1-0.5 ha) temporary ponds, and including small sinkholes whose hydrology is driven by perched, temporary, surficial aquifer waters as well as sinkholes fed by the permanent waters of the Floridan Aquifer. Study Pond #1 is a shallow limesink depression located on the west side of U. S. Highway 319 about 0.3 km south of its junction with Florida Road 61 in the NW1/4 of the SW1/4 of Section 35, T1S, R1W on the Apalachicola National Forest, and about 3.5 km S of the City of Tallahassee, Florida (see Means et al. 1994a).

In September 1995, an approximately 300-m long drift fence was buried on edge about 10 cm in the ground encircling Study Pond #1. The fencing was the standard black plastic silt-fence used to prevent sedimentation in wetlands during road construction, about 90 cm high and supported by 2.5 cm X 2.5 cm upright wooden rods to which it is tacked. Thirty-three pairs of twenty-liter plastic buckets were buried flush with the ground surface on each side of the fence about every 10 m. A unique number was spray painted on the fence next to each bucket such that immigrating individuals dropped into odd-numbered buckets outside the fence and emigrating individuals dropped into even-numbered buckets inside the fence.

Drift fence buckets were checked for animals three days a week, usually Monday, Wednesday, and Friday, except that if heavy rains fell the fence was checked daily. All animals (especially the amphibians and reptiles) were removed from each bucket and released on the opposite side of the fence, under the assumption that an animal had been moving in that direction when intercepted by the bucket into which it fell. We maintained 10-15 cm of water in the buckets to aid the amphibians and reptiles in resisting desiccation.

Weather data were monitored with a minimum/maximum thermometer and rain gage placed within 7 m of the fence. Water depth in the largest and deepest part of the limesink depression was monitored by driving a white 2.5 cm-diameter PVC pipe into the deepest part of the pond. The PVC pipe was graduated with bold black centimeter marks for viewing from a distance.

Pond #1 was chosen for study because it is a known breeding pond of the gopher frog and striped newt, and because it is adjacent to a major federal highway, U. S. 319. The limesink depression is somewhat heart-shaped, with the truncated apex facing northeast (Fig. 1). The northeast, north, northwest, and southwest sides of the drift fence faced a zone of 20-50 m of gently rising terrain with a mesic forest of longleaf pines and a dense shrubby growth of *Vaccinium arboreum* and *V. darrowi*. Beyond, the land rises more steeply into a second-growth longleaf pine/wiregrass/turkey oak sandhill habitat, the pines having been clear cut in the 1930s. The southeast side of the drift fence lies adjacent to a major two-lane federal highway. A narrow forested zone about 7 m wide separates the limesink depression from the grassy road shoulder. The road shoulder is about 7 m wide, giving way to an asphalt surfaced road 20 m wide.

The drift fence is positioned in such a manner that 10 pairs of the total of 33 pairs of buckets are positioned along US Highway 319. These 10 pairs of pit-fall buckets sample animals that are going into and out of Study Pond #1 in the direction of the highway. All else being equal, migrating animals going in and out of Study Pond #1 should have the same chance of falling into any one either set of the 33 buckets while either entering or exiting the pond. Under this assumption, that is, the null hypothesis that nothing affects immigration, I compare the percentage of immigrating individuals of each species falling into the highway-adjacent buckets with the percentage falling into the remaining 23 buckets, doing so for each of three different years. I also compare the percentages of emigrating individuals for each species among the three years to test the null hypothesis for out-migration. For both immigration and emigration, therefore, under the null hypothesis, I should expect 30% (10 of 33 buckets) of the migrating individuals to fall into the highway-adjacent buckets.

Three different drift fences were set out in the longleaf pine habitat of the Munson Sandhills to determine the distance away from breeding ponds to which amphibians disperse. Drift Fence B was situated 200 feet from Drift Fence A and Drift Fence C was 400 feet from Drift Fence A. Drift Fence A was, itself, about 200 feet away from the middle of Study Pond #1 so that altogether the three fences were staggered at 200, 400, and 600 feet away from the pond, respectively. The site for Drift Fence D was chosen in order to sample for migrating amphibians as far away from a breeding pond as could be found in the Munson Sandhills. It was almost impossible to find any terrestrial site that was as far as a half mile away from any breeding pond, but we selected a site in longleaf pine forest on the east side of U. S. Highway 319 in the middle of Section 25, T1S R1W (see Figure 1). This site was about 3000 feet from any depression that might hold water and be available to amphibians for breeding.

During the winters of 1994-1997, we seined and dipnetted 245 ponds in the Woodville Karst Plain specifically looking for larvae, metamorphs, or adults of pond-breeding amphibians, with special emphasis on the striped newt and gopher frog. One hundred sixty (65 %) of the ponds were located on publicly owned lands of the Apalachicola National Forest and 85 (35 %) were located on privately owned commercial paper company lands. Ponds were sampled in a standard fashion by listening for calling males and by 50 to 200 sweeps of a 24 X 46-cm dipnet (1 mm X 1 mm mesh) until we sampled and measured either 10 striped newts or made 50 or more sweeps of the dipnet. In larger ponds we pulled a 4' X 10' net with 1/4-inch mesh for a minimum of 10 seine hauls. See Means and Means (2002) and Appendix II for further details. From 1997-2001 an additional 20 ponds were surveyed so that the total number at the time of this report (September 2001) is 265.

Results

Some of the results of this study have already been published. A list of the scientific research papers and technical reports that have been generated as of September 2001 is presented in Appendix I.

Results.--Number of breeding ponds utilized by the striped newt and gopher frog in the Woodville Karst Plain. Surveying for the presence of the striped newt and gopher frog in temporary ponds is a difficult task for several reasons. First, ponds are often dry in some years or at some seasons (Dodd 1993). Second, although ponds may have water in them at the appropriate breeding season, rainfall may not have been sufficient to trigger breeding migrations (this study). Third, a given species may be so flexible in its breeding times that in one year it might breed in October and in another year in March (e.g., gopher frog). Fourth, through a combination of factors, breeding might not take place for several years (this study).

Means et al. (1994a, b) reported the presence of the striped newt in 13 of 100 ponds that they surveyed in the Woodville Karst Plain during fieldwork over a 19-month period between 22 February 1993 and 7 September 1994. During that survey rainfall and pond water levels had not been sufficient to stimulate a region-wide breeding episode for the gopher frog, but in the early part of this study, following high pond water levels and heavy rainfall in 1995-1997, conditions were perfect throughout the Woodville Karst Plain for larval development of both the striped newt and the gopher frog. Combining the results of the earlier study with more extensive surveys in the winter and spring of 1995, 1996, and 1997, Means and Means (2001) surveyed a total of 245 ponds in the Woodville Karst Plain. They found larvae or adults of the striped newt in 17 ponds and either larvae or adults of the gopher frog in 26 ponds. In addition, a few additional breeding ponds for the gopher frog were located since the Means and Means (2001) study period (Table 2). On the basis of the presence of salamander larvae, however, only 9 of these ponds were proven to be breeding ponds for the striped newt, whereas all 40 gopher frog ponds had tadpoles (Table 2).

Means and Means (2001) found dramatic differences in the presence of four species of salamanders and five frogs between the eastern and western halves of the Woodville Karst Plain (see details in Appendix II). A survey of 245 ponds throughout the Woodville Karst Plain revealed that the striped newt was found in only 17 of 160 (10.6%) ponds on the Apalachicola National Forest whereas no striped newts were found in 85 ponds (0.0%) on private paper company lands. Adults and/or tadpoles of the gopher frog were discovered in 26 of 160 (16.3%) ponds on the Apalachicola National Forest but in only 1 of 85 (1.2%) ponds on private paper company lands. These results indicate that a decline has occurred in the use of ponds on private paper company lands. This was corroborated by fieldwork in the preceding 30 years in which both the gopher frog and striped newt had been documented on the private paper company lands. The ecological quality of the upland habitat surrounding breeding ponds is as important in the survival of local populations as is the breeding pond, itself. Certain types of silvicultural practices are harmful to these species (see Appendix II).

Table 2.--Ponds in which adults or larvae or tadpoles were found for the striped newt and gopher frog in the Woodville Karst Plain. Explicit location data for these ponds are given in Means et al. 1994a, b and Means and Means 1996, 2001. * = historical record.

	striped newt		gopher frog	
Pond #	adults	larvae	adults	tadpoles
1	X	X	X	X
2	X			X
3	X	X	X	X
5			X	X
6	X	X	X	X
9	*X			
13				X
14				X
15				X
16	X			X
18	X			X
20	X			X
22				X
24				X
25				X
26		X		X
29				X
30				X
33	X			
37	X	X		X
41	X			
42	X			X
43				X
45				X
48	X	X		X
50	X	X		X
51				X
54	X			
55				X
56				X
60		X		X
64				X
71	X			X
73	X			X
74				X
75	X	X		X
87				X
91				X
142				X
187				X
188				X
196				X
203				X
251				X
Totals		20		40

Results.--Biological and physical characteristics of 25 ponds on the Apalachicola National Forest portion of the Woodville Karst Plain, 1997-2000. The aquatic vertebrate species composition of 25 ponds that were chosen to represent the full spectrum of biological and physical characteristics of the lentic water bodies in the Woodville Karst Plain is illustrated in Tables 3 & 4. As expected, the striped newt was not recorded from any pond having fish, but the gopher frog was found to breed in some ponds with fish, although by far tadpoles were more commonly taken in ponds without fish. In one instance of a "permanent" pond, Study Pond #55, the gopher frog had a highly successful breeding episode after a 16-month drought in which this pond lost its abundant fish population (Table 4).

Appendix III displays graphs of the water levels and rainfall recorded at each of the 25 ponds from November 1997 to March 2001. Study of these graphs and the populations of aquatic vertebrates utilizing these ponds reveals at least four types of ponds. Type 1 is the set of ponds (#19, 21, 92, 182) that have very short hydroperiods. They were dry for the entire 3-year study period except for about three months (March - May) in 1998, and neither the striped newt nor gopher frog was found in them when they contained water. Type 2 is the set of solution collapse sinkhole ponds (# Hammock, Gopher Sink) that permanently held water of the Floridin Aquifer. These ponds were inhabited by predaceous fishes and even blind cave crayfishes. Type 3 is the set of "permanent" ponds (#5, 55, and 158) that contained predaceous fishes such as centrarchids and which rarely dry out unless there is a severe multi-year drought such as that which was experienced during this study from 1998-2001. Type 4 is the largest group of ponds (#1, 3, 6, 7, 20, 33, 37, 38, 41, 42, 48, 50, 51, 56). These have modest hydroperiods of a few months to a few years and are the type of pond exclusively utilized by the striped newt and mostly by the gopher frog.

Table 3. Biological characteristics of 25 ponds in the Woodville Karst Plain (Apalachicola National Forest) that were monitored for three years, November 1997 - November 2000. * = gopher frog breeding activity noted in these ponds AFTER the 1999/2000 drought when fishes were all killed off.

Pond #	description	fish	striped newt	gopher frog
1	0.2 mi S jct Fla Rd 61 with US 319	no	yes	yes
3	borrow pit off US 319	no	yes	yes
5	"permanent" pond off LL Wallace Road	yes	no	yes*
6	"permanent" pond off powerline road	no	yes	yes
7	large cypress depression W of pond #6	no	no	no
17	deep oak-leaved pond on E side US 319	no	no	no
18	pretty pond on E side US 319	no	yes	yes
19	another pond on E side US 319, shallow	no	no	no
20	another pond on E side US 319,	no	yes	yes
21	very ephemeral bike trail pond on E side US 319	no	no	no
33	deep pond on W side US 319	no	yes	no
37	huge depression w/maidencane & peat	no	yes	yes
38	tupelo pond off LL Wallace Rd	no	no	no
41	shallow clam & fairy shrimp pond off US 319	no	yes	no
42	grassy pond with fireline through it	no	yes	yes
48	maidencane pond on E side US 319, line of ponds	no	yes	yes
50	pretty round maidencane pond in cluster of 5	no	yes	yes
51	shallow tupelo depression next to 50	no	no	yes
55	lost glasses pond	yes	no	yes*
56	tiny, deep tadpole pond in cluster of 5	no	no	yes
92	borrow pit #2, very short hydroperiod	no	no	no
178	big pond on E side US 319	yes	no	no
182	shallow pond just W of pond 48	no	no	no
Gopher	sinkhole "cave" with blind crayfish, ANF	yes	no	no
Hammock	Little Dismal sink	yes	no	no

Table 4. Biological characteristics: the fish, amphibians, and reptile species, recorded from 25 selected ponds on the Apalachicola National Forest portion of the Woodville Karst Plain.

Species	Pond Number																							
	1	3	5	6	7	17	18	19	20	21	33	37	38	41	42	48	50	51	55	56	92	178	182	G	H
Striped newt (*Notophthalmus perstriatus*)	x	x		x			x		x		x	x		x	x	x	x								
Eastern newt (*Notophthalmus viridescens*)	x	x	x	x								x				x	x	x							
Mole salamander (*Ambystoma talpoideum*)	x	x	x	x	x				x		x	x	x		x	x	x	x		x					
Dwarf salamander (*Eurycea quadridigitata*)	x		x	x	x		x		x			x					x	x							
Eastern spadefoot (*Scaphiopus holbrooki*)	x	x		x																					
Oak toad (*Bufo quercicus*)	x			x			x								x		x								
Southern toad (*Bufo terrestris*)	x	x		x	x												x				x		x		
Narrowmouth (*Gastrophryne carolinensis*)	x	x																							
Green tree frog (*Hyla cinerea*)	x			x			x																		
Pinewoods tree frog (*Hyla femoralis*)	x		x	x			x							x	x	x	x			x	x				
Barking tree frog (*Hyla gratiosa*)	x	x	x	x			x		x					x	x	x	x	x					x		
Squirrel tree frog (*Hyla squirella*)	x			x					x																
Southern cricket frog (*Acris gryllus*)	x	x	x	x	x	x	x		x		x	x	x	x	x	x	x	x	x	x		x			
Spring peeper (*Pseudacris crucifer*)	x																								
Little grass frog (*Pseudacris ocularis*)	x	x													x			x							
Ornate chorus frog (*Pseudacris ornata*)	x	x		x	x	x	x		x	x			x	x	x	x		x					x		
Southern chorus frog (*Pseudacris nigrita*)		x			x													x							
Gopher frog (*Rana capito*)	x	x	x	x		x	x		x	x		x			x	x	x	x	x	x					
Bullfrog (*Rana catesbeiana*)	x			x			x							x	x										
Pig frog (*Rana grylio*)				x								x													
Southern leopard frog (*Rana utricularia*)	x	x		x	x	x	x		x		x		x	x	x	x	x	x		x					
Mud turtle (*Kinosternon subrubrum*)	x		x	x			x					x													
Stinkpot (*Sternotherus odoratus*)	x			x																					
Chicken turtle (*Dierochelys reticularia*)	x	x		x	x	x	x		x							x				x					
Florida cooter (*Pseudemys floridana*)	x																								
Pond slider (*Trachemys scripta)*	x																								
Eastern softshell turtle (*Apalone ferox*)	x																								
Snapping turtle (*Chelydra serpentina*)	x																								
Alligator (*Alligator mississippiensis*)				x																					
Banded water snake (*Nerodia fasciata*)	x	x		x													x								
Garter snake (*Thamnophis sirtalis*)	x																								
Swamp snake (*Seminatrix pygaea*)	x			x																					
Golden topminnow (*Fundulus chrysotus*)																			x			x			
Banded topminnow (*F. cingulatus*)																			x						
Lined topminnow (*F. lineolatus*)																			x						
Starhead topminnow (*F. notti*)																			x						
Least killifish (*Heterandria formosa*)																			x						
Bluefin killifish (*Lucania goodei*)																			x						
Pygmy killifish (*Leptolucania ommata*)																			x						
Mosquitofish (*Gambusia affinis*)			x																x			x		x	x
Banded pygmy sunfish (*Elassoma zonatum*)																			x						
Largemouth bass (*Micropterus salmoides*)																			x						
Flier (*Centrarchus macropterus*)			x																x						
Swamp darter (*Etheostoma fusiforme*)																			x						

1 3 5 6 7 17 18 19 20 21 33 37 38 41 42 48 50 51 55 56 92 178 182 G H
Pond Number

Results.--Six-year rainfall versus water level data for Pond #1. Rainfall and pond water level data reveal that the hydroperiod of Study Pond #1 was highly erratic over the six-year period of this study, 1995-2001 (see Appendix IV). The pond was never dry in years 1-3, then went dry in the spring of year 4 (1999) and remained dry for 16 months until September 2000. In year 6, Study Pond #1 filled three times after three short bouts of drying out and was at relatively high water levels at the end of the project in September 2001. Sporadic information on water levels at Pond #1 over the previous 20 years indicated that the 16-month drought of 1999-2000 may have been the most severe since at least the mid-1950s or before (Means, personal observations). Ironically, the highest and longest lasting water levels in the ponds of the Woodville Karst Plain probably took place just prior to the initiation of this six-year study following extraordinary high rainfall that accompanied the passage of three tropical storms in the autumn of 1994.

Results.--Migration of amphibians and reptiles in and out of Study Pond #1 for the six-year period, September 1995 - September 2001. The six-year data set for the movement of four species of salamanders, fifteen frogs, five turtles, and three snakes in and out of Study Pond #1 is given in Appendix V. An additional 15 species of terrestrial reptiles were recorded in the drift fence drop buckets, but since they play a small or no role in the ecology of the pond, they are not included in a pond-study analysis. Most of the records in Appendix V reflect the breeding or nesting activity of the salamanders, frogs, and turtles as adults migrated in and out of the pond to lay eggs, as hatchling turtles migrated into the pond to grow up, or as amphibian young emigrated from the pond following metamorphosis. We had very few records for the dwarf salamander, cricket frog, and swamp snake because these species live out their adult lives closely associated with the pond or its edge. Also, our records for many of the treefrogs were slight because they climbed up the drift fence or out of the drop buckets.

Because we were focusing on the ecology of the striped newt and gopher frog, they and two other species are the main object of this report. The other species are the mole salamander and the common (=central) newt. These two species are not found in association with the striped newt in Central Florida, but are probably the most important predator and competitor, respectively, of the striped newt in the Woodville Karst Plain, which is at the southwesternmost corner of the range of the species. Histograms of the migrations of all four species in and out of Study Pond #1 over the six-year study period are presented in Appendices VI, VII, VIII, and IX.

In this report, data are displayed in all the graphs from September through August of each year because of the life cycles of the winter-breeding component of the pond fauna that we were primarily studying. Year 1 of the study, therefore, runs from September 1995 through August 1996, and so on. This makes displaying the peaks and valleys of migration more easily read from graphs that best bracket the life cycle events of the species rather than the arbitrary Julian Calendar whose yearly termini lie in the middle of the important events of the animals.

Adults of the striped newt immigrated into Pond #1 in decreasing numbers over the six-year period, 1995-2001 (Appendix VI). No adults immigrated into the pond in year 5 and only a few in year 6, no doubt as a result of a prolonged regional drought when the pond was dry. Immigration took place as early as September in some years and as late as April. Two out-migrations of striped newt metamorphs took place in years 1 and 3, the first in the autumn from September to February and the second in midsummer from June to August. Following the breeding activity in year one, no efts emerged from the pond in year two although there was water in the pond, indicating that something killed off that year's reproductive effort. One huge emigration of metamorphs occurred in year 4 from September to April. No efts were caught in our drift fence drop buckets in years 5 and 6, during the long-term drought (Appendix VI). Altogether over a six-year period, there were five emergences of striped newt metamorphs, in three of the six years.

The migration pattern of the common or central newt was similar to that of the striped newt with two exceptions (Appendix VII). Generally the numbers of the common newt were greater than those of the striped newt by a factor of 2X to 5X; more adults immigrated into Pond #1 and more metamorphs emigrated. And there was no second emigration of metamorphs in year 4.

In numbers and sheer biomass, the mole salamander had the most spectacular and more regular amphibian migrations (Appendix VIII). Immigration of adults and emigration of metamorphs was unimodal for each life history category in four of the six years, adults immigrating into the pond from September until April with the main pulse in December and January. Metamorphs emigrated about one year later over the same period of time, from September to April, but with a mode that shifted among the years from January to March. Following the disastrous Year 5 when no breeding of any kind took place in the dry pond, there was an unusually large movement of adults into the pond in September of Year 6. Metamorphs were not produced in Year 6, either, and the histogram of emigrating individuals in midwinter is for out-going adults, not metamorphs.

The gopher frog is an explosive breeder, adults keeping to the upland habitats until there is a particularly heavy rainfall event. Small numbers (<10) of adult gopher frogs entered Pond #1 sporadically following heavy rains in years 1, 2, 3, 4, and 6, but only one successful reproduction event took place in the pond in six years. Following a >7.0 cm rain in September 1996, a large immigration of adult gopher frogs (n = 34) yielded an emigration of more than 500 metamorphs with a modal emergence date seven months later in May, 1997 (Appendix IX).

Some of the other frogs utilizing Pond #1 demonstrated similar rare but explosive breeding following special weather conditions. We did not graph the six-year history of the spadefoot, but two rains totaling >30 cm in early September, 1999, stimulated the immigration of 247 adults. Six weeks later the drift fence buckets were overwhelmed by the emergence of > 40,000 metamorphs (see Appendix V). In spite of the immigration of dozens of adults following different less heavy rains over the rest of the six-year period, either no breeding took place or the eggs and tadpoles were destroyed before metamorphosis.

Results.--Larval growth of the striped newt in Study Pond #1 for the years 1973, 1993-1997. Striped newt larvae were measured when dipnetted from Study Pond #1 in six years, 1973 and 1993-1997 (Appendix X). Hatchlings (<10mm snout-vent length, or SVL) first showed up in April or May and were present and growing in the pond through the middle of November, after which time they metamorphosed and emerged as efts (see Appendix VI for histograms of out-going striped newts). In years when water remained in the pond (1993-1997), some developing larvae remained and grew to sexual maturity as neotenes (sexually mature larvae). Neotenes generally were >30 mm SVL and usually metamorphosed and left the pond just as the hatchlings of the young of the year were showing up.

The data generated by the drift fence around Study Pond #1 are voluminous, a separate six-year set for each of the 27 species. It is an additional goal of this project to work up and publish all the results for every species. The data provided in this report for the striped newt is an example of what exists for the rest of the fauna.

Results.--Dispersal of the striped newt and gopher frog in the Munson Sandhills of the Woodville Karst Plain, Leon County, Florida. Because the upland drift fences (B, C, D) intercepted far fewer animals than did Drift Fence A (totally surrounding Study Pond #1), and because these fences were activated to assess distance away from breeding ponds that amphibians migrate, the data were collapsed into summary tables. The amphibians intercepted by Drift Fence B (400 feet south of Study Pond #1) are presented in Table 5. Amphibians intercepted by Drift Fence C (600 feet south of Study Pond #1) are presented in Table 6. Amphibians intercepted more than 3000 feet from any potential breeding pond are presented in Table 7.

Table 5.--Five-year record of number of individuals migrating in and out of Drift Fence B, 200 feet south of Drift Fence A and 400 feet south of Study Pond #1. Year 1 = 3/1997 - 8/1997; Year 2 = 9/1997 - 8/1998; Year 3 = 9/1998 - 8/1999; Year 4 = 9/1999 - 8/2000; Year 5 = 9/2000 - 8/2001. Figures on left hand side of double columns = IN-migration toward Study Pond #1; figures on the right hand side of double columns = OUT-migration. At = *Ambystoma talpoideum*; Np = *Notophthalmus perstriatus*; Nv = *Notophthalmus viridescens*; Eq = *Eurycea quadridigitata*; Sh = *Scaphiopus holbrooki*; Bt = *Bufo terrestris*; Bq = *Bufo quercicus*; Gc = *Gastrophryne carolinensis*; Po = *Pseudacris ornata*; Rc = *Rana capito*; Ru = *Rana utricularia*; Ag = *Acris gryllus*.

Species	Yr 1		Yr 2		Yr 3		Yr 4		Yr 5		totals	
At	4	6	41	20	4	16	1	0	4	0	54	42
Np	0	0	9	36	2	38	0	0	0	0	11	74
Nv	2	0	10	35	5	58	1	0	0	1	18	94
Eq	0	0	0	0	0	0	0	0	0	0	0	0
Sh	4	4	87	109	2	26	0	0	36	1934	129	2073
Bt	16	27	12	4	5	12	1	15	22	86	56	144
Bq	9	6	12	12	2	2	0	0	0	1	23	21
Gc	168	73	13	13	16	39	0	10	4	38	201	173
Po	1	1	9	9	1	1	0	0	1	0	12	11
Rc	4	15	7	7	4	2	0	0	0	0	15	24
Ru	2	1	2	2	1	0	0	0	0	0	5	3
Ag	1	0	7	4	0	0	0	0	0	0	8	4

Table 6.--Five-year record of number of individuals migrating in and out of Drift Fence C, 400 feet south of Drift Fence A and 600 feet south of Study Pond #1. Year 1 = 3/1997 - 8/1997; Year 2 = 9/1997 - 8/1998; Year 3 = 9/1998 - 8/1999; Year 4 = 9/1999 - 8/2000; Year 5 = 9/2000 - 8/2001. Figures on left hand side of double columns = IN-migration toward Study Pond #1; figures on the right hand side of double columns = OUT-migration. At = *Ambystoma talpoideum*; Np = *Notophthalmus perstriatus*; Nv = *Notophthalmus viridescens*; Eq = *Eurycea quadridigitata*; Sh = *Scaphiopus holbrooki*; Bt = *Bufo terrestris*; Bq = *Bufo quercicus*; Gc = *Gastrophryne carolinensis*; Po = *Pseudacris ornata*; Rc = *Rana capito*; Ru = *Rana utricularia*; Ag = *Acris gryllus*.

Spec	Yr 1		Yr 2		Yr 3		Yr 4		Yr 5		totals	
At	1	0	23	18	1	6	1	0	4	1	30	25
Np	0	0	3	14	3	11	0	0	1	0	7	25
Nv	0	0	6	11	1	27	0	0	3	0	10	38
Eq	0	0	0	0	0	0	0	0	0	0	0	0
Sh	3	4	74	115	10	23	5	6	30	587	122	735
Bt	11	15	9	3	8	10	5	3	7	43	40	74
Bq	58	27	20	8	0	1	0	0	0	0	78	36
Gc	230	50	23	11	37	18	2	4	21	47	313	130
Po	12	10	4	0	0	0	0	0	0	0	16	10
Rc	15	7	5	2	1	0	0	0	0	0	21	9
Ru	13	1	0	10	0	0	0	0	13	7	26	18
Ag	6	9	0	0	0	0	0	0	0	0	6	9

Table 7.--Four-year record of number of individuals intercepted by Drift Fence D, about 3000 feet from any potential breeding pond. Year 1 = 2/1998 - 8/1998; Year 2 = 9/1998 - 8/1999; Year 3 = 9/1999 - 8/2000; Year 4 = 9/2000 - 8/2001. At = *Ambystoma talpoideum*; Np = *Notophthalmus perstriatus*; Nv = *Notophthalmus viridescens*; Eq = *Eurycea quadridigitata*; Sh = *Scaphiopus holbrooki*; Bt = *Bufo terrestris*; Bq = *Bufo quercicus*; Gc = *Gastrophryne carolinensis*; Po = *Pseudacris ornata*; Rc = *Rana capito*; Ru = *Rana utricularia*; Ag = *Acris gryllus*.

Spec	Yr 1	Yr 2	Yr 3	Yr 4	totals
At	1	0	0	0	1
Np	0	0	0	0	0
Nv	7	0	0	0	7
Eq	0	0	0	0	0
Sh	3	0	0	0	3
Bt	7	0	0	0	7
Bq	23	0	0	0	23
Gc	15	0	0	0	15
Po	0	0	0	0	0
Rc	0	0	0	0	0
Ru	0	0	0	0	0
Ag	2	0	0	0	2

Discussion

Some very important conclusions were derived from the survey of 245 ponds when ecological conditions were optimal for breeding (see Appendix II). We determined that many fewer ponds than expected on private paper company lands were utilized by both the striped newt and gopher frog and that historical records verified that these species had been more common in that part of the Woodville Karst Plain twenty and more years earlier. The most obvious reason for the decline of these species on paper company lands when compared with national forest lands was not the quality of the breeding ponds, themselves, but the ecological integrity of the surrounding uplands. National forest ponds were surrounded by native longleaf pine, open canopy forest. Ponds on paper company lands were surrounded by densely stocked sand pine plantations.

Sand pine plantations are unsuitable upland habitat for these species because of the heavy shading that virtually eliminated the native groundcover and thus the microhabitats and food webs that both the striped newt and gopher frog depend upon (Appendix II). Partial corroboration of this hypothesis was the fact that a once-thriving gopher tortoise population on the private paper company lands had also disappeared with the planting of the sand pines (personal observations). In the absence of other subterranean refugia such as stumpholes (which are absent on mechanically site-prepared pine plantations), gopher tortoise burrows probably would play an important role in the success of a local gopher frog population (Means 2001) if burrows were present.

For the striped newt in Florida, Franz and Smith (1999) recorded an estimated 81 sites from 20 Florida counties since 1922. By the time of their study in 1994, however, they were able to verify the presence of the species at only 27 sites, including 21 new sites that they established during the period of their fieldwork. Of 30 of 40 identifiable striped newt localities that they re-visited, only 6 were found to have the striped newt. Populations of the striped newt in many of the historical ponds have been extirpated by human activities (see also Means and Means 1998, 2001).

The fact that the striped newt was found in 20 ponds during this study may be misleading. Only 9 of the 20 ponds contained striped newt larvae, a more reliable indication that breeding had taken place. However, only one or a few adults were found in the remaining 11 ponds and follow-up collections to locate larvae in the ponds were unsuccessful. We are not sure what this means. On the one hand, considering that striped newts repeatedly migrated unsuccessfully to breed in one small pond in Central Florida over a 5-year period (Dodd 1993), it may be the case that eventually these ponds will support a breeding event. On the other hand, we do not know if the adults that we found in the 11 ponds were dispersing individuals that had encountered these ponds accidentally and would not, or could not, have brought off successful reproduction.

Study Pond #18 is a case in point. In the spring of 1994 and 1995, we found lots of adults in breeding condition, but subsequently we never dipnetted any larvae from it because the pond dried up shortly afterward, and was dry during the breeding seasons of 1996-2001. Although robustly healthy adults in breeding condition were taken from this pond in the mating season, no larvae were collected over a 7-year period. In 1998 we considered this pond so likely to be a striped newt breeding pond that we included it in our hydrology study of 25 selected ponds. If, in fact, this pond does serve occasionally as a breeding pond for the striped newt, even on a 5-10 year basis, it would be very useful to know what role such a pond serves in the overall success of the Woodville Karst Plain regional metapopulation. Can the dipnetting of a single adult, such as we recorded from several ponds, indicate that the pond is a breeding pond for the species?

The gopher frog represented a different kind of situation. Adults are very wary and difficult to find or hear calling. Many individuals vocalize underwater and cannot be heard without special hydrophonic equipment (Jensen et al. 1995). We recorded adult males calling from only 4 ponds during the six-year study period, but we dipnetted larvae from 40 ponds. Ponds from which gopher frog tadpoles were collected in some years had no tadpoles in other years, even when other ponds had tadpoles in them. After our pond survey, following heavy rains in August 2001, gopher frogs were heard calling and tadpoles were dipnetted from two "permanent" fish-inhabited ponds that had been dry for many months and from which no records for the gopher frog had previously been made.

While studying the biological and physical characteristics of the whole spectrum of ponds in the Woodville Karst Plain, we discovered significant variation in both aspects of pond ecology. For instance, the gopher frog successfully bred in some ponds with fish in some years. Although we did not record fish in any pond in which we found the striped newt, it would not be surprising if fish were occasionally found in a striped newt breeding pond. The reason for this is that during very high and prolonged water levels in some striped newt and gopher frog breeding ponds, the ponds are often colonized by fish across shallow connections to larger, more permanent ponds or up small streams connecting them. Later, during extended drought, the ponds dry, the fish die out, and when moderate water levels return, there are no fish for a number of years. Even "permanent" ponds that have a robust fish population can sometimes dry out (e. g. during the severe two-year long drought of 1999-2000) and temporarily lose their fish populations. Ironically, the gopher frog was heard calling from Pond #5 (Margaret Gunzburger, personal communication) and tadpoles were dipnetted from Pond #55 following the filling of these normally fish-inhabited ponds after a two-year long drought.

A major conclusion, reached after monitoring 25 ponds through the most severe drought of the past half-century, is that few ponds in the Woodville Karst Plain are truly permanent, even those with fish. The gopher frog is highly capable of capitalizing on the presence of water over a wide range of pond sizes and hydroperiods. The gopher frog is stimulated to breed only after excessively heavy rains at almost any time of the year, thus insuring that its breeding ponds will have water over the three-month period required for its tadpoles to reach metamorphosis. The striped newt seems less capable of utilizing the full spectrum of ponds, but it may rely more on the occasional or "rare" filling of ponds with extremely short hydroperiods. Being a larger, more mobile animal, the gopher frog can find breeding ponds over longer distances during particularly favorable single weather events. The striped newt may rely more on long-distance dispersal of propagules over a season or several years. Long-lived individuals may make repeated attempts to breed in very ephemeral ponds over a period of a decade. Their noxious skin secretions may protect them from heavy mortality, so that one successful breeding event in a half decade or more might be entirely sufficient to maintain a local population.

The results of the studies of migration of amphibians and reptiles in and out of Study Pond #1 point to the extreme importance of dispersal to all 27 species that utilized the pond over the long history of our observations there. To illustrate this point, we recorded five species of turtles, all of which appeared in the pond as hatchlings at one time or another. All five species emigrated from Study Pond #1 as it dried out and, for at least 16 months, either remained under the leaf litter of the longleaf pine woodlands surrounding the pond or wandered across the hilly terrain until they found water in another pond that had not yet dried out. These five species recolonized the pond once water levels returned. That many species of turtles wander throughout the Woodville Karst Plain was made further obvious when a single adult snapping turtle (*Chelydra serpentina*) and an adult Florida softshell turtle (*Apalone ferox*) turned up in the pond on different occasions. These species were not included in the pond herpetological inventory nor was the sole cottonmouth moccasin (*Agkistrodon piscivorus*) that wandered in one year because the species were recorded only once and seemed not to be regular inhabitants of, or visitors to, the pond. The turtles eventually left the pond but the cottonmouth was never seen again.

Likewise, other reptiles that utilize the numerous ponds of the Woodville Karst Plain also display a high degree of vagility in moving among the ponds. Occasionally an alligator will turn up in a small pond for a while, and it is not an uncommon event to see alligators crossing roads and highways, most frequently during droughts. Two species of snakes on the Pond #1 inventory clearly move among ponds opportunistically, immigrating when the pond has water and abundant life, and emigrating when it dries out. The garter snake and banded water snake are common residents when Pond #1 is full of water and laden with tadpoles or large mole salamander larvae. We have records from Pond #1 of at least six large banded water snakes that were gorging themselves on large mole salamander larvae during one of our visits to the pond as the pond was drying down and concentrating the larvae. Soon afterward, the pond dried out and the snakes disappeared, presumably moving off to other ponds that had not dried out.

Because of the highly ephemeral nature and short hydroperiods of many of the breeding ponds of the striped newt, gopher frog, and all the other amphibians and reptiles that utilize the ponds of the Woodville Karst Plain, it is highly likely that a local population utilizing a particular pond might go extinct. If that were to happen in the Woodville Karst Plain, the chance for re-colonization by propagules from a nearby pond is much greater than if the first pond were isolated in the landscape. A landscape full of ponds, therefore, is much more important in the long-term survival of these species.

Data gathered from the upland drift fences, numbers B and C (and see Tables 5-7), give us a hint of the dispersal capabilities of the amphibians that utilize Study Pond #1. Fences B and C were placed at 200 feet increments away from Study Pond #1 into the adjacent longleaf pine/wiregrass habitats. Unfortunately, because of the high cost of emplacement and labor to check them, the drift fences could not be made to encircle the entire study pond like Drift Fence A does. They did give us a good idea, however, of how far amphibians travel away from Study Pond #1.

Comparing values for 12 amphibian species in tables 5 and 6, one can see five main results. First, whereas 11 of 12 species were recorded in both fences during the five-year period, only the dwarf salamander, *Eurycea quadridigitata*, was not found in traps along either fence in any of the five years of the study. It is present in Pond #1 because we found larvae in several years by dipnetting. That it did not migrate into drift fences B and C is probably because this species spends most of its adult life in the wet margins of the ponds and rarely migrates into the adjacent uplands. The aquatic cricket frog, *Acris gryllus*, was not very well represented either, as expected, but some dispersing individuals were recorded.

Second, there was a marked fall-off in numbers of individuals intercepted by drift fences B and C over time, but especially in year 4. Year 4 was the second year of the severe regional drought. The local area in that year received only about one-half of its average annual rainfall, which greatly inhibited amphibian movement.

Third, although drift fences B and C were 200 feet apart, and 400 and 600 feet from the middle of Study Pond #1, respectively, the numbers of captures do not differ very greatly. This is an indication that dispersing amphibians that make it to Drift Fence B are probably continuing to disperse away from Study Pond #1 when they reach Drift Fence C. If one compares the numbers of emigrating amphibians for the same years leaving Drift Fence A (Appendix V) with the numbers arriving at drift fences C and B (Tables 5 and 6), it is apparent that huge numbers of out-migrating individuals that cross Drift Fence A don't make it the 200 feet to Drift Fence B. Apparently a large percentage of out-migrating individuals stop and take up residence in the 200 feet of habitat between fences A and B. This habitat happens to be a ring of pines mixed with hardwoods consisting mostly of sand live oak (*Quercus geminata*) shading a dense cover of leaf litter. Upslope further south between drift fences B and C is a mature second-growth longleaf pine/wiregrass community. By contrast, very few individuals take up residence in the 200 feet between the middle of Study Pond #1 and Drift Fence A because it is a bare soil zone created by high water stands following heavy rains. This zone has little or no groundcover to serve as microhabitats for the desiccation-prone amphibians.

Fourth, although no breeding took place in year 4 for any amphibian because the pond was dry, movement increased again at both drift fences B and C in year 5 for several species. This indicates that individuals survived the drought and moved about on land more readily in year 5 when rainfall increased in that year.

Fifth, only a few bouts of reproductive success are obvious in tables 5 and 6. In most years for most species, as judged by the ratios of in-going versus out-going numbers, few metamorphs reached these fences because the in-going individuals either didn't breed or mortality destroyed any young that were produced. Metamorphs of the common newt (*Notophthalmus viridescens*) and striped newt (*N. perstriatus*) were abundant at drift fences B and C only in years 2 and 3 but absent in years 1, 4, and 5. In years 2 and 5, metamorphs of the spadefoot (*Scaphiopus holbrooki*) reached drift fences B and C, but not in years 1, 3, and 4). Metamorphs of both the common toad (*Bufo terrestris*) and the narrowmouth (*Gastrophryne carolinensis*) trickled through the fences in most years, but metamorphs of the gopher frog (*Rana capito*) reached the fence only once in five years, in year 1.

Data from the fourth drift fence (#D) were a bit perplexing. In the six months that the fence operated in Year 1 (February - August, 1997), the fence intercepted a moderate number of individuals (N = 1 - 23) of 7 of the 12 species of amphibians (Table 7). Strangely, over the next three years, not a single amphibian of any species was recovered from the funnel traps. Reptile numbers were down dramatically, also, but a few lizards and small snakes were caught which verified that the traps were working. The only explanation for such dramatic absences of individuals in this fence is that something was removing trapped animals before the traps were checked. Differences between drift fences A, B, and C versus fence D may be telling, however. The drift fences associated with Study Pond #1 (A, B, C) had 5-gallon drop-buckets half-filled with water into which animals fell, preventing amphibians from dessication. Drift Fence D, however, had window screen funnel traps that rested on the ground. It is possible, judging from a few observations we made to this effect in the field, that fire ants (*Solenopsis invicta*), became adroit at swarming over the soft-bodied amphibians and devoured them during the night before we checked the traps later in midday.

Data from Drift Fence D, therefore, do not give very clear results about the numbers of amphibians that travel far from breeding ponds, but 7 dispersing common newts were taken. No striped newts were intercepted by Drift Fence D, but since the common newt reached this fence and is very similar in morphology, there is no reason to assume that the striped newt could not also disperse up to 3000 feet from a breeding pond. No gopher frogs were taken at Drift Fence D, but this is not surprising since the fence only intercepted amphibians in its first six months of operation and that was not a time when the gopher frog was recorded moving about or breeding anywhere in the Munson Sandhills.

Results of this study have shown that at least three aspects of the ecology of the both the striped newt and gopher frog (as well as most of the rest of the pond-breeding amphibians listed in Appendix V) are crucial to the long-term survival of the species in the Munson Sandhills. First, breeding ponds must exist in the landscape and be free from pollution and impacts that alter the natural water and vegetative quality of the ponds. Second, the uplands surrounding breeding ponds must be vegetated in the natural community that existed in presettlement times (longleaf pine/wiregrass community). Third, natural connections in the landscape must exist among ponds to insure that if local breeding populations go extinct because of drought or some other factor, they will be re-established by colonization of individuals from nearby breeding populations.

<u>Management and Future Study Recommendations</u>.--Although the Munson Sandhills of the Woodville Karst Plain is a relatively small geographic area (10 X 20 km), it contains more than half (n = 20) of the known "active" localities in the entire geographic range of the striped newt. It has been documented, however, that this species and others have declined severely or been extirpated from the eastern half of the Munson Sandhills (Means and Means 2001), where records as recently as 1990 (Franz and Smith 1990) establish that the striped newt once was there. The long-term survival of the populations in the western half of the area (on the Apalachicola National Forest), therefore, is crucial in the survival of the species. Every effort should be made to understand the complexities of the life history and ecology of the species in the Woodville Karst Plain, especially since this species has such enigmatic breeding ecology and its population biology is highly dependent upon dispersal and the presence of more than one breeding pond.

All species require sufficiently large areas of prime habitat to support a minimum viable population. Individuals must be able to move throughout their home ranges freely or move among suitable patches in the landscape to find food, shelter, mates, and escape predators. For many animals that carry out their entire life cycle in one continuous habitat type such as the longleaf pine forest, maintenance of that one habitat type in good condition is all that is required to ensure the survival of those species. In the case of the 27 species of amphibians and reptiles that utilize Study Pond #1 and many other of the 265 ponds we sampled, however, prime habitat for these species is of two types: 1) upland habitat where adults live or lay eggs and 2) special pond environments in which adults either live or breed and juvenile stages develop. Long-term survival for these species requires that these two types of habitats persist in good quality through time, making these species more vulnerable in a landscape in which a crucial component is, by definition for them, patchy.

The striped newt has been the focus of most of this project because all of the other 26 species have been recorded using more ponds than the striped newt, and on this basis, they probably are not so vulnerable in the Munson Sandhills as the newt. The striped newt may be rarer because it is struggling with competition from the common newt and mole salamander and from predation by the mole salamander. These hypotheses beg study.

The information generated by this overall project in the past six years has enabled some insights into the problems of the survival of the striped newt in the Munson Sandhills, which are similar problems faced by many of the species that live with it. First, the striped newt is dependent upon only 9, or not more than 20, breeding ponds in the entire 10 km X 20 km of the Munson Sandhills. Breeding ponds are probably more important to this species, therefore, than to the rare gopher frog that seems more mobile and able to utilize at least 40 ponds in the same area. A first recommendation for the management of the striped newt would be to make sure that all 20 of the known ponds in which the species has been found are kept free from pollution and from physical impacts such as drainage or filling.

A second recommendation is that the upland habitats of the species be maintained in prime condition. Because the upland habitat for the striped newt is the longleaf pine sandhills ecosystem, it may not be enough simply to set aside longleaf pine acreage around breeding ponds and let nature take its course. That is because longleaf pine ecosystems are fire-maintained communities and the natural fire cycles have been severely interrupted by roads, towns, agriculture, silviculture, and active fire suppression. What constitutes prime longleaf pine forest habitat for the striped newt and the 26 other species that cohabit the temporary breeding ponds with the newt is not known. Clearly, the loss of the native groundcover under 20-year old sand pine plantations is deleterious to these animals (Means and Means 2001). A necessary and somewhat urgent need to properly manage upland habitats for the striped newt and associates is to understand what role fire might play in their biology. The accumulation of dry, dead litter over the years in the absence of fire might affect the insect and other arthropod fauna on which the ground-dwelling amphibians and reptiles live. A study of the population response of the striped newt and associates to fires at different frequencies in longleaf pine would go far to develop knowledge to assist in the best management of the upland habitats utilized by these animals.

Because the striped newt breeds in temporary ponds with erratic and unpredictable hydroperiods, dispersal among ponds is probably a critically important component of the longevity of local populations. If a local population that utilizes one breeding pond goes extinct because of drought, lack of fire in the uplands, disease, excessive predation, or some other cause, it could be restored by individuals that disperse into it from other ponds in the area. Considering the patchy occurrence of suitable Type 4 breeding ponds in the Munson Sandhills, dispersal must be important in the persistence of the species there. If this is true, then the focus of management should be on the greater metapopulation of the striped newt in the Munson Sandhills, not on the small localized population that utilizes any specific pond. To maintain the metapopulation will require insurance that all the ponds are in undisturbed condition (e.g. ponds are not stocked with game fish as some in the Munson Sandhills have been in the past), and that the longleaf pine forest milieu in which the ponds are embedded is managed in ways to benefit the newt and its associates. Migratory corridors through the longleaf pine forest must be critical to the long-term survival of the species on the Apalachicola National Forest. Roads, powerline, and natural gas rights-of-way, and other disturbances of the longleaf pine groundcover between the ponds might prove to be severely harmful to dispersal and the long-term survival of many species. Research on the effects of man-made disturbances to dispersal is greatly needed.

This report comes at the end of the most severe regional drought recorded in the past century, a time when ponds in the Woodville Karst Plain were at their lowest levels. There was no breeding of the striped newt in any of the 20 "striped newt active" ponds in the past two years, 1999 - 2001. It is highly desirable, therefore, to monitor Study Pond #1 until after the drought breaks in order to ascertain how the drought has affected the adult populations of the striped newt and the 26 other species that have survived, or have not survived, in the dry longleaf pine uplands surrounding the pond. With the background study reported here, established over the past six years, this is a unique opportunity that may not arise for another century.

Following the return of winter rains and filling of breeding ponds, it would be desirable, also, to monitor the 20 "active" striped newt ponds to determine if those 11, in which only one or a few adults were previously found, might eventually be ponds in which successful reproduction takes place. In short, our studies over the past six years (as well as preliminary studies previously) have clearly pointed out that most of the amphibians and reptiles that utilize temporary ponds of our Type 4 in the Munson Sandhills probably are highly dependent upon MORE THAN ONE POND in their long-term survival in the region.

Finally, in the specific case of the proximity of a federal highway, U. S. 319, to Study Pond #1, research over the past six and more years has shown this pond to be one of the more important breeding ponds of 27 species of amphibians and reptiles in the Munson Sandhills, and especially of the striped newt. Study Pond #1 was cut in half many years ago when US 319 or its progenitor was constructed. Part of the original depression wetland lies on the east side of US 319 and has a shorter hydroperiod than Pond #1. What's worse, Florida Road 61 lies on the eastern side of this pond, so that any animals dispersing into it from the east, west, or north (US 319 and FL 61 come together immediately north of the pond) have to run the desiccating gauntlet of macadam and highway right-of-way, let alone death by crushing. All of the species of amphibians and reptiles that utilize Pond #1 also use this other half of the original pond. In fact, for every species a significant proportion of the breeding and metamorph population emigrates across US 319 out of Pond #1. Returning immigrants have been fewer than expected (Means and Printiss 1996). Any future alterations of US 319 that can facilitate the migration and dispersal of the striped newt, gopher frog, and their associates across the US 319 right-of-way and reduce highway mortality on these species will be very helpful in the long-term survival of all of these species.

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Ryan C. Means set up rain gages and water level measuring devices in 25 ponds in the Munson Sandhills and ran the "pond water check" route every other day for 9 months. The pond water check route was run once a week for 12 months by Trisha Spears.

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Appendix I.

Research papers and reports that have been generated out of this study.

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Means, D. B. , T. E. Ostertag, & D. Printiss. 1994a. Distribution, habitat ecology, and management of the striped newt, *Notophthalmus perstriatus*, in the Apalachicola National Forest, Florida. Report under contract with the U. S. Forest Service, National Forests in Florida, Tallahassee, FL, 30 pages.

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Appendix II.

A scientific research paper generated by this study:

Means, D. B. and R. C. Means. 2001. Effects of sand pine silviculture on pond-breeding amphibians of the Woodville Karst Plain of north Florida. *In* W. Meshaka and K.Babbitt, eds. Status and Conservation of Amphibians and Reptiles of Florida. Florida University Presses, Gainesville, Florida. (In press.)

Effects of Sand Pine Silviculture on Pond-breeding Amphibians in the Woodville Karst Plain of North Florida

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Abstract.--The ecological quality of the upland habitat surrounding small isolated water bodies is as important for metamorphosed amphibians as the quality of the aquatic habitat is to their larvae. We sampled the occurrence of four species of salamanders and five frogs among 245 ponds in the Woodville Karst Plain of north Florida during ideal natal conditions following heavy rains of 1996. Ponds on one-half of the study area were surrounded by native longleaf pine savanna of the Apalachicola National Forest; ponds on the other half of the study area were surrounded by 15-year old sand pine plantations of a private paper company. Proportions of ponds utilized by four species (*Acris gryllus, Pseudacris crucifer, P. ornata, Rana sphenocephala*) were not significantly different on the two forest types, but five species (*Notophthalmus perstriatus, N. viridescens, R. capito, Ambystoma talpoideum, Eurycea quadridigitata*) were strongly underrepresented in ponds in the sand pine plantations. This finding, and old records from there for the gopher frog and striped newt, indicate that these species formerly were more common in ponds of the pine plantations and have declined on that half of the study area. The decline is best explained by silvicultural modifications of the surrounding uplands. Successful management of amphibians requires maintaining the natural vegetative quality of their upland habitats as well as the ecological integrity of their breeding ponds.

INTRODUCTION

Small isolated water bodies, also called temporary ponds, provide either larval or adult habitat for many species of amphibians that live in the Coastal Plain of the southeastern United States (Moler and Franz, 1987; Means, 1990; Dodd, 1992; Semlitsch et al., 1996). Temporary ponds are surprisingly diverse, having unique species compositions in different landscapes such as floodplains or flatwoods. The marbled (*Ambystoma opacum*) and the spotted (*A. maculatum*) salamanders, for example, breed almost exclusively in floodplain ponds (Petranka, 1998), whereas the flatwoods salamander (*A. cingulatum*) breeds only in flatwoods ponds (Palis and Means, 2002).

One would not expect ponds to be a major feature of relieved terrain, but in fact, the sandhills of the Coastal Plain are abundantly endowed with ponds of many sizes and hydroperiods, including many temporary ponds. The reason is that sandhills habitats are almost always underlain by soluble limestones in which closed-basin sinkholes, solution pits, and sunken terrain are commonplace. It is in these karst depressions that water stands when the bottom of the depression lies below the local water table. Sandhills temporary ponds have been around in the Coastal Plain for millions of years, so that a large number of amphibians have evolved that obligately depend upon them. Two such species, the striped newt (*Notophthalmus perstriatus*) and gopher frog (*Rana capito*), are endemic in sandhills. They are becoming so rare in their global distributions, however, that both were designated C2 candidates for federal listing as threatened species (U. S. Fish and Wildlife Service, 1994).

The global distribution of the striped newt is small and restricted to the northern half of the Florida peninsula and parts of southern Georgia (Conant and Collins, 1998; see also the chapter in this book by Steve Johnson). Recently, Dodd (1993) and Franz and Smith (1994) resurveyed all 162 historical localities for the striped newt in Georgia and Florida and concluded that the striped newt is presently known from only three general and widely separated locations in Georgia and from 27 ponds in Florida. Based on the newt's limited distribution and low number of breeding ponds in Georgia, Dodd (1993) recommended the "…initiation of immediate efforts to conserve and manage known striped newt breeding ponds." Franz and Smith (1994) believed that the paucity of recent records from Florida strongly suggested a serious decline in the striped newt throughout its Florida range. They concluded that "…this salamander is threatened throughout its geographic range and that there is sufficient evidence to warrant both state and federal listing." The Woodville Karst Plain, containing half of the known Florida breeding ponds of the striped newt (Means et al. 1994a; b), may well be the most important refuge left in its global range.

Likewise, the gopher frog is rare and declining throughout its geographic range, but does not appear to be so severely reduced in Florida as the striped newt. Franz and Smith (1994) surveyed museum records, published literature, unpublished field notes, and conducted their own field work establishing 259 sites in 45 counties for the gopher frog. The species was active in 79 of these sites, including only two historic sites. Franz and Smith (1994) plotted only 6 localities on their range map for the gopher frog between the Apalachicola and Suwannee rivers in the Florida panhandle. Half of these were in the Woodville Karst Plain on the Apalachicola National Forest and were ponds also known to harbor the striped newt.

We have been monitoring Woodville Karst Plain ponds since 1969 and reported the results of a survey of 100 ponds sampled on the Apalachicola National Forest portion of the Woodville Karst Plain (Means et al. 1994a; b). These 100 ponds, however, represent only about one-third of all the ponds in the Woodville Karst Plain. A similar number of ponds occurs on private paper company lands immediately to the east. One of the difficulties in surveying for pond-breeding amphibians is that the species are found only when adults are vocalizing from ponds during brief breeding bouts or when larvae are developing in ponds. Hydroperiods of temporary ponds are so short and rainfall so unpredictable, however, that several years may pass without any breeding activity. Following unusually heavy rains of October 1996, the ponds of the Woodville Karst Plain were filled to capacity so that widespread breeding stimulated by the ensuing winter rains offered the best opportunity for censusing ponds for amphibian larvae in more than a decade.

Because of the potential importance of the Woodville Karst Plain to these rare and declining species, the presence of native and silviculturally modified forests, and the exceptional opportunity to sample for larvae following the longest hydroperiods in years, we attempted to survey as many new ponds as possible for the striped newt and gopher frog while we had the opportunity. Altogether we gathered data during 1994-1997 on nine species of amphibians. This paper presents the results of those surveys.

Methods

The study area was the northern part of the Woodville Karst Plain in a group of rolling sandhills south of the City of Tallahassee, in southern Leon County, Florida (Fig.1), comprised of quartzite sands lying up to 10 m deep over limestones of late Miocene age (Hendry and Sproul, 1966). The study area extends about 20 km in an east-west direction and about 8 km north-south. The sands of the Woodville Karst Plain probably represent an old barrier island complex or sand bars offshore from the mouth of the ancient Ochlockonee River, deposited during the early Pleistocene (Hendry and Sproul, 1966).

The western one-half of the study area is owned by the Apalachicola National Forest and is vegetated with second-growth longleaf pine (*Pinus palustris*) savanna (Platt, 1999). It lies west of Woodville Highway (Florida Road 363). The eastern one-half of the study area lies east of the Woodville Highway and is in commercial paper company ownership. Over the past 45 years it has had a history of intensive pine silviculture (Fig. 2). Like the Apalachicola National Forest, the commercial timberlands were originally in longleaf pine savanna until 1950, after which time the second-growth longleaf pine was bedded and planted to slash pine (*P. elliottii*). Then from 1977 to 1980, all of the commercial slash pine plantations on the eastern half of the study area were clearcut and the site was roller chopped and replanted to sand pine (*P. clausa*). At the time of this study, these pines were 16 years old (Fig. 3).

We were fortunate that until 1998 the public was allowed unlimited access to the commercial paper company lands, but in that year roads were gated and posted by hunt clubs which leased the hunting rights and excluded trespassers. This prevented us from resurveying the ponds in subsequent years. Moreover, the most severe three-year drought on record set in at that time and most of the ponds dried out in 1999 and 2000 and remained dry until spring 2001. It is regrettable that we did not have the foresight in the

1970s to conduct a thorough inventory of pond-breeding amphibians over the entire study area that we could compare with the survey we conducted in the 1990s.

We sampled ponds for nine species of amphibians whose presence was likely to be detected because they were either winter-breeding amphibians with large, relatively long-lived or easily identifiable larvae (mole salamander, *Ambystoma talpoideum*; dwarf salamander, *Eurycea quadridigitata*; striped newt, *Notophthalmus perstriatus*; common newt, *N. viridescens*; gopher frog, *Rana capito*; leopard frog, *R. sphenocephala*; ornate chorus frog, *Pseudacris ornata*), loudly chorusing over a long period of time (spring peeper, *P. crucifer*), or aquatic and omnipresent (cricket frog, *Acris gryllus*).

During the winters of 1994-1997, we seined and dipnetted 245 ponds in the Woodville Karst Plain specifically looking for larvae, metamorphs, or adults of pond-breeding amphibians, with special emphasis on the striped newt and gopher frog. One hundred sixty (65 %) of the ponds were located on publicly owned lands of the Apalachicola National Forest and 85 (35 %) were located on privately owned commercial paper company lands. One of us (DBM) has casually seined and dipnetted many of these ponds over a 35-year period since 1966, establishing during that period important records for pond-breeding amphibians on the commercial paper company lands.

Ponds were found by inspecting USGS topographic quadrangles and Florida Department of Transportation aerial photographs, then reached by means of a four-wheel drive vehicle or on foot. Some ponds were discovered by simple field reconnaissance. Ponds were sampled in a standard fashion by listening for calling males and by 50 to 200 sweeps of a 24 X 46-cm dipnet (1 mm X 1 mm mesh) until we sampled and measured either 10 striped newts or made 50 or more sweeps of the dipnet. In larger ponds we pulled a 4' X 10' net with 1/4-inch mesh for a minimum of 10 seine hauls. Differences in the percent occupation of ponds by species were analyzed using chi-square analyses.

Results

Four species (*Eurycea quadridigitata, Notophthalmus perstriatus, N. viridescens, R. capito*) were much more common in the national forest ponds than in ponds on paper company lands (Table 1). *Ambystoma talpoideum* was found on 37% of ponds on national forest lands compared to 13% on paper company lands, a difference that was marginally significant (Table 1). The remaining 4 species did not differ significantly in pond occupancy between national forest and paper company lands. Only two species (*Acris gryllus, Pseudacris crucifer)* were found proportionally slightly more often on paper company lands, but for them and two other species (*P. ornata, Rana sphenocephala*) we found no significant differences (p = < 0.05) in pond utilization between the two areas (Table 1).

Discussion

Of the nine species of amphibians we censused, four did not differ significantly in their occurrence in ponds of both forest types. Five species were significantly reduced in their occurrence in ponds surrounded by sand pine versus longleaf pine, although this difference was marginal for the mole salamander. We see no reason why these five species were not once as common in ponds of the paper company lands as on the Apalachicola National Forest. Nothing about the geology or original physiography of the two halves of the study area explains why amphibians would utilize fewer ponds in the sand pine plantations than ponds in the native longleaf pine habitat. The reduced occurrence in breeding ponds of these five species probably has developed over the past three decades, therefore, and was probably the result of dramatic vegetative changes in the upland habitats surrounding the sand pine ponds (Fig. 4).

Among the species that were common in ponds on both study areas, the cricket frog is largely aquatic or a wetlands dweller as an adult, occurring in and around the margins of water bodies all its life (Wright and Wright, 1949). We would not have expected the occurrence of this species in ponds on the two types of forests to be different. Likewise, the leopard frog spends most of its adult life in wetlands surrounding water bodies, but it is also noted for long-distance dispersal overland during rains at all seasons (Wright and Wright, 1949).

It is interesting that the two species of *Pseudacris* (spring peeper and ornate chorus frog) did not differ significantly in pond utilization on the different halves of the study area because both live in the uplands as adults (Brown and Means, 1984). Very little is known about the adult habitat and microhabitat requirements of either of these species. The spring peeper lives in damp places in wooded areas after metamorphosis (Mount, 1975), such as the mesic hardwood forests that surrounded a few of our study ponds. It is a terrestrial frog, living in leaf litter on the forest floor. We have observed it several times moving out of the ground litter during creeping ground fires in hardwood hammock vegetation (personal observations), notwithstanding the statement that "they apparently live high in trees during summer" (Ashton and Ashton, 1988).

The ornate chorus frog, after metamorphosis, burrows underground and is distributed rather ubiquitously in longleaf pine savanna in all the major types of soils such as clayhills, sandhills, or flatwoods (Brown and Means, 1984). We have studied populations that recovered from agriculture and were living and reproducing in ponds in oldfield successional forests of mixed hardwoods and pines (Brown and Means, 1984). Its ability to survive agriculture and its ubiquitous distribution throughout its range probably explain why it has not declined significantly in the sand pine forest.

The mole salamander migrates into woodlands surrounding its natal ponds where it spends a fossorial life (Semlitsch, 1981). This species has high reproductive potential, however, and breeds in several waves during winter. It also has the ability to become sexually mature and breed in the larval morphology without leaving its natal pond if the hydroperiod is favorable in any given year (Petranka, 1998). Never-the-less, this species does utilize only about half the paper company ponds than are utilized on national forest lands.

We found the dwarf salamander, striped newt, common newt, and the gopher frog in far fewer ponds on paper company lands than expected, all things being equal. Three of these species (dwarf salamander, common newt, and gopher frog) were present in one or more ponds in the sand pine forests (Table 1), but we failed to find the striped newt. Evidence exists that at least two of these species were more common in ponds there in the past. An old record for the striped newt exists (UF-74097-98) on paper company lands, and records for the gopher tortoise are presented below.

In the mid-1970s, while the paper company half of the study area was still in slash pine plantations, one of us (DBM) found juvenile and adult gopher frogs in four old gopher tortoise burrows scattered about in Sec 35, T1S, R1E on 11 July 1969 and 17-19 July 1970, and heard adult males calling from a pond on 25 March 1987. During our survey, we made intensive efforts to seine and dipnet this same pond and 7 adjacent ponds for tadpoles of the gopher frog on four dates from 31 December 1996 through 31 May 1997 but found none. This was during the period when gopher frog tadpoles were abundant in 26 ponds on the national forest lands and also in a single pond on paper company lands, 3.0 km SE. The terrain is classic rolling sandhills that is well known as prime habitat for the gopher frog (Franz and Smith, 1994).

The dwarf salamander lives most of its adult life in the wetlands surrounding its breeding pond (Petranka, 1998) and one would not have expected silvicultural alterations of the uplands adjacent to its breeding ponds to have an effect on its populations. We are unable to explain why we found significantly fewer ponds containing larvae on the paper company lands in comparison with ponds on the national forest.

As far as we know and could observe, the water quality and general ecological integrity of the breeding ponds were the same in the sand pine plantations as in the longleaf pine forest. The most obvious difference, however, between the paper company and national forest halves of the study area was the drastic change that has taken place over the years in the vegetation of the paper company lands (Figs. 2, 5). Aerial photographs from the 1940s reveal that the paper company half of the study area was originally vegetated in longleaf pine savanna just as on the national forest half, but for for the past 5 decades it was planted to slash pine, then to sand pine. Sand pine does not naturally occur inland more than a kilometer or two from the seacoast in the Florida panhandle (Davis, 1967), so it is an exotic tree species on the soils of the Woodville Karst Plain. The ecology of sand pine forests is very different from that of longleaf pine forests. Sand pine normally grows in dense stands that do not permit much light to reach the ground (Myers, 1990; Fig. 4B, 6B), whereas longleaf pine is an open-canopy forest with a lush and highly diverse groundcover (Bridges and Orzell, 1989; Peet and Allard, 1993; Platt, 1999). Under intensive silviculture, sand pine becomes a virtual desert of needle and twig litter on the forest floor (Fig. 4B), an ecological condition highly alien to what was once a sandhills longleaf pine savanna.

Sand pine plantations have dramatically altered the structural characteristics of the native longleaf pine forest (Noel et al., 1998). We were unable to find any stumpholes or tree bases because the sand pine plantations had undergone stump removal and mechanical site preparation during both the slash and sand pine plantings that took place there in the past (see the discussion of the importance to vertebrates of stumpholes and pine tree bases in this book, Means, 2002). Moreover, from the late 1960s through the 1980s on the paper company lands, gopher tortoise burrows were common in the slash pine plantations (personal observations) because the slash pines were growing very poorly and sparsely on the deep, sandy soils, allowing for the groundcover vegetation to survive and provide food for the tortoises. During this study, under the closed sand pine canopy, we found no active gopher tortoise burrows and those that we had marked following clearcutting of the slash pines in 1981 had either collapsed, were buried, or were no longer active (Fig. 5).

For the five species of amphibians that were underrepresented in ponds of the sand pine plantations, altered structural characteristics in the sand pine forests may have changed the microhabitat relationships needed for living space and protection from environmental stresses and predation. Another ecological change, however, may have had a greater impact on their populations. The trophic relationships of the forest floor have changed from a situation in which the food webs were driven by primary productivity to one that is now driven by detritus. Live vegetable matter necessary to support herbivores has been replaced by dead pine litter. Chewing insects and macro-herbivores such as the gopher tortoise have nothing to eat. Aresco and Guyer (1999) have documented gopher tortoise declines in slash pine plantations and we have observed the same for the gopher tortoise in the sand pine plantations of our study area (Fig. 5). All nine species of amphibians in this study are insectivores or carnivores requiring live arthropods and/or small vertebrates in their diet (Petranka, 1998; Wright and Wright, 1949).

High levels of variation in breeding population sizes and larval success of amphibians in breeding ponds have been documented in the southeastern U. S., but these have usually been recorded from year to year--and even over long periods up to 16 years--

in a single pond (Semlitsch et al., 1996). In this study we compare the proportional use by amphibians of many ponds between two halves of a geologically uniform region with major differences in land management practices. Neither approach allowed for the direct measurement of amphibian populations in upland habitats, but breeding population sizes can be affected by what takes place annually or over longer bouts of time in the uplands. Semlitsch et al. (1996) reported on the structure and dynamics of an amphibian community utilizing a natural pond in South Carolina, finding that hydroperiod, predation, and competition in the pond all had detectable influences on their amphibian community. Unfortunately, like us, they did not assess the effects of rainfall, soil moisture, vegetation, land management, predation, or competition on the adult populations of amphibians living in the uplands surrounding their pond, but a growing number of studies (e.g. Johnson, this book) are recognizing that the amount of the uplands adjacent to small isolated water bodies is important and even critical in the survival of amphibians that utilize the ponds (Semlitsch and Jensen, 2001).

Burke and Gibbons (1995) showed that nesting and hibernation sites of pond-inhabiting turtles in a Carolina Bay occurred extensively beyond wetland boundaries delineated by federal guidelines. Dodd and Cade (1997) showed that there was both a distance and directional component to the terrestrial habitat sought by amphibians emigrating from a temporary pond in north Florida. Likewise the width of terrestrial habitat along streams was found to be critical to the abundance of both reptiles and amphibians (Rudolph and Dickson, 1990).

Thus, both the amount *and* the quality of terrestrial habitat surrounding the breeding wetlands of amphibians is critical to amphibian conservation. As this point relates to our study, it is not enough to set aside a "terrestrial buffer" of longleaf pine forest if it is not burned regularly, nor is it sufficient to expect that plantations of off-site pine species are an adequate substitute for longleaf pine habitat in its native condition.

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Table 1.—Number and percentages of Woodville Karst Plain ponds in which nine species of amphibians were found, ranked by decreasing percentage of ponds occupied on the Apalachicola National Forest, and compared with percentages of ponds occupied on paper company lands. Ponds on the national forest half of the study area, n = 160; paper company half, n = 85. * = significant at p < 0,05.

Species	national forest ponds		paper company ponds		
	#	%-age	#	%-age	chi square
Acris gryllus	65	40.6 %	36	42.4 %	0.7937
Rana sphenocephala	53	33.1 %	23	27.1 %	0.3285
Pseudacris ornata	42	26.3 %	15	17.6 %	0.1293
Ambystoma talpoideum	37	23.1 %	11	12.9 %	0.0559
Rana capito	26	16.3 %	1	1.2 %	0.0003*
Notophthalmus viridescens	21	13.1 %	2	2.4 %	0.0059*
Eurycea quadridigitata	18	11.3 %	3	3.5 %	0.0399*
N. perstriatus	17	10.6 %	0	0.0 %	0.0018*
Pseudacris crucifer	8	5.0 %	7	8.2 %	0.3147

Figure 1.--Woodville Karst Plain study area showing the location of 245 ponds sampled for this study from 1994-1997. Ponds (n = 85) on the east side of Woodville Highway are on privately owned paper compamy lands planted to sand pine (*Pinus clausa*); ponds (n = 160) on the west side of Woodville Highway are on the Apalachicola National Forest vegetated by native longleaf pine savanna.

Figure 2.--Aerial photograph of part of the Woodville Karst Plain showing closed canopy aspect of sand pine plantations on the east side of Woodville Highway and open canopy aspect of longleaf pine/wiregrass sandhill vegetation on the west side; 19 January 1996.

Figure 3.--Identical views to the east down Capital Circle Southeast showing: top = residual turkey oak/wiregrass vegetation following clearcutting of slash pine plantation on both sides of highway, April 1981; and bottom = densely stocked sand pine plantation at the same photo point 16 years later at the time of our study, 22 October 1997.

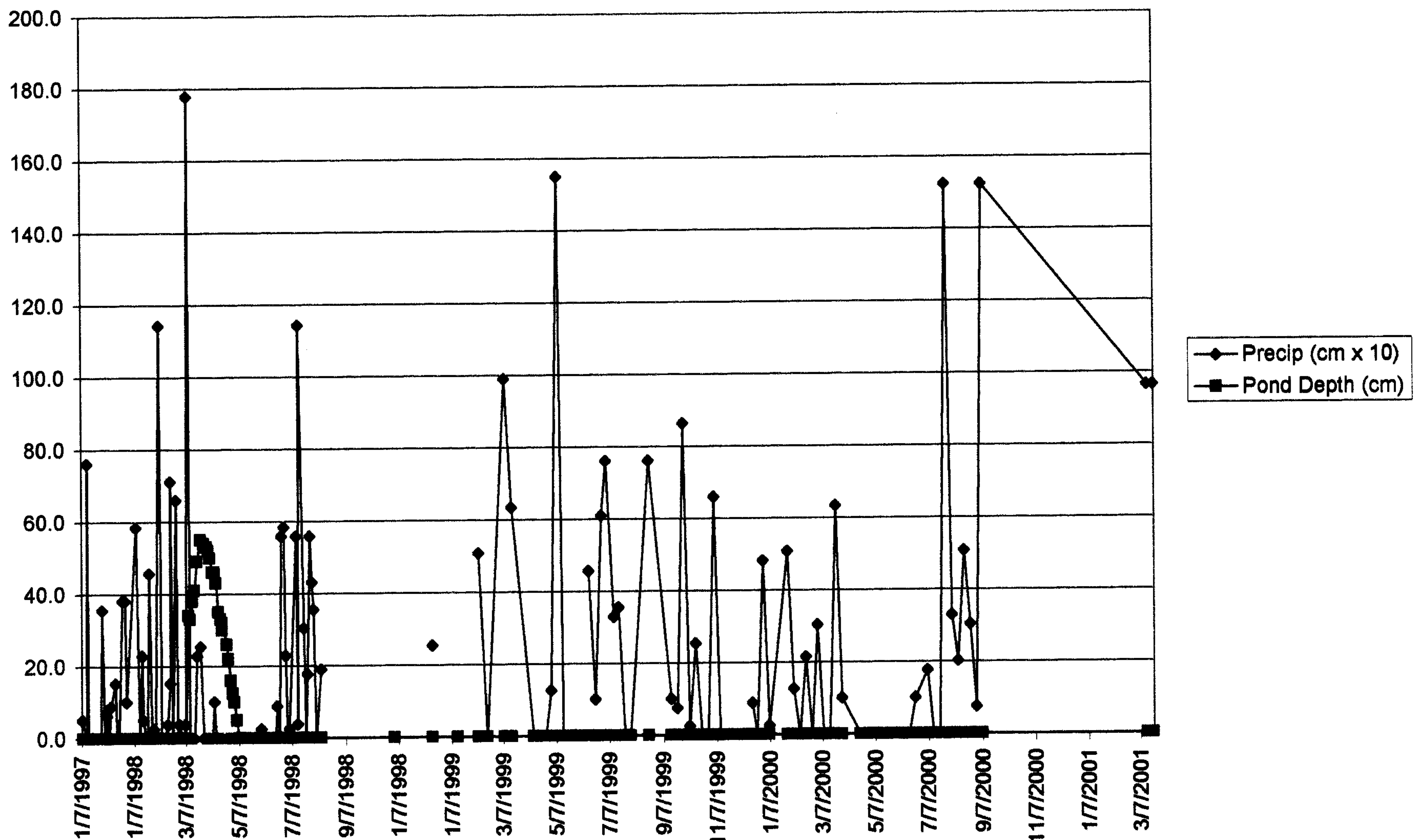
Figure 4.--Top = Looking east into the third forest surrounding study pond #184, a sand pine plantation that has replaced the original native longleaf pine sandhills vegetation which was first replaced by a slash pine plantation; 26 February 1997. As recently as 25 March 1987, this was a breeding pond for *Rana capito*, but exhaustive sampling in 1997 failed to turn up any tadpoles during the period when widespread breeding had taken place in the Woodville Karst Plain. Bottom = looking west back to study pond #184 from inside the sand pine plantation. Groundcover flora is almost absent, only needle and twig litter and a few ground lichens are present.

Figure 5.--Top = active gopher tortoise burrow on recent clearcut site south of Capital Circle Southeast showing residual native turkey oak/wiregrass vegetation in spite of 20 years of slash pine plantation, April 1981. Bottom = same burrow 16 years later, now inactive because canopy closure of planted sand pines has shaded out native groundcover (see Aresco and Guyer, 1999).

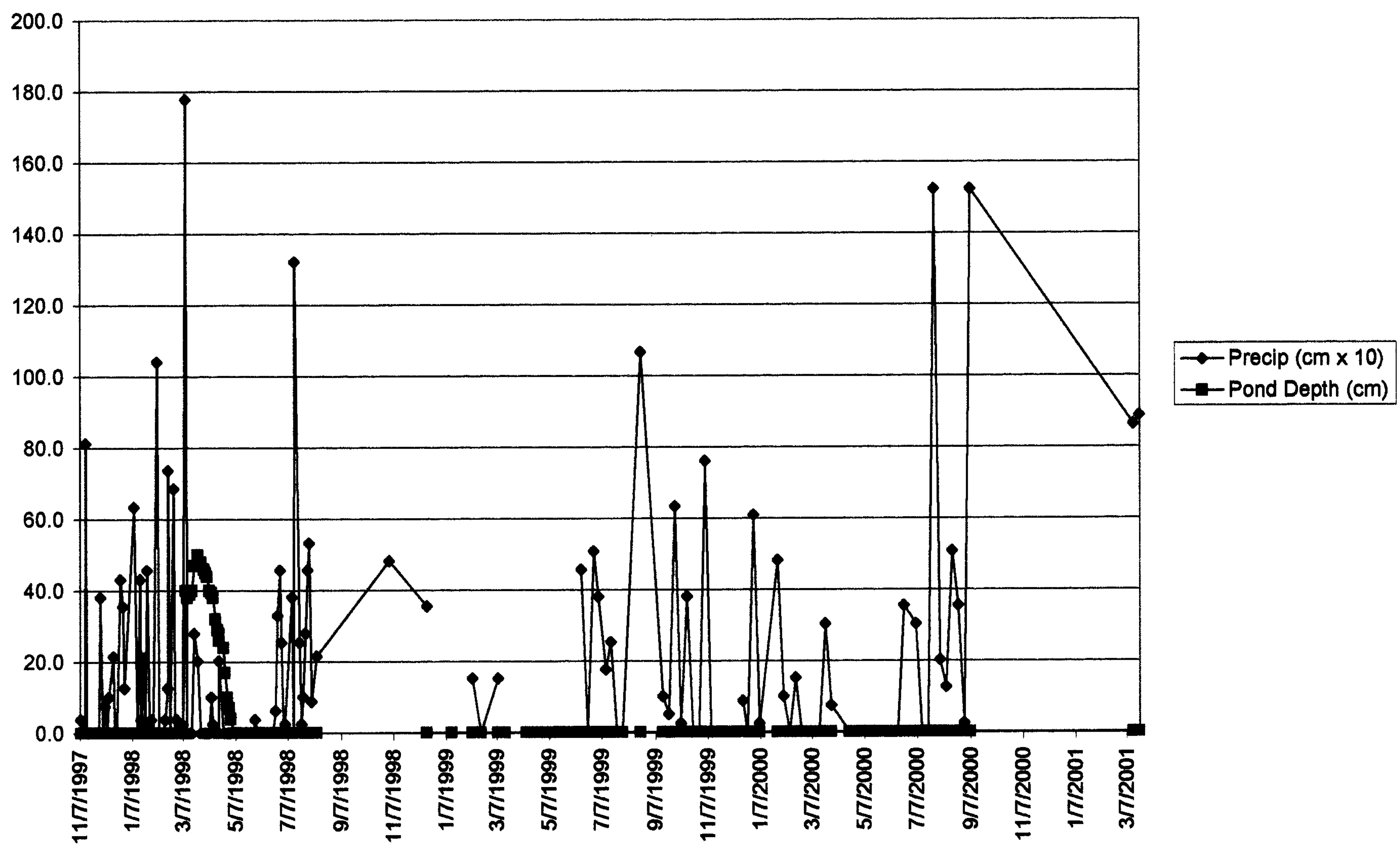
Appendix III.

Water Levels and Rainfall for 25 Ponds in the Munson Sandhills, Leon County, Florida for the Three-year Period, November 1997 - November 2000.

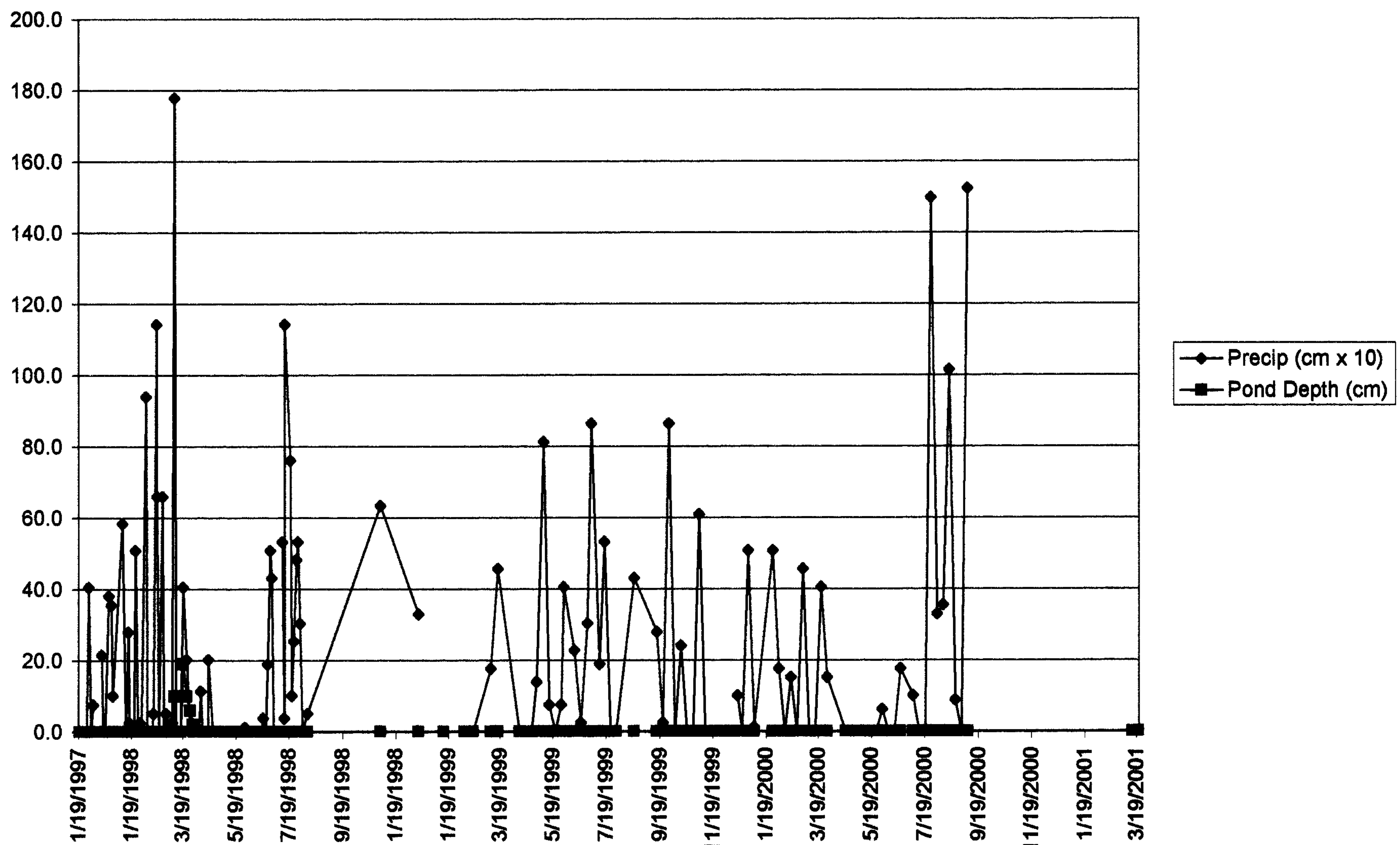
Precipitation and Pond Depth for Study Pond 19 from 11/97 to 3/01



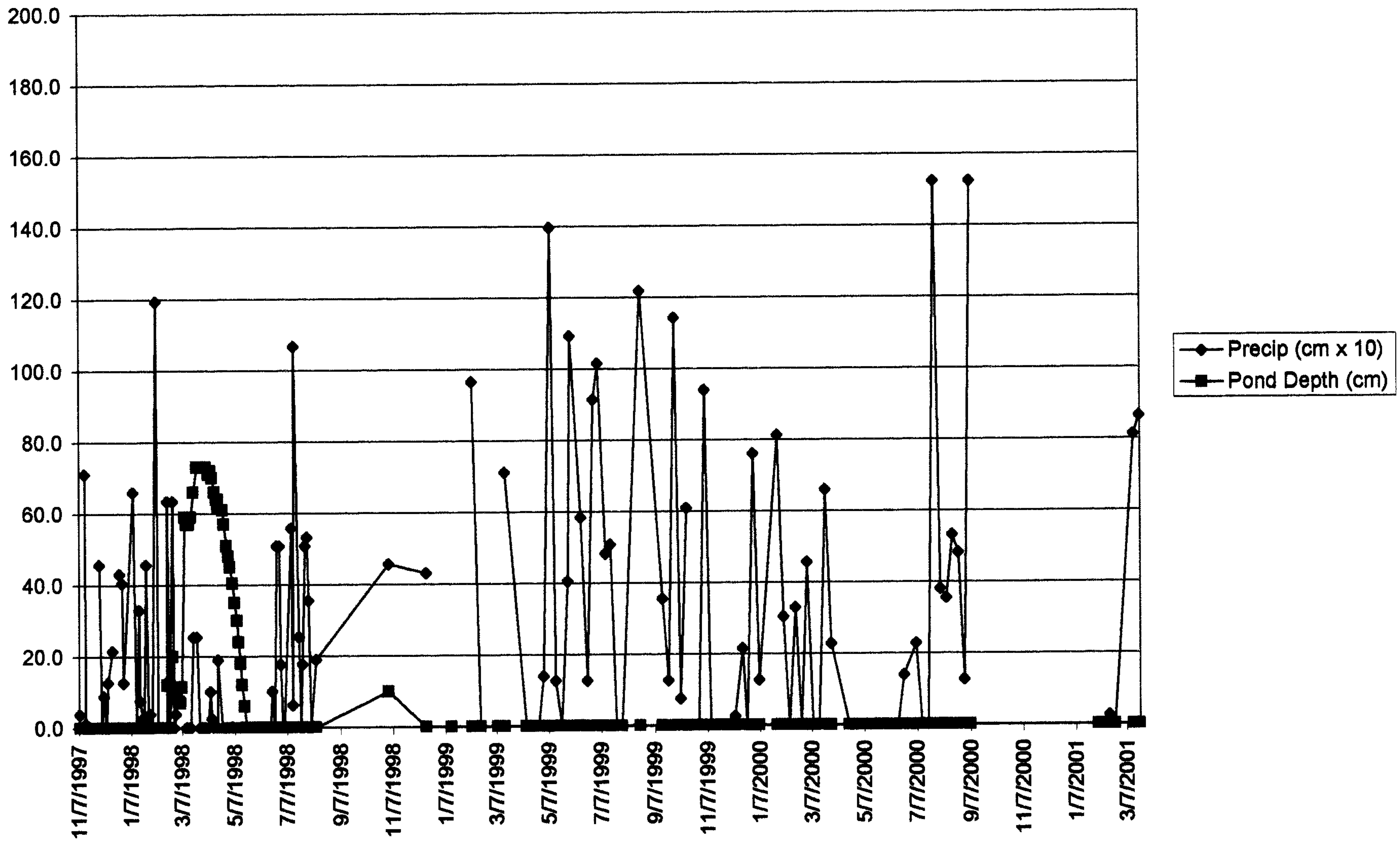
Precipitation and Pond Depth for Study Pond 21 from 11/97 to 3/01



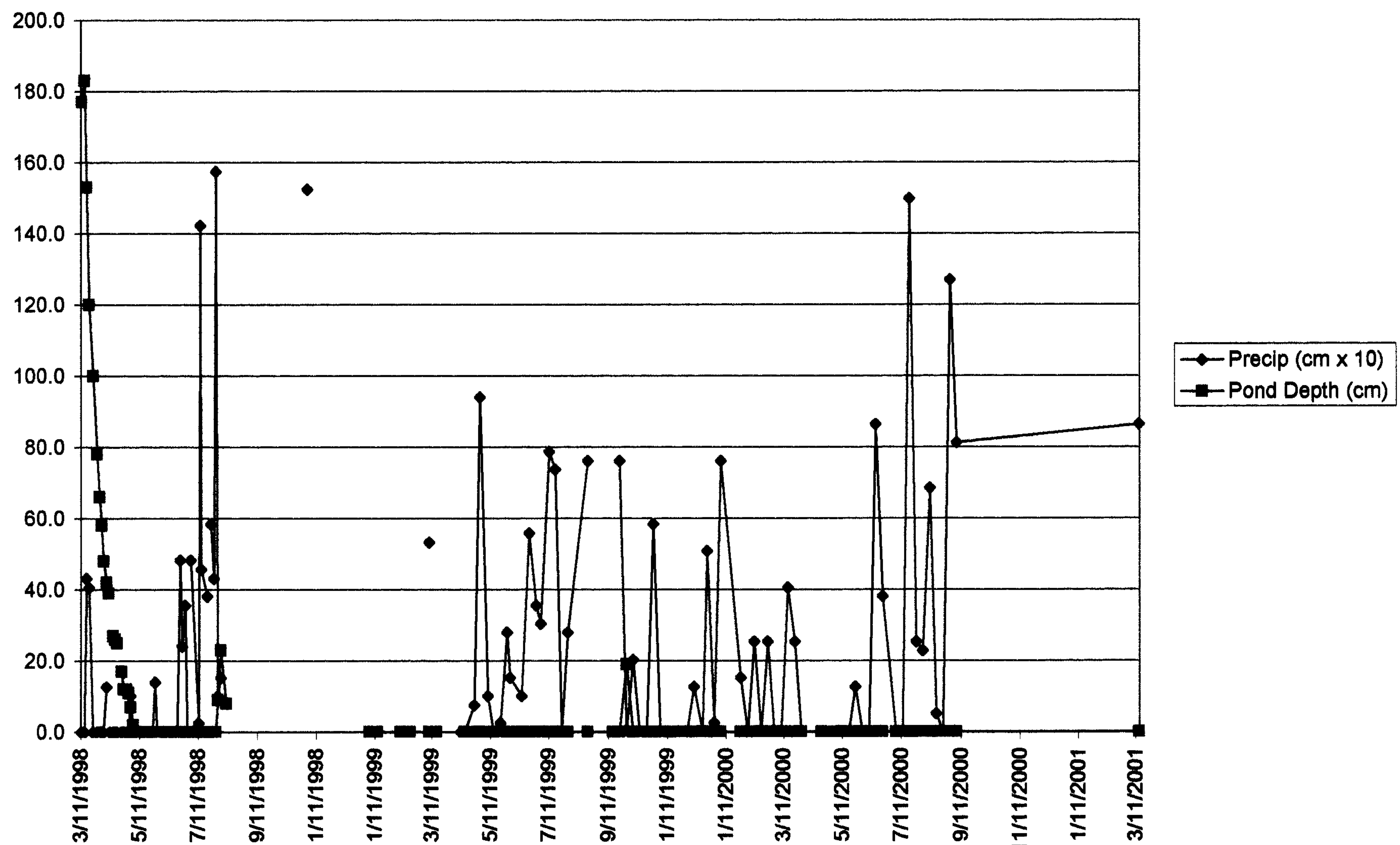
Precipitation and Pond Depth for Study Pond 92 from 11/97 to 3/01



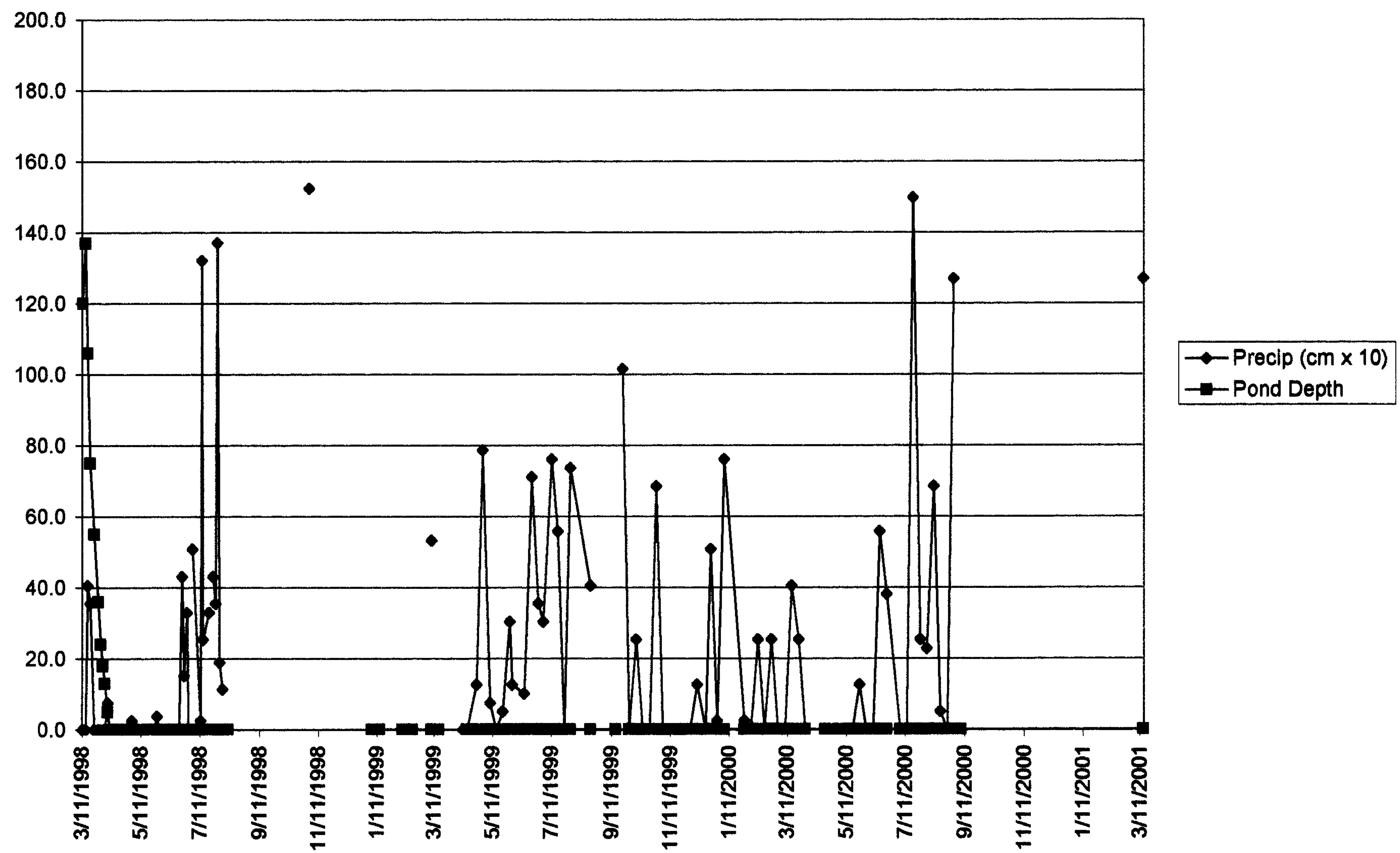
Precipitation and Pond Depth for Study Pond 182 from 11/97 to 3/01



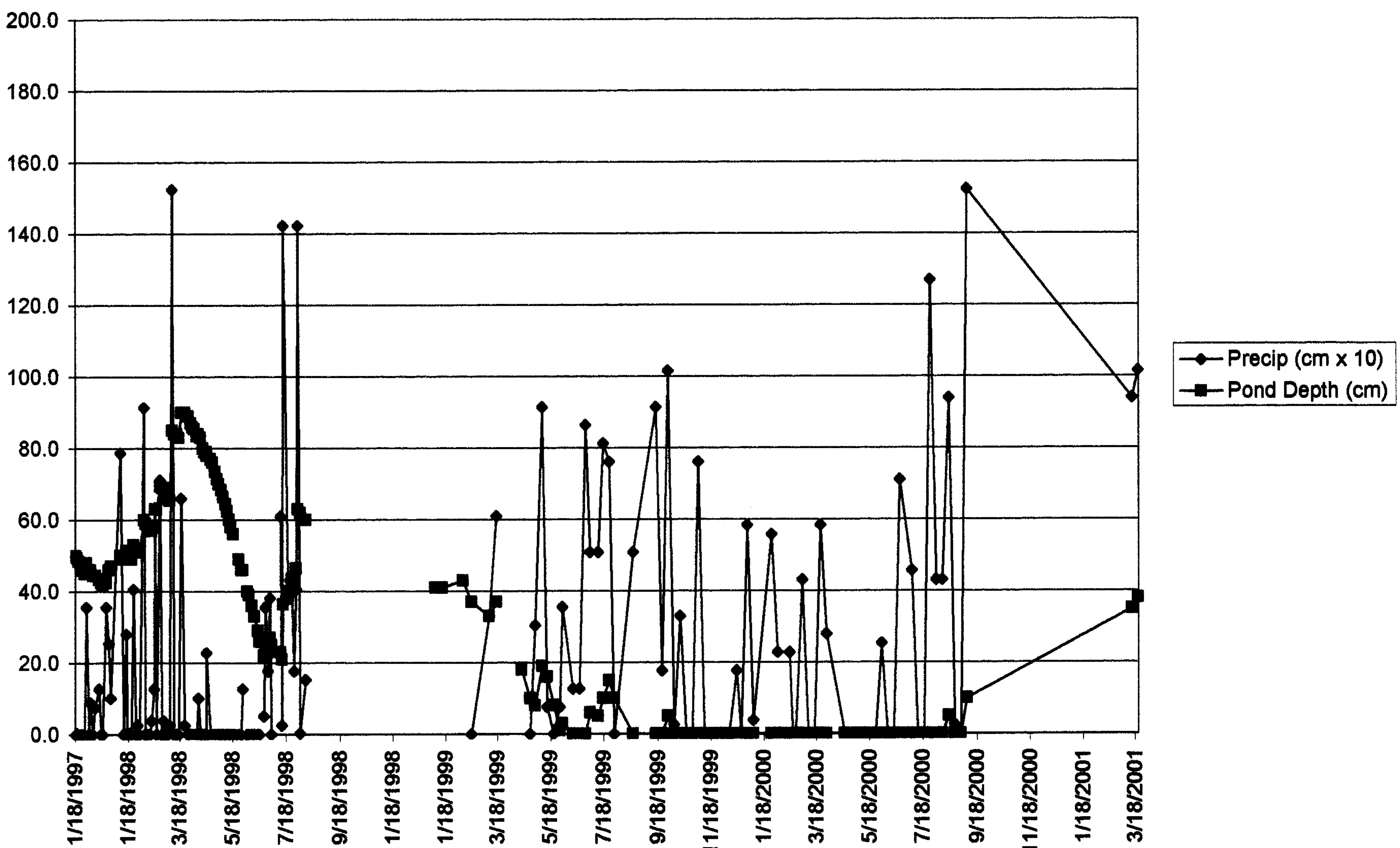
Precipitation and Pond Depth for Study Pond Hammock from 11/97 to 3/01



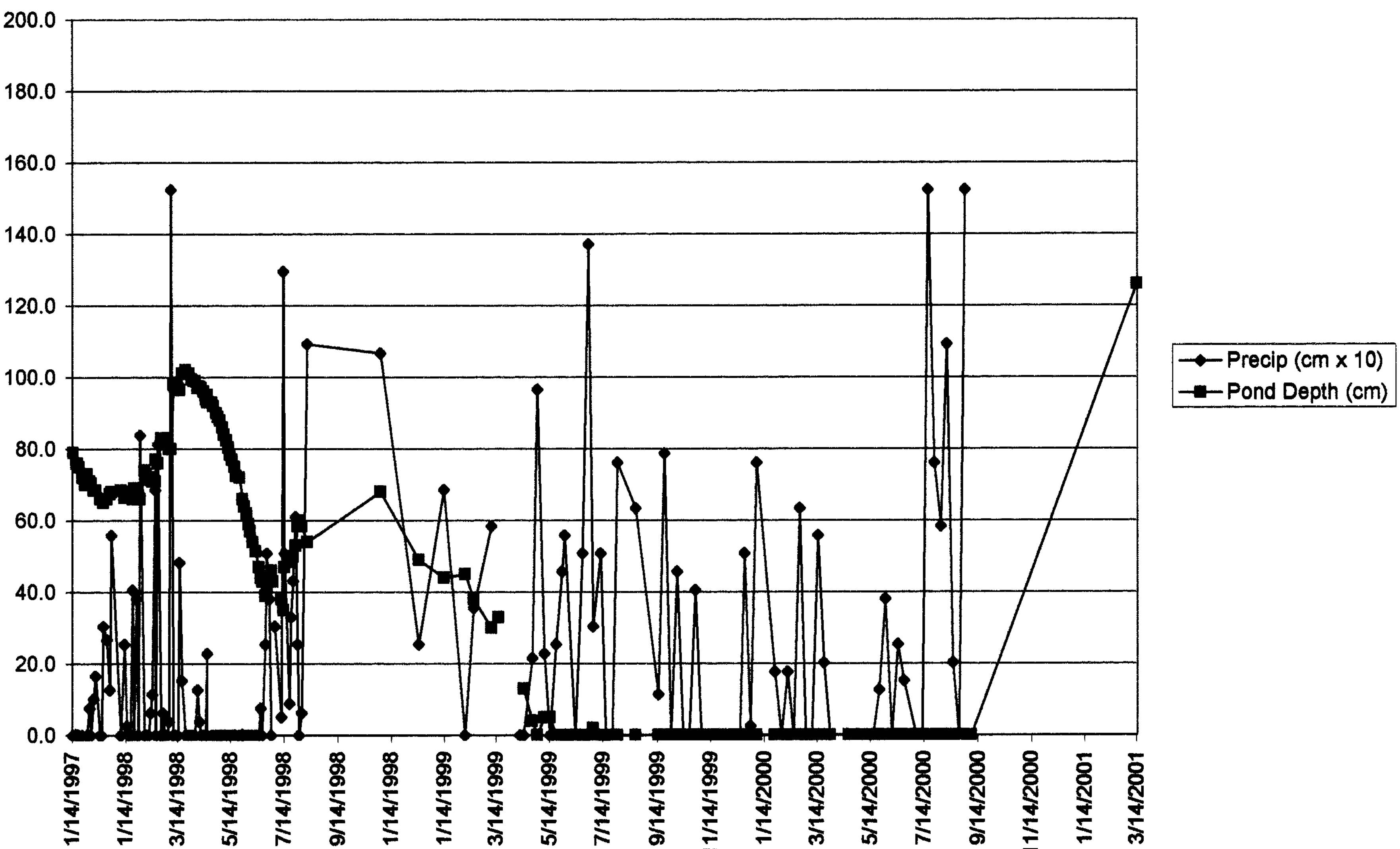
Precipitation and Pond Depth for Study Pond Gopher from 11/97 to 3/01



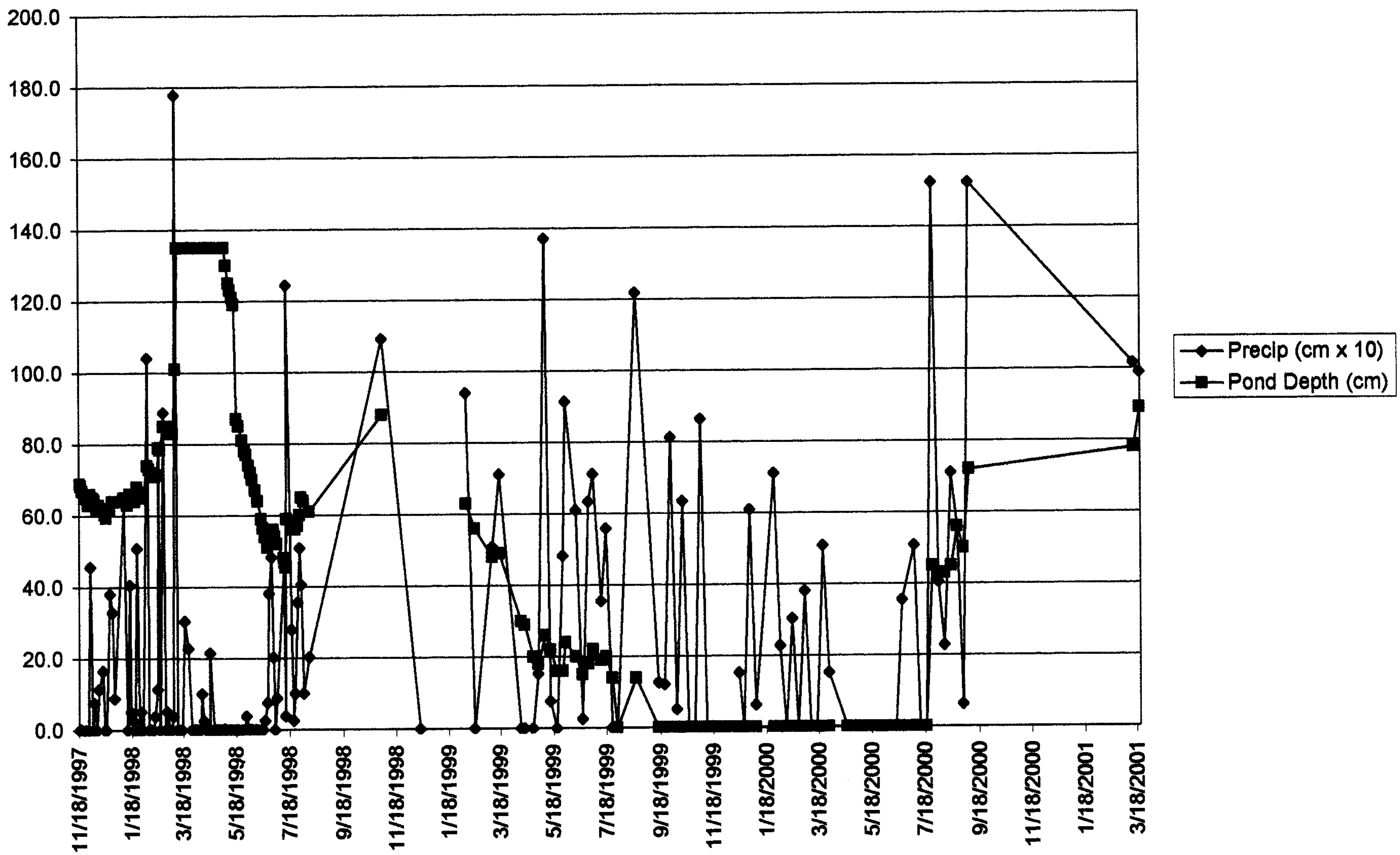
Precipitation and Pond Depth for Study Pond 5 from 11/97 to 3/01



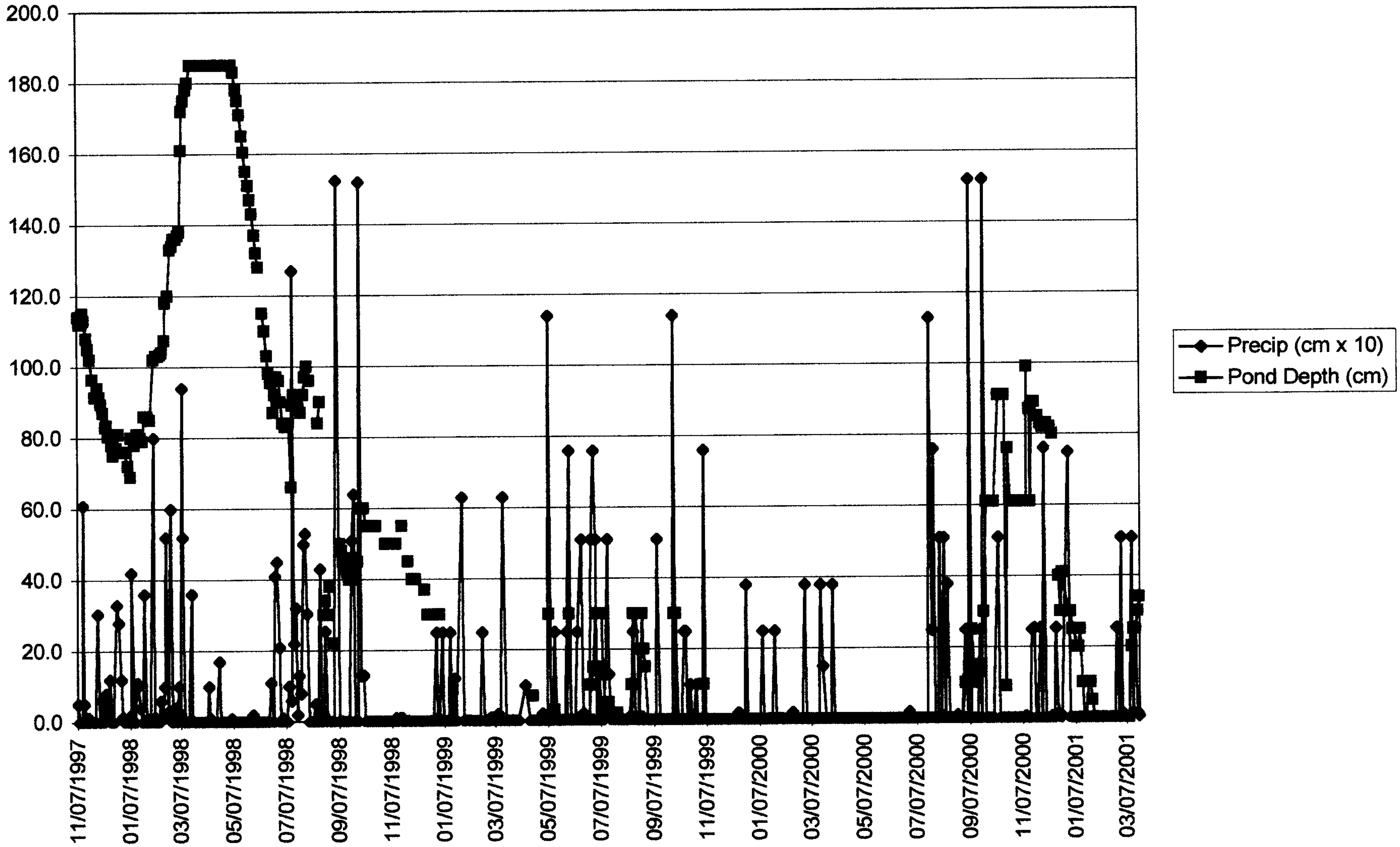
Precipitation and Pond Depth for Study Pond 55 from 11/97 to 3/01



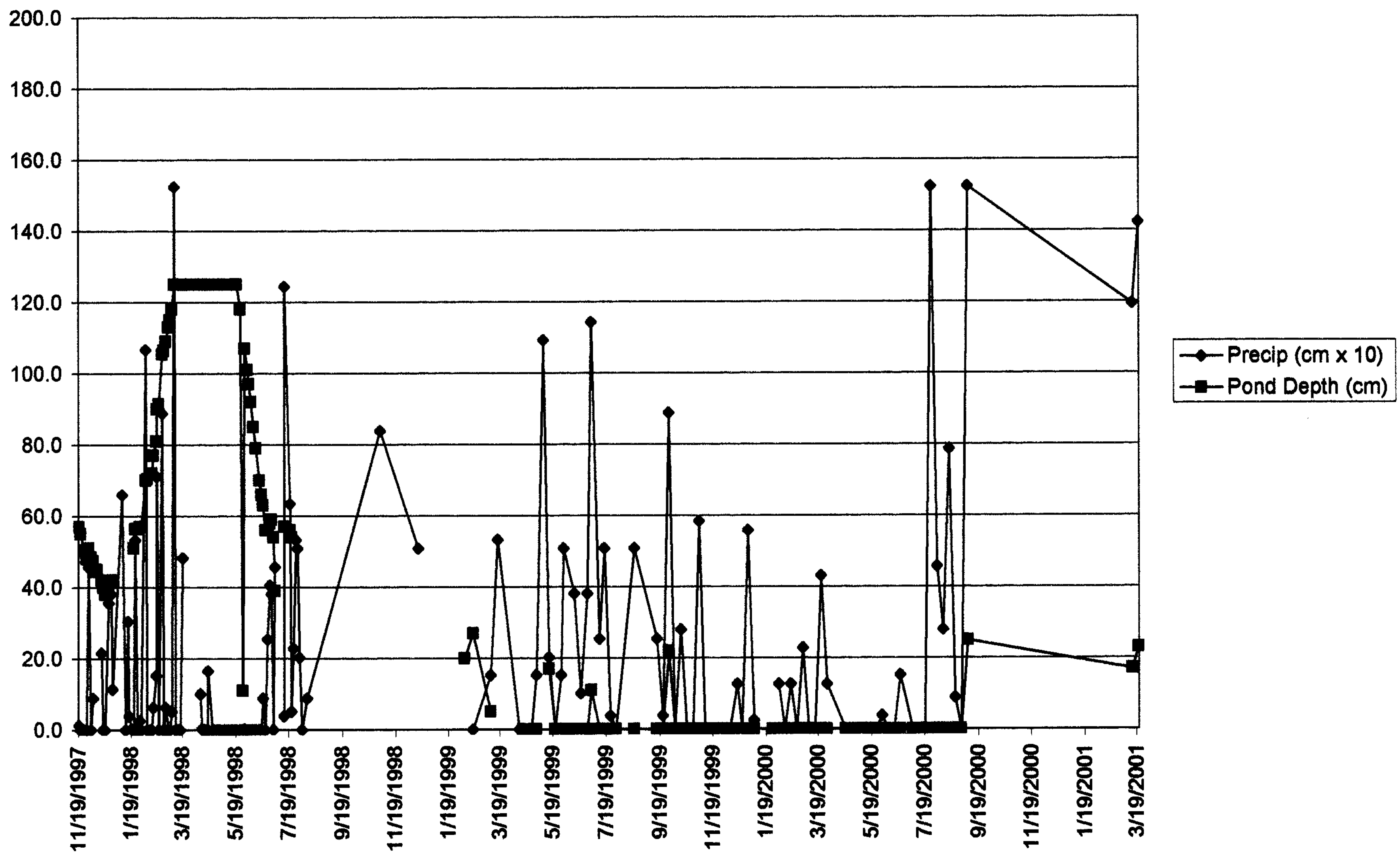
Precipitation and Pond Depth for Study Pond 178 from 11/97 to 3/01



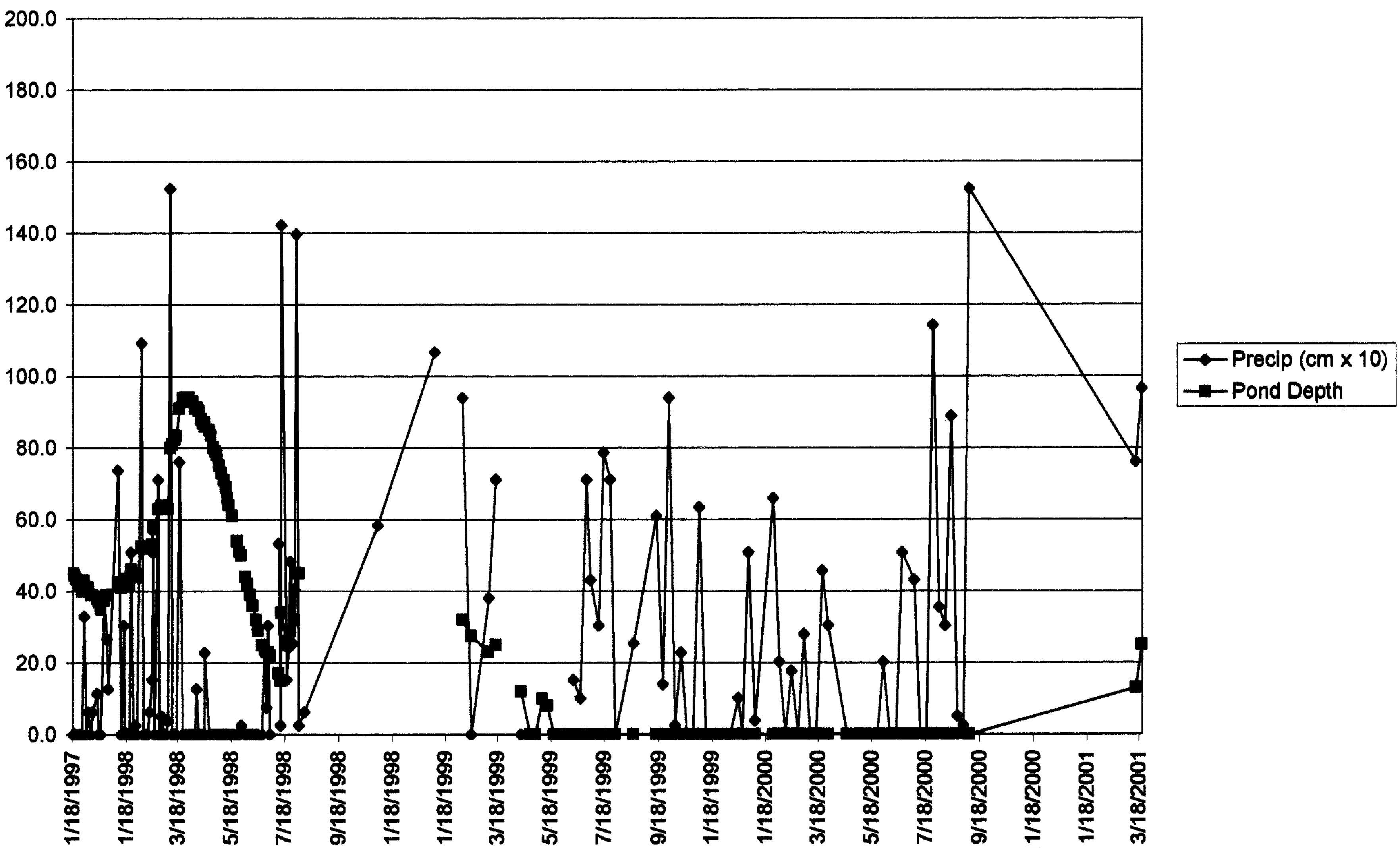
Precipitation and Pond Depth for Study Pond 1 from 11/97 to 3/01



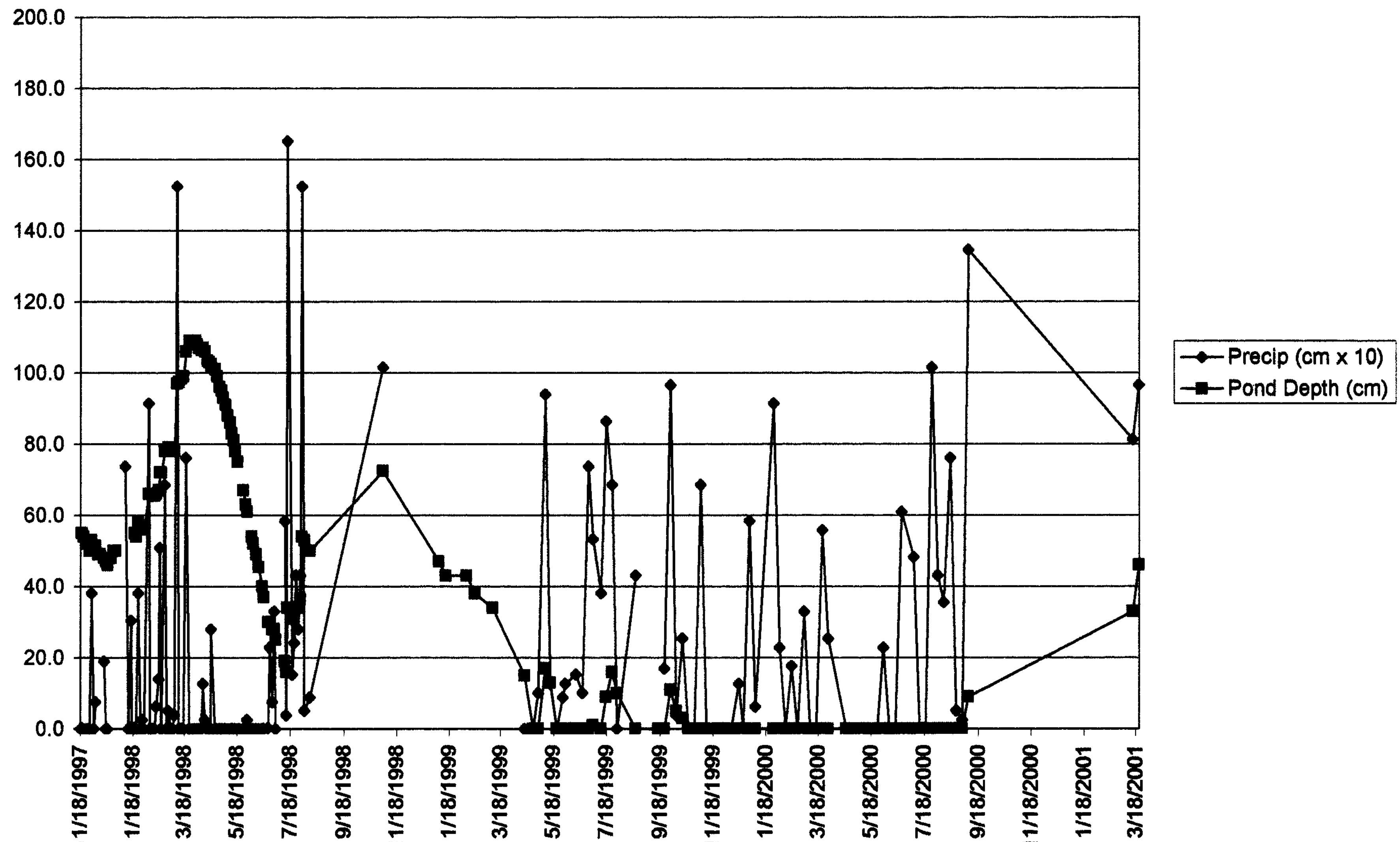
Precipitation and Pond Depth for Study Pond 3 from 11/97 to 3/01



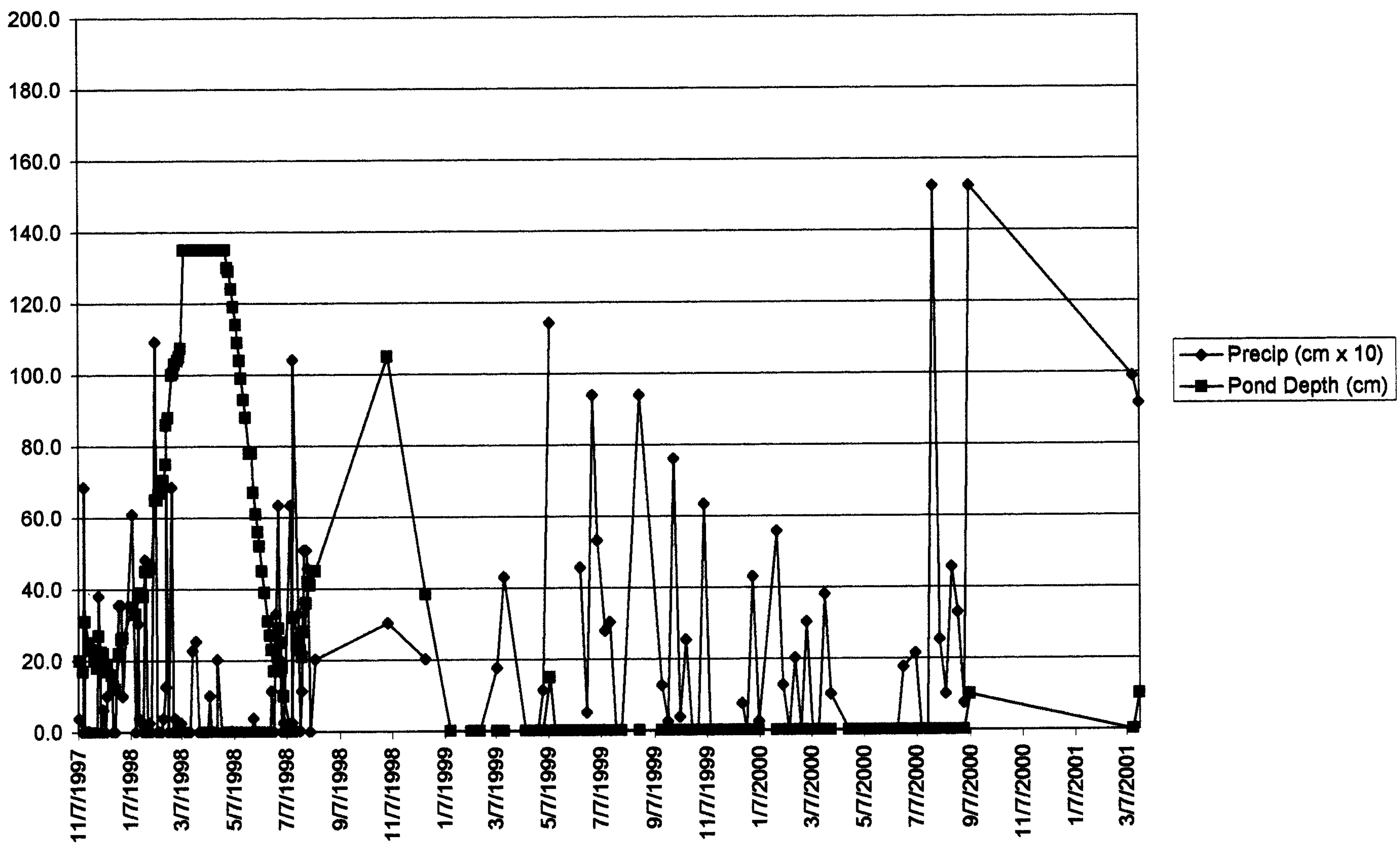
Precipitation and Pond Depth for Study Pond 6 from 11/97 to 3/01



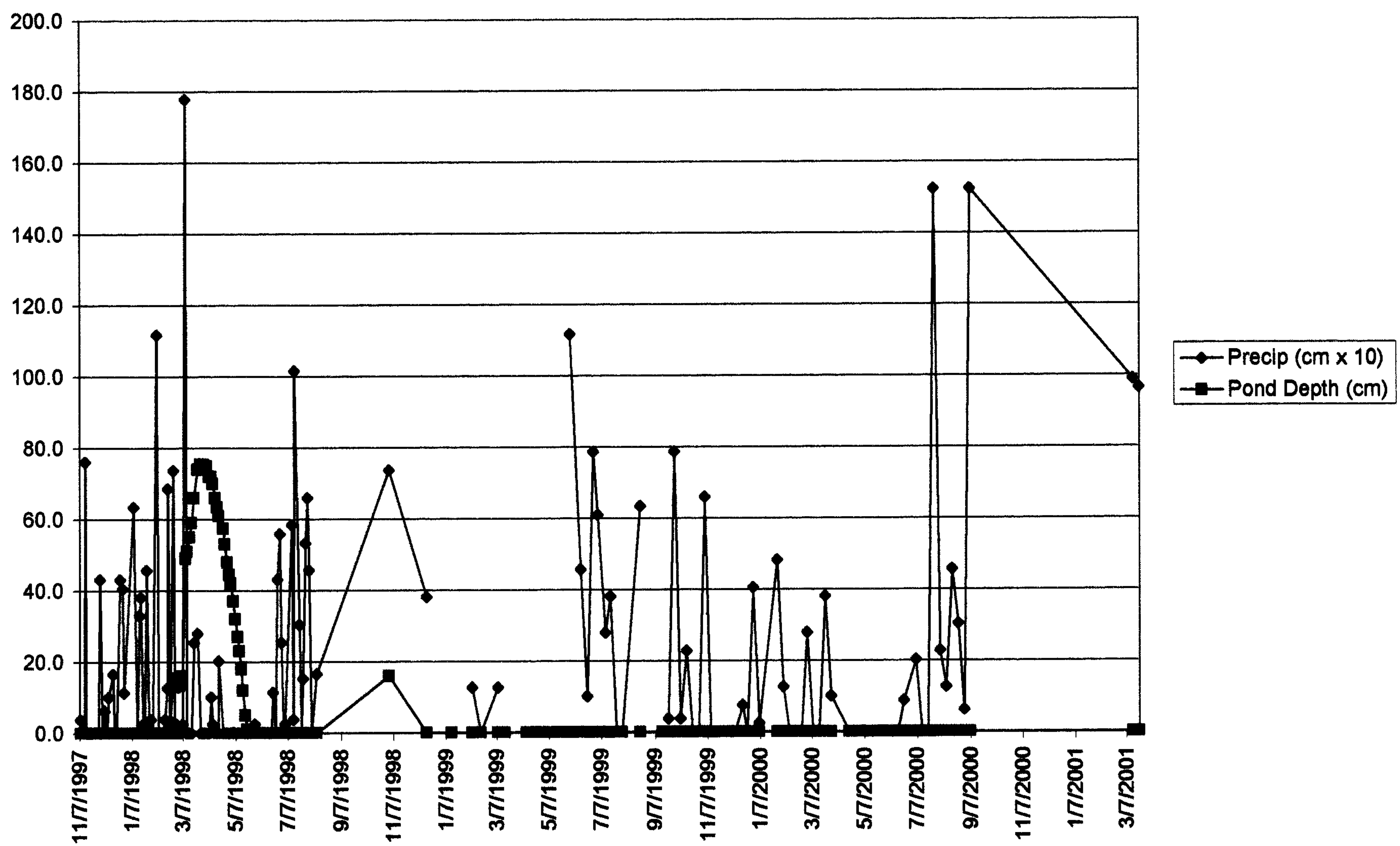
Precipitation and Pond Depth for Study Pond 7 from 11/97 to 3/01



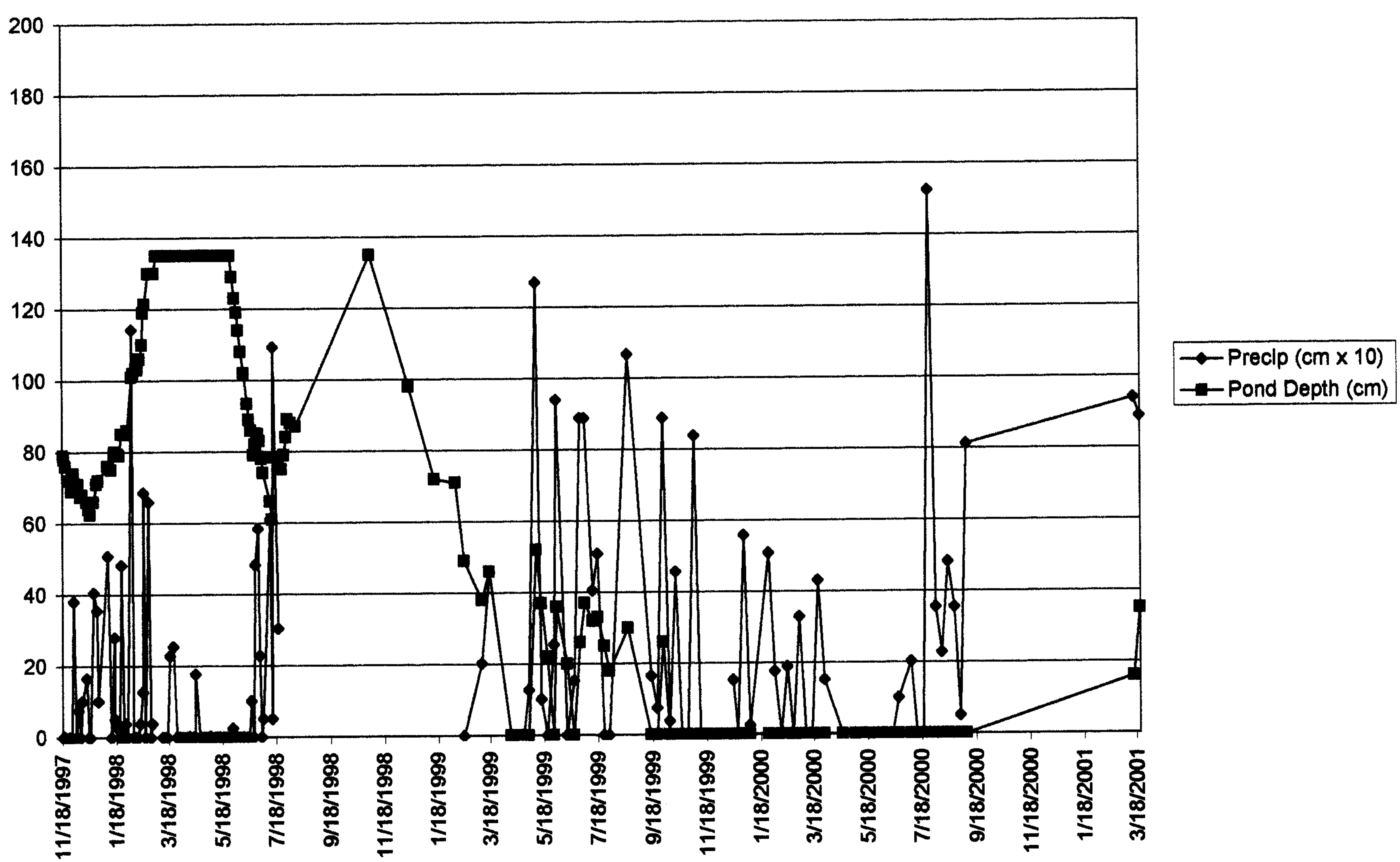
Precipitation and Pond Depth for Study Pond 17 from 11/97 to 3/01



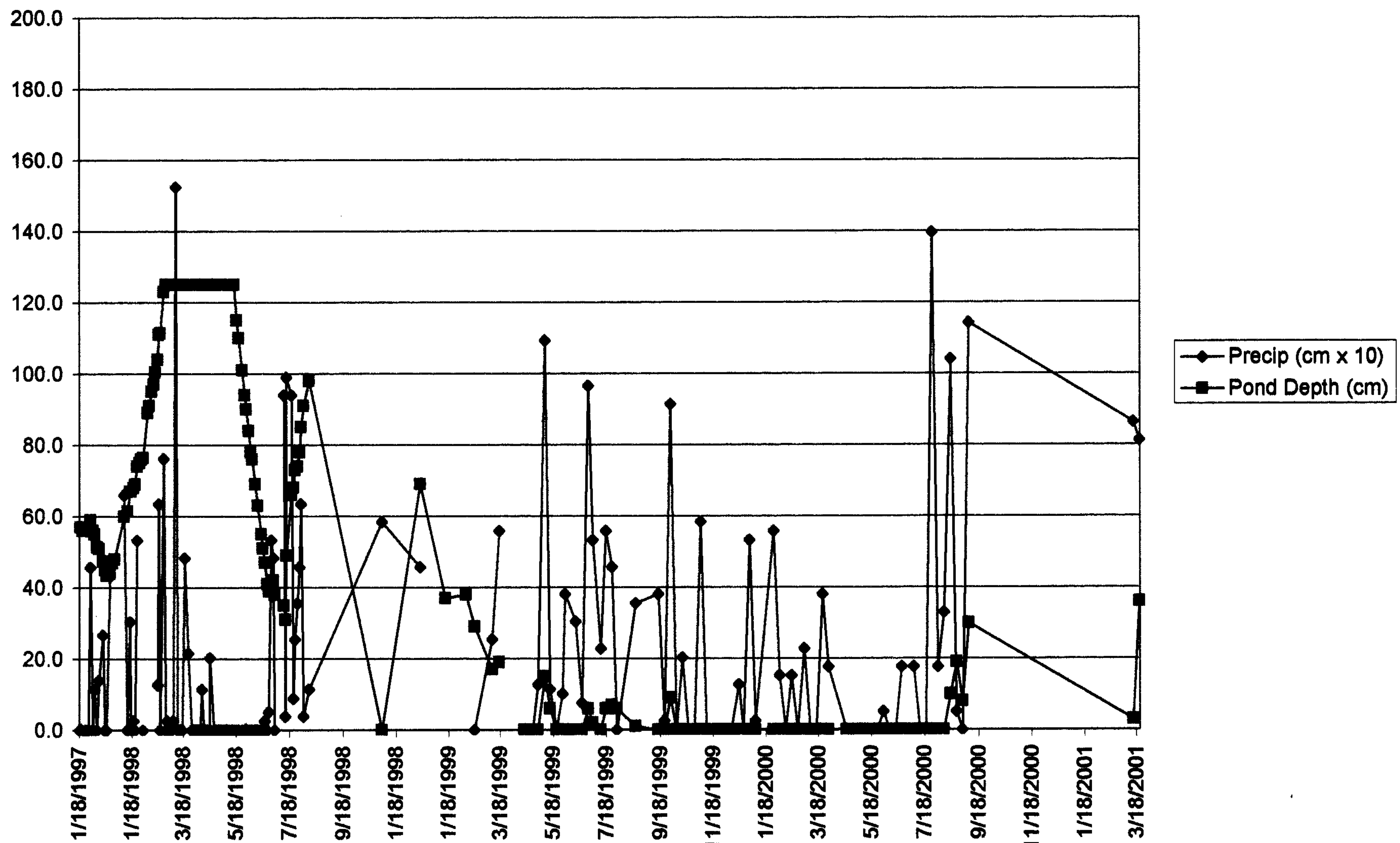
Precipitation and Pond Depth for Study Pond 18 from 11/97 to 3/01



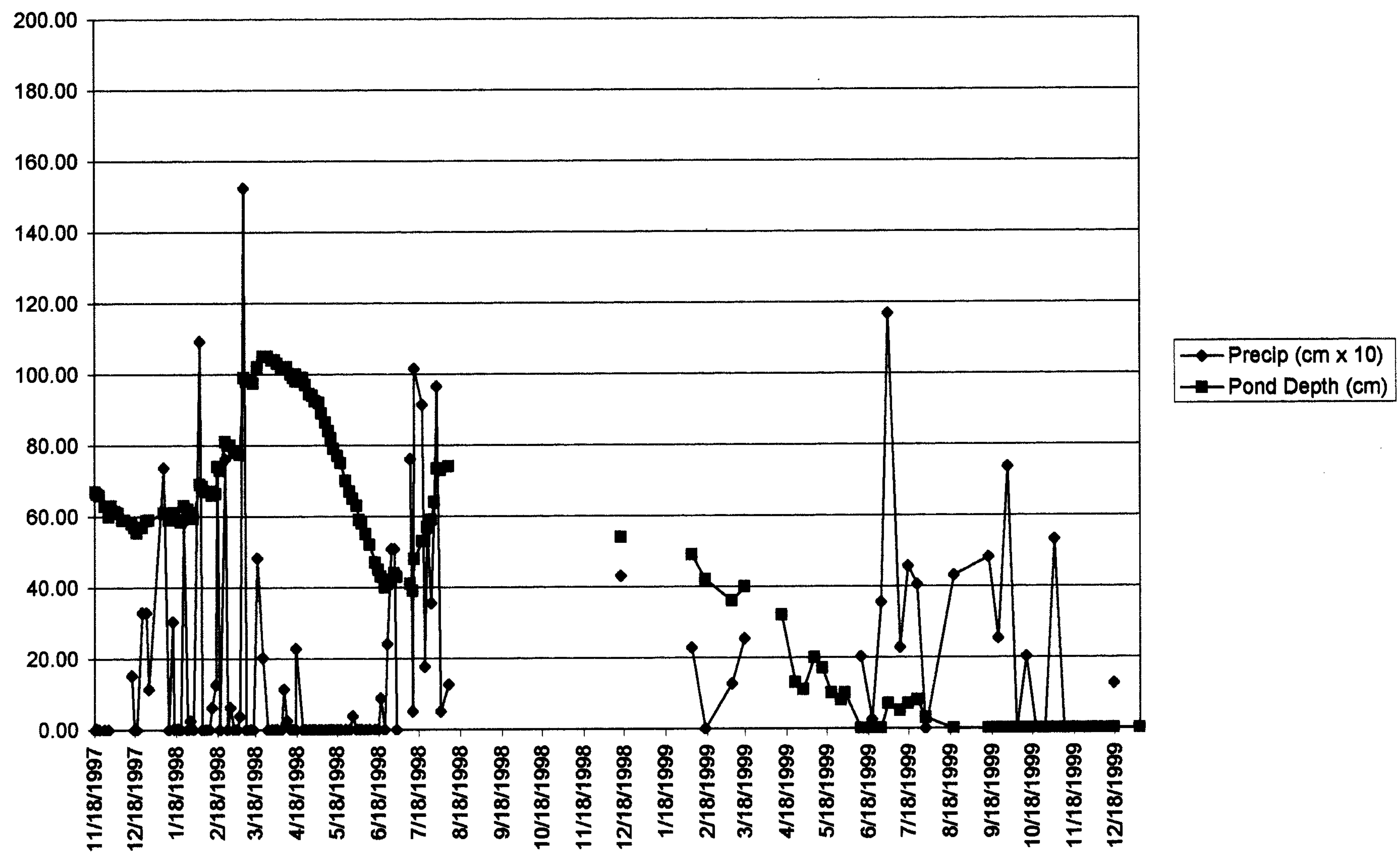
Precipitation and Pond Depth for Study Pond 20 from 11/97 to 3/01



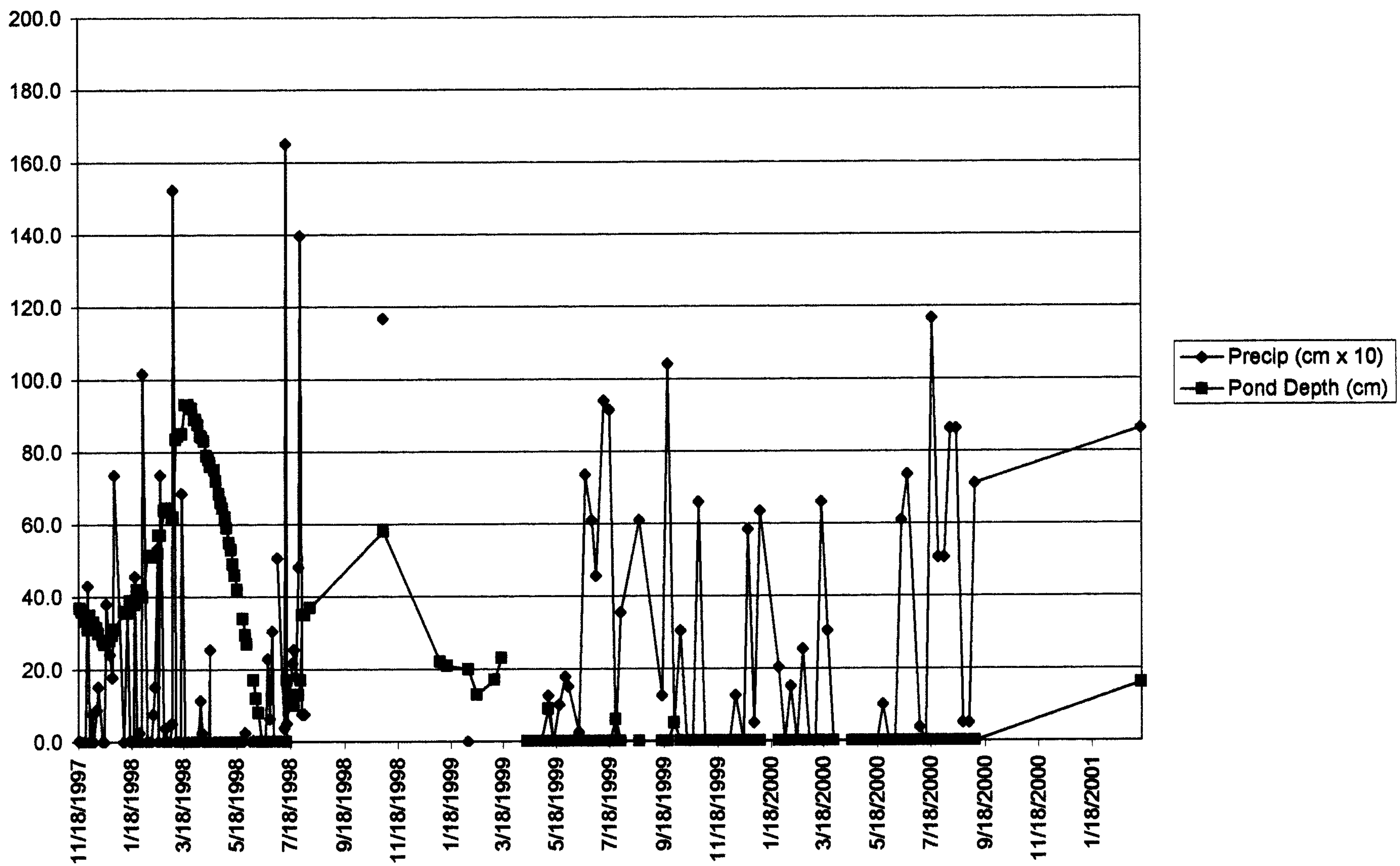
Precipitation and Pond Depth for Study Pond 33 from 11/97 to 3/01



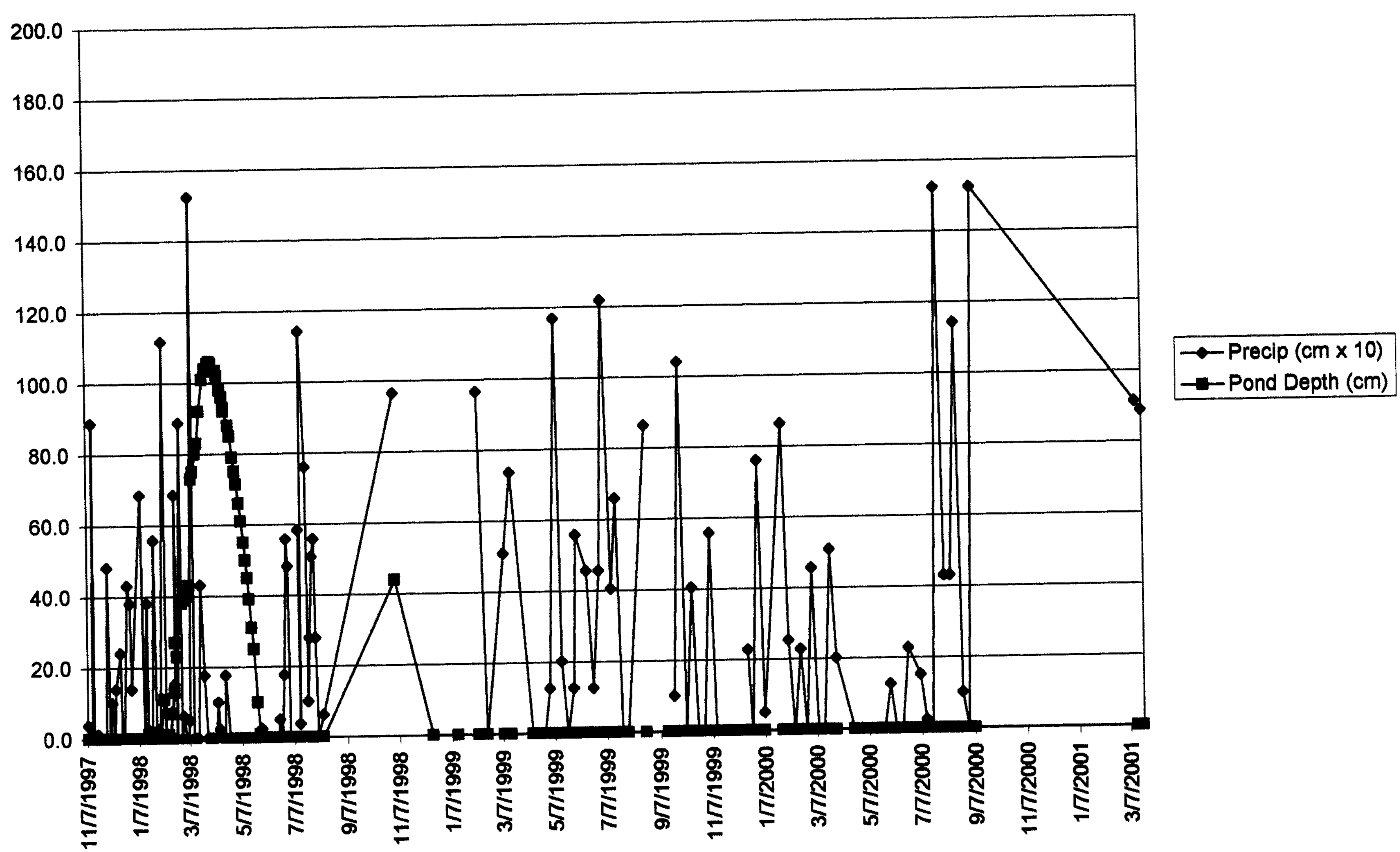
Precipitation and Pond Depth for Study Pond 37 from 11/97 to 3/01



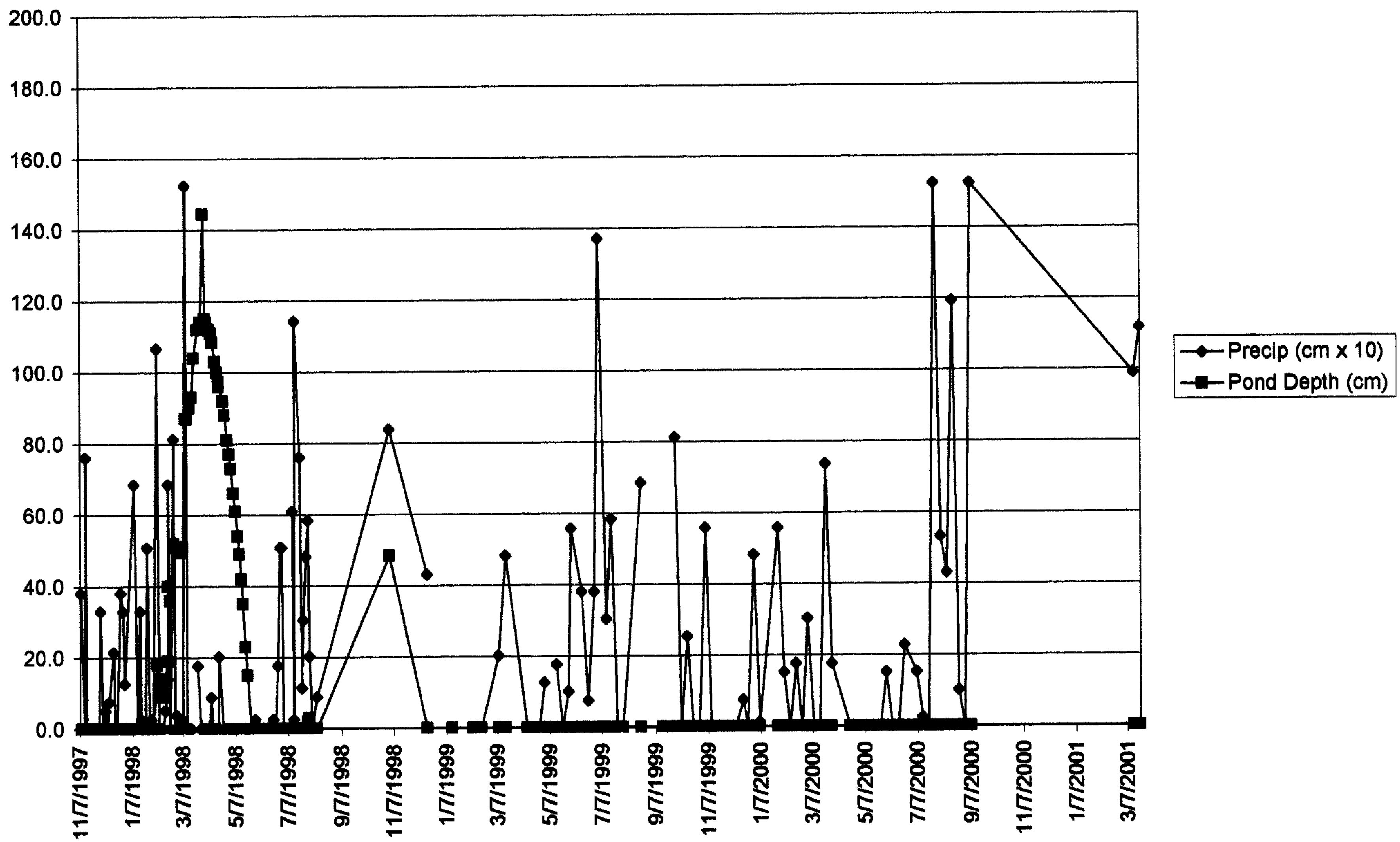
Precipitation and Pond Depth for Study Pond 38 from 11/97 to 3/01



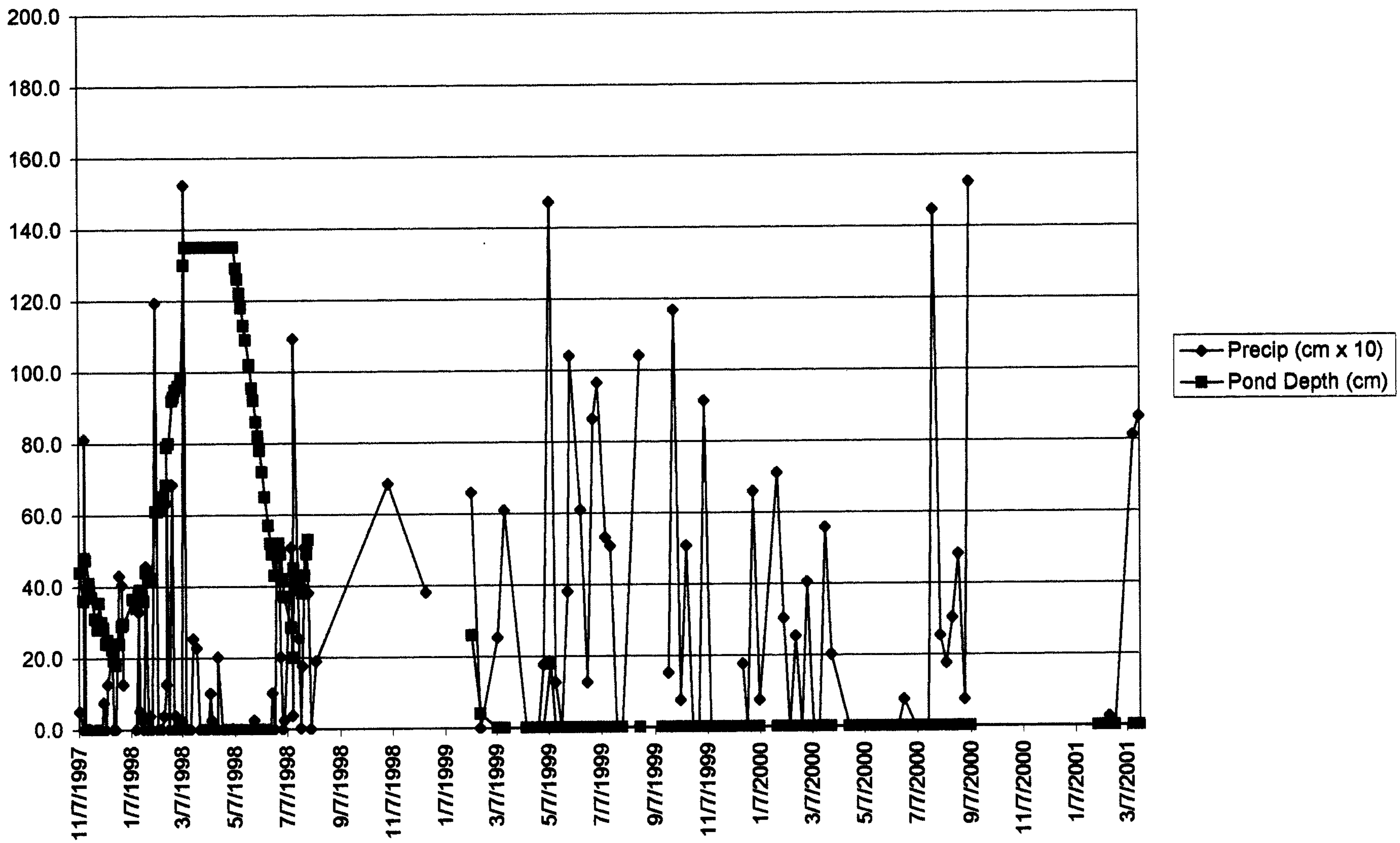
Precipitation and Pond Depth for Study Pond 41 from 11/97 to 3/01



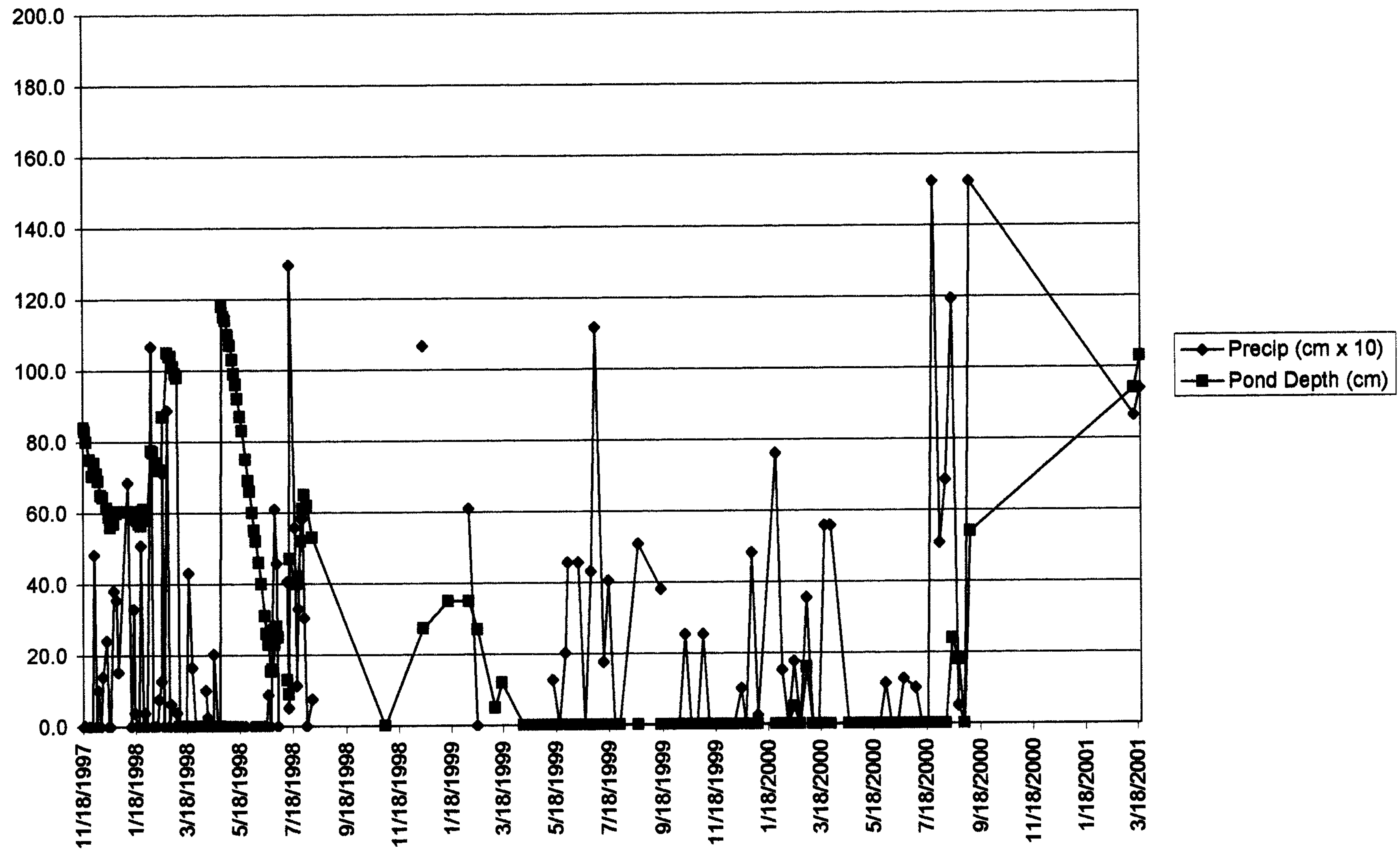
Precipitation and Pond Depth for Study Pond 42 from 11/97 to 3/01



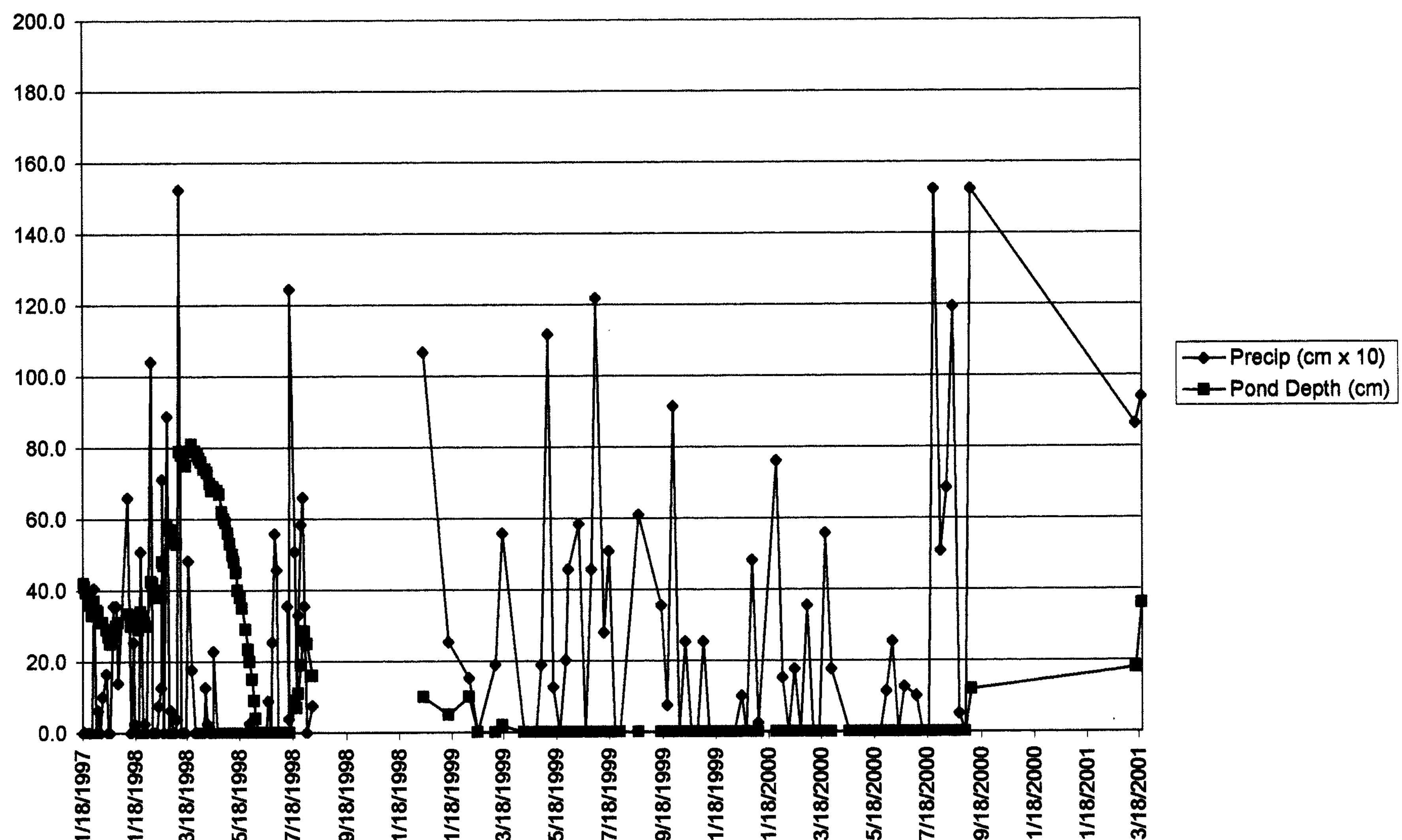
Precipitation and Pond Depth for Study Pond 48 from 11/97 to 3/01

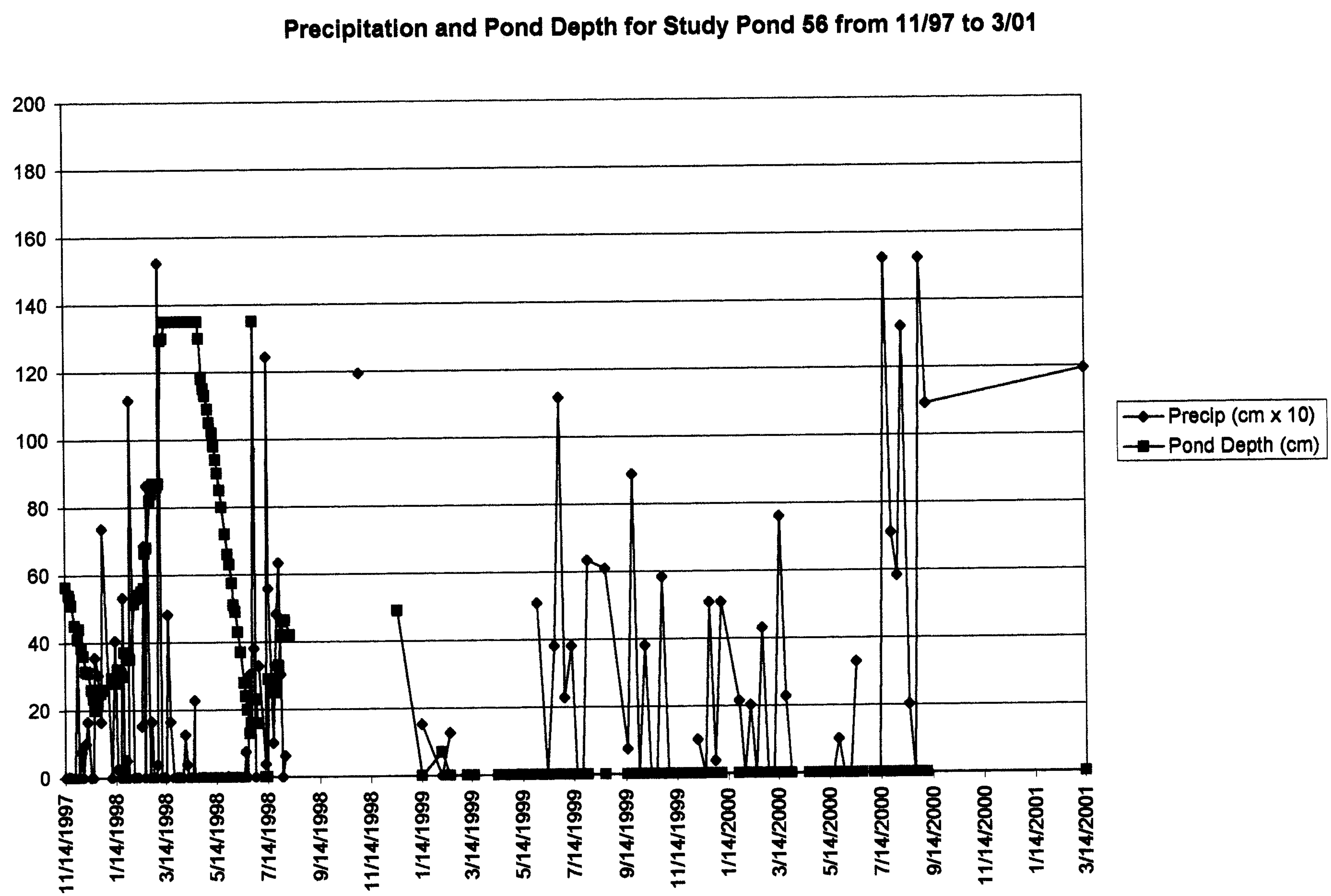


Precipitation and Pond Depth for Study Pond 50 from 11/97 to 3/01



Precipitation and Pond Depth for Study Pond 51 from 11/97 to 3/01

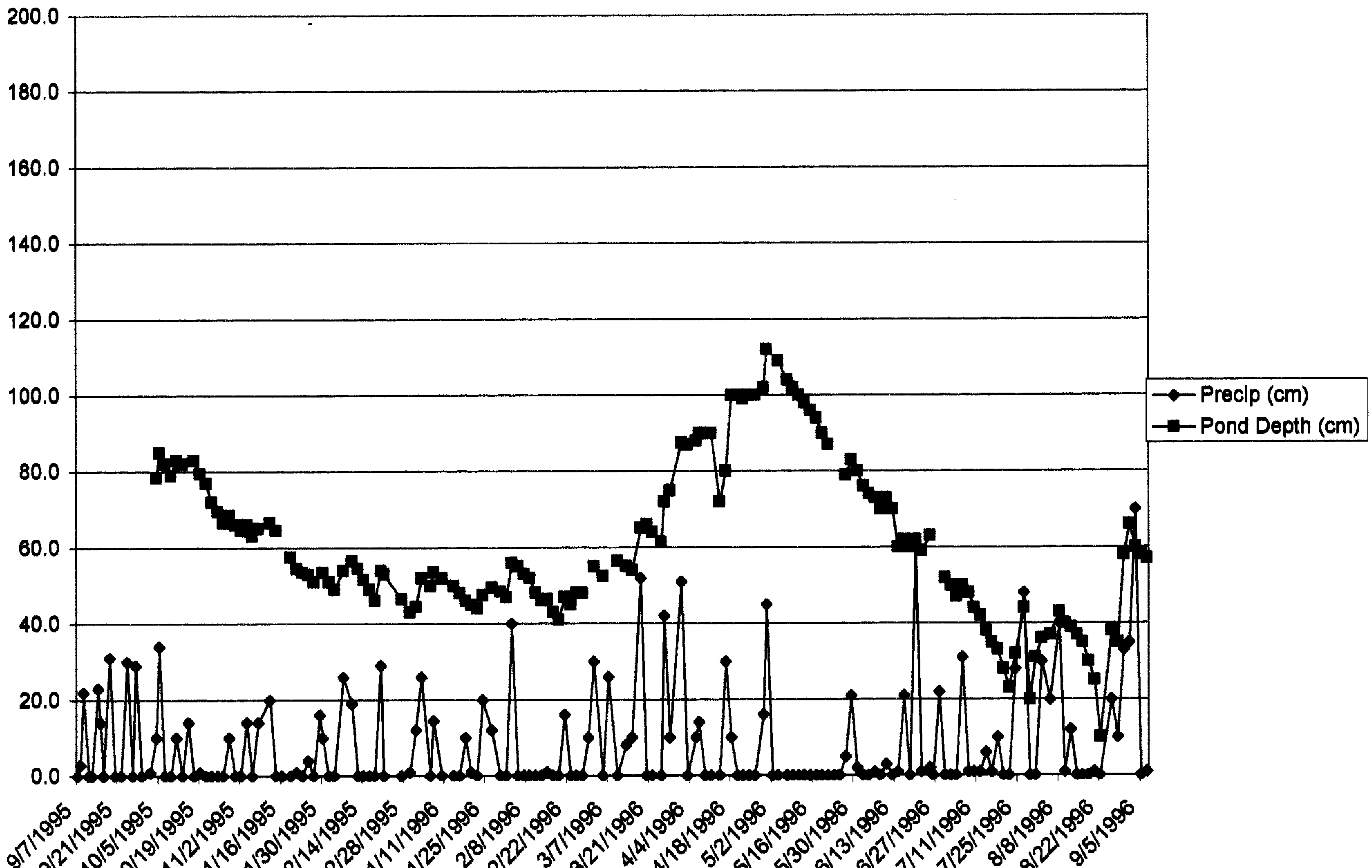



Precipitation and Pond Depth for Study Pond 56 from 11/97 to 3/01
200
180
160
140
120
100
80
60
40
20
0
11/14/1997
1/14/1998
3/14/1998
5/14/1998
7/14/1998
9/14/1998
11/14/1998
1/14/1999
3/14/1999
5/14/1999
7/14/1999
9/14/1999
11/14/1999
1/14/2000
3/14/2000
5/14/2000
7/14/2000
9/14/2000
11/14/2000
1/14/2001
3/14/2001
Precip (cm x 10)
Pond Depth (cm)

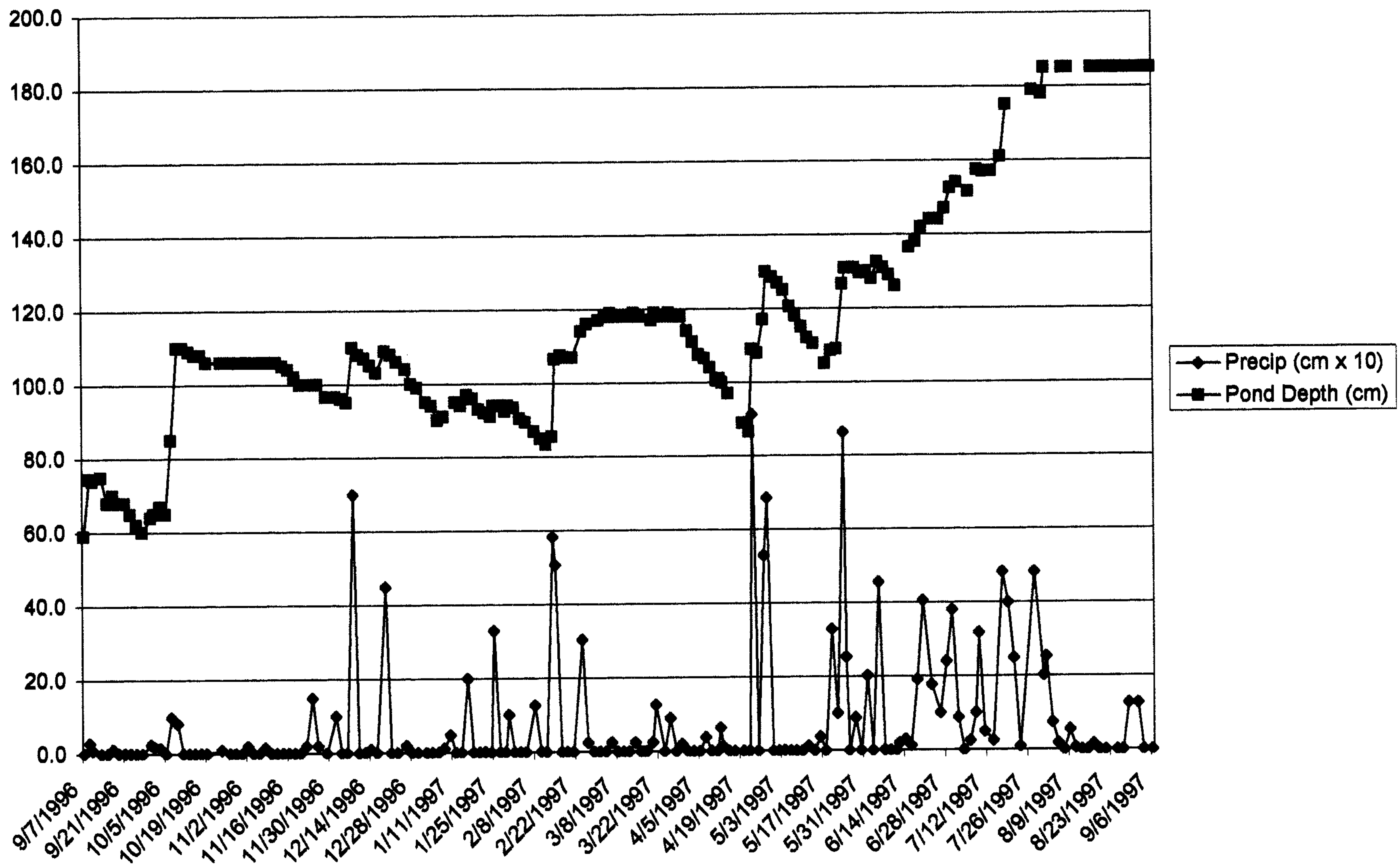
Appendix IV.

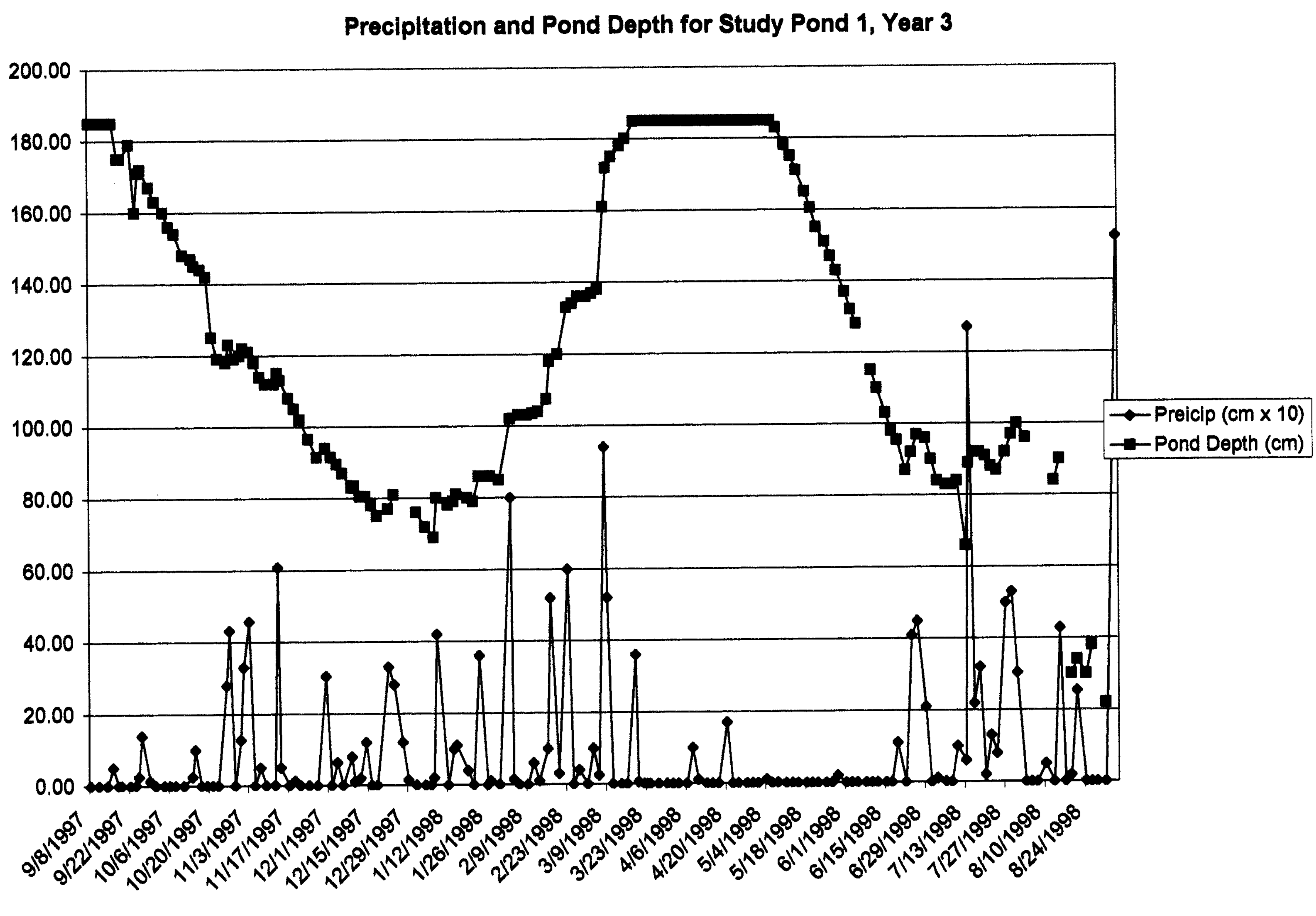
Water Levels and Rainfall for 25 Ponds in the Munson Sandhills, Leon County, Florida for the Three-year Period, November 1997 - November 2000.

Precipitation and Pond Depth for Study Pond 1, Year 1

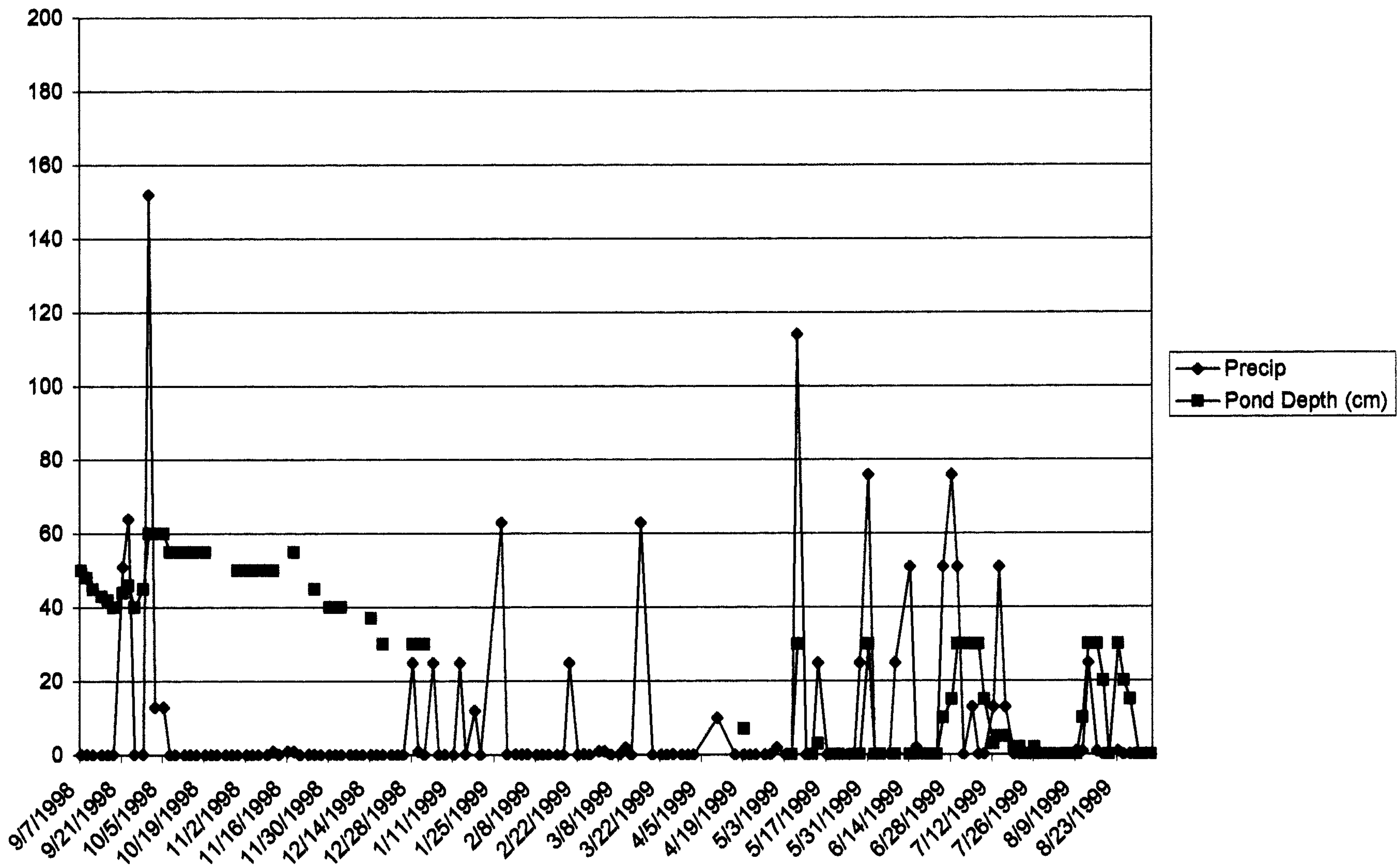


Precipitation and Pond Depth for Study Pond 1, Year 2

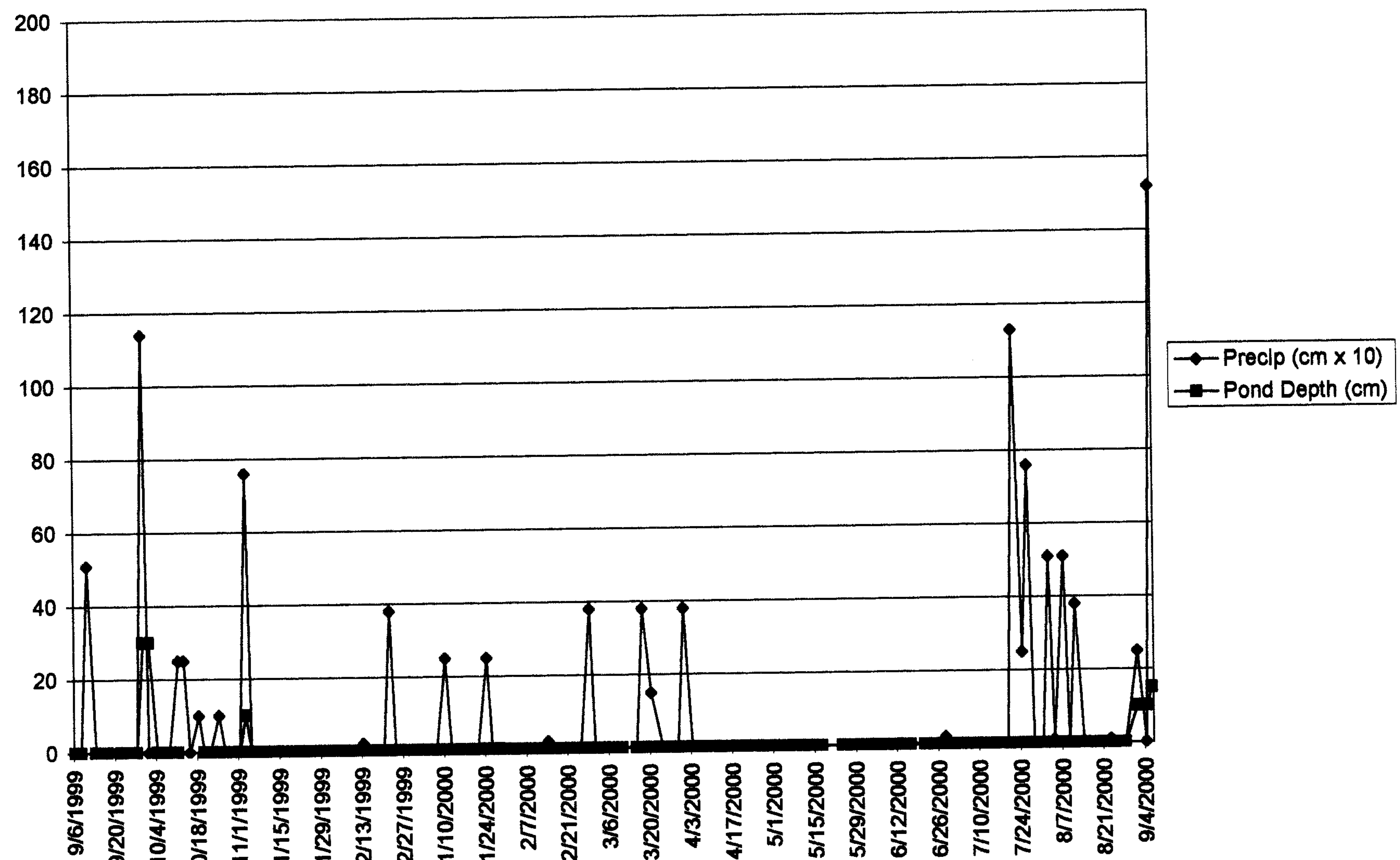



Precipitation and Pond Depth for Study Pond 1, Year 3
200.00
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
9/8/1997
9/22/1997
10/6/1997
10/20/1997
11/3/1997
11/17/1997
12/1/1997
12/15/1997
12/29/1997
1/12/1998
1/26/1998
2/9/1998
2/23/1998
3/9/1998
3/23/1998
4/6/1998
4/20/1998
5/4/1998
5/18/1998
6/1/1998
6/15/1998
6/29/1998
7/13/1998
7/27/1998
8/10/1998
8/24/1998
Preicip (cm x 10)
Pond Depth (cm)

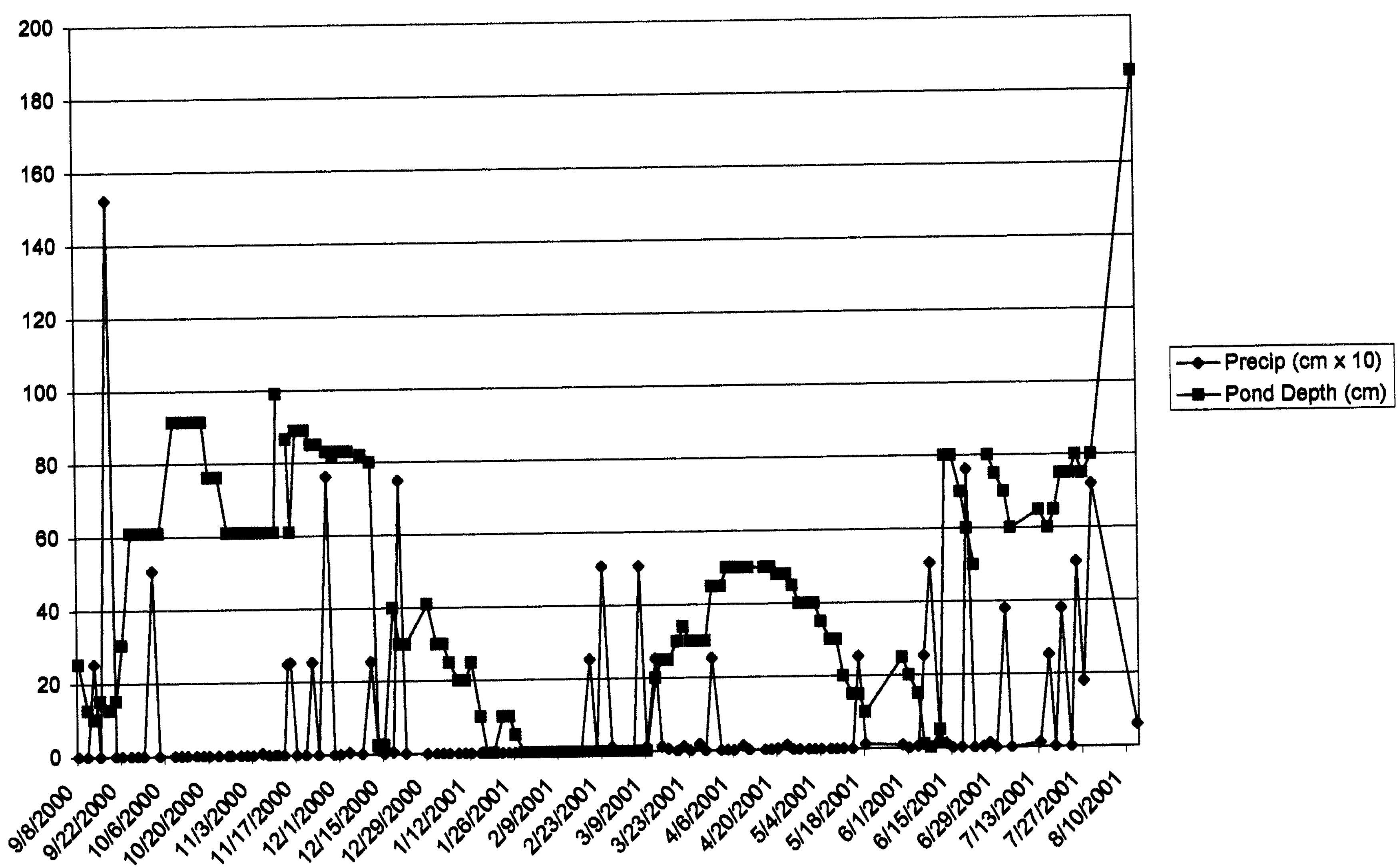
Precipitation and Pond Depth for Study Pond 1, Year 4



Precipitation and Pond Depth for Study Pond 1, Year 5



Precipitation and Pond Depth for Study Pond 1, Year 6



Appendix V.

Migration of all 27 Species of Amphibians and Reptiles in and out of Study Pond #1 for the Six-year Period, September 1995 – September 2001

Appendix V
Year #1

Study Pond #1: Vertebrates trapped in drift fence buckets over a one-year period, 9/6/1995 - 9/5/1996. IN-migration data on left, OUT-migration on right. Species are At=*Ambystoma talpoideum*, mole salamander; Np=*Notophthalmus perstriatus*, striped newt; Nv=*Notophthalmus viridescens*, common newt; Eq=*Eurycea quadridigitata*, dwarf salamander; Sh=*Scaphiopus holbrooki*, spadefoot; Bt=*Bufo terrestris*, southern toad; Bq=*Bufo quercicus*, oak toad; Gc=*Gastrophryne carolinensis*, narrowmouth toad; Ag=*Acris gryllus*, cricket frog; Po=*Pseudacris ornata*, ornate chorus frog; Pc=*Pseudacris crucifer*, spring peeper; Lo=*Limnaoedus ocularis*, little grass frog; Hf=*Hyla femoralis*, pinewoods treefrog; Hg=*Hyla gratiosa*, barking treefrog; Hs=*Hyla squirella*, squirrel treefrog; Hc=*Hyla cinerea*, green treefrog; Rcp=*Rana capito*, gopher frog; Ru=*Rana utricularia*, leopard frog; Rct=*Rana catesbeiana*, bullfrog; Ks=*Kinosternon subrubrum*, mudturtle; So=*Sternotherus odoratus*, stinkpot; Dr=*Dierochelys reticularia*, chicken turtle; Af=*Apalone ferox*, eastern softshell turtle; Ps=*Pseudemys scripta*, pond slider; Ts=*Thamnophis sirtalis*, garter snake; Nf=*Nerodia fasciata*, banded water snake.

date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf
1995																										
9/6					0-1	1-0		6-0					85-8	2-1	1-2	3-0				0-1						
9/7						4-7		12-0	2-0				6-0							1-2		0-1				
9/8	0-1				1-0	5-22		10-18											0-1	0-3						
9/9	0-18	0-1	0-2			7-8		4-49										1-2		1-3	1-0					
9/11	1-4	0-3	0-2			23-2												2-0		0-1		0-1	1-0		1-0	0-1
9/12	0-1		0-1			3-3		5-5						0-1											0-2	
9/14	2-36	0-2	0-7		1-1			2-10	1-0									1-3			2-0					
9/15	1-19	0-3	0-9		0-1			0-6	0-1									1-0			2-1					0-1
9/16	2-3	0-1	0-4			3-2		2-1	2-0						0-1											0-2
9/18	1-94	0-5	0-14		1-0	0-2		0-17	0-1									3-2	1-0	1-0	5-1					
9/20	2-7	0-4	0-6		1-1	1-0		5-0	3-0									1-0	1-0		2-3					0-1
9/22	4-9	1-6	0-2		3-0	5-0		3-0	1-0					0-1							1-0					
9/24	1-26	0-4	0-7	1-0	1-2	0-1		3-4						0-1						0-1						0-1
9/26	2-4	0-1						1-2																		
9/27	0-29	0-1	0-2			1-0		2-10										0-1			5-0					
9/29	2-5	0-3	0-3		1-0	2-0														1-1	2-0				2-0	
10/2	0-7	0-1				0-1														0-2						
10/4	1-154	0-1	0-2			1-2		1-0	0-1											0-1		0-1				
10/5	1-127	0-4	0-6		0-1	1-1		0-7	0-1								0-1	3-1		1-1	2-0		0-1		0-1	0-1
10/7	3-5	0-7	0-7			1-0			1-0																	
10/9	0-6	1-0			0-1	2-0			3-0																	
10-11	4-344	0-5	0-3		3-1	1-4		1-0												0-1	1-1			0-1		0-3
10-13	9-18	0-7	0-3		1-0	1-0		0-1																		0-1
10-15	3-164	0-9	0-16					0-5										1-0		2-2	1-0					3-0
10-17	7-9	1-2	0-3					1-0	1-0												0-1					
10-19	3-7	0-1	0-2			1-0		0-1																	0-1	
10-21	1-9					2-0			13-0	2-0			1-0							0-1						
10-23	0-2	0-1	1-1						1-0																	
10-25	1-1		3-0					1-0	1-0																	
10-27	2-2	1-0							2-0													0-1				
10-29	3-587	0-5	0-22	1-0	2-0	0-3		0-2		0-1										0-2	1-0					
10-31	10-4	2-0	1-0			1-0																				
11-2	4-4	1-0	0-2			0-2															1-0					0-2
11-4	17-47	0-6	0-46		1-0	3-0		0-2		1-0											1-0					
11-6	1-8		1-10							1-0																
11-8	13-612	0-8	1-46		2-3			1-0		1-2								0-1		0-2						0-1
11-12	2-2		0-17															1-0								
11-14	0-2	0-2	1-0																							
11-16			1-0																							

date At Np Nv Eq Sh Bt Bq Gc Ag Po Pc Lo Hf Hg Hs Hc Rcp Ru Rct Ks So Dr Af Ps Ts Nf

Appendix V
Year #1

date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf
11-19	2-1	2-0								3-0																
11-21	7-205	0-4	0-26		1-0				1-0	2-0																0-1
11-23	41-3	1-0	1-0							0-1																
11-25	4-60	0-1	1-12							1-0																
11-27	0-1		0-2																							
11-29	6-1542	1-8	6-66		1-1	0-2				1-4															0-1	0-1
12-2	15-15		0-4							0-1																
12-4	2-5	1-1																								
12-7	8-177	0-8	5-55		1-3	0-1				3-0									0-1	2-2						0-1
12-10	29-427	5-1	12-11							5-0									0-1							
12-12	25-2		1-0																							
12-14	12-14		0-1																			0-1				
12-17	2-13	0-2	1-4							1-1								1-0			1-0					
12-18	2-5		7-0							1-1											0-1					
12-21	14-616	4-4	1-14		3-5	0-2				6-4								5-2			0-2					
12-27	36-9									1-1								0-1								
12-30	3-0																									
1996																										
1-1	16-166	3-0	7-12		2-2	1-0				9-0								3-1								
1-3	50-189	10-1	20-2		1-1					2-4							2-0	18-2			0-1	0-1				0-1
1-6	13-15	0-2	0-8							0-1							0-1	0-7								
1-7	14-43	8-0	3-0							9-0								2-0								
1-10	0-5		0-1															0-1								
1-14	0-5									0-2																
1-16																										
1-18																										
1-20	4-33	2-2	3-3							3-3																
1-22	6-2		0-1																							
1-24			1-1		0-1																					
1-27	1-4					0-1				0-1																
1-30	0-1																									
2-1	1-1		0-2			1-0				2-1											1-0					
2-3	6-24	1-3	1-5							6-11								6-2			2-0					
2-5	5-5		0-1							1-4								1-6								
2-7	0-1	0-1																1-1								
2-9	2-1	1-2	0-1							5-1																
2-11	3-0		1-0							2-0								2-0								1-0
2-13			0-1							2-0								0-1								
2-15	2-6	0-1								1-6								0-1								
2-17	1-2								1-0	1-1																
2-19	2-0								1-0	1-1										1-0						
2-21	8-30	1-0	3-6		1-0					2-2							1-0	9-1		1-0						
2-23	3-10	1-2	2-3		1-0					2-5								3-4		13-1	1-0					
2-25	1-2	0-1	1-1		1-1			0-1	1-0	0-5							0-1	4-3		4-0						3-0
2-27	2-0	1-0			1-0				1-0	0-2								1-0		4-0						
2-29	2-14	0-2	0-4		19-1	2-1				3-6								1-12		1-2	1-0					
3-2	7-8	1-0	4-3		0-6					3-2								6-0			1-0					
3-5	0-2																			1-0						
3-7	0-2		0-1		1-8	5-1			0-1	0-3										4-0	1-0					
3-10	2-5					1-2				2-0																
date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf

Appendix V
Year #1

date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf
3-13	1-1									1-0										1-0	1-0					
3-15																				1-0						
3-18	5-46		4-0		12-4	4-3				1-4	0-1						2-0	6-9	0-1	7-0	1-0			2-0?		1-0
3-20	2-6	1-1	2-2		0-7	8-2				5-1	0-1						0-1	6-0		1-2	0-1					
3-22	2-0				1-0	0-4			2-0	1-0								0-2								
3-25	2-1		0-1						0-1		0-1							2-0								
3-26	4-23	0-1	2-3		1-0	0-1			1-0	1-3								4-1								
3-28	10-22	1-0	4-0		5-1	5-0		3-1	0-1	2-1							1-0	1-1		5-1	1-0			1-0		
4-1	51-16	19-0	6-2		0-3	1-5		3-0		5-3	2-0						2-1	8-2		6-3	1-0	2-0		5-0		2-0
4-3	2-13							0-1		0-2								2-1		1-2		0-2				
4-6	0-6	1-0						1-0		1-2										1-1		1-0		2-0		
4-7	3-50	0-1								2-0										0-1		1-0				
4-9	2-0		0-1						1-0		0-1															
4-11									1-0																	0-1
4-14	2-3	1-0			2-0	0-2		14-0	1-0	0-4										0-1		1-1				
4-16	4-18		1-0			3-1		3-4	1-0									1-1		2-1		1-0		1-0		
4-18	0-4					0-1			1-0									1-0		1-1		1-0				
4-20	0-1					1-0			1-0											1-0						
4-22	3-2							1-0	2-0											1-0						0-1
4-24	2-1				1-0	2-0		18-0	3-0									0-1		1-0						0-1
4-26	0-2							7-0												1-0						1-0
4-29	3-3				0-1		2-0	1-0												3-1		1-0				
4-30	0-54				6-4	2-7	2-0	2-5		0-1							3-0	5-5		1-0	1-0	1-0				1-1
5-2	3-2							2-0	1-0									1-0								
5-4	0-2				1-2	1-1	1-0	6-1									0-2			0-1						
5-7	0-2					2-1		14-2	1-0											4-0		2-1		1-0		0-1
5-9	2-1					1-0	2-0	4-0	3-0													2-1		1-0?		
5-11	1-4				1-0		1-0	5-1												0-1						
5-13	4-1						1-0	6-0												0-1		1-0				
5-15	1-0							2-0																		
5-17	1-2					1-1		4-0							0-1											
5-19	3-3							8-4	3-0												1-0					
5-21	1-1					1-0		14-0												2-0						
5-23	2-0							5-4												1-1		0-2				
5-25	1-3					1-2		15-1												3-0		0-3				
5-27	4-2					1-0		10-3														0-1				0-1
5-29	1-22		1-1			1-2	0-1	0-33		0-1										0-1						
5-31	0-1					2-1	0-1	0-16										1-1		0-1						
6-2		0-1				1-0	1-0	4-2													1-0				0-1	
6-4	1-0				1-0	3-0		5-2																		
6-6	1-3					1-0	0-1	3-3							0-1			1-0								
6-8		0-1				2-4	1-0	6-5																		
6-10	1-6				1-0	0-1		1-4																	0-1	
6-12					0-1			10-1																		
6-14	0-2					1-0		2-8												0-1				0-1		0-1
6-16	0-2	0-2			1-1	1-0		15-8										2-0		0-3	0-4	0-1				
6-18	0-3	0-1						5-9										0-1				0-1				
6-20	0-1					0-3	5-16	20-6										1-1							1-0	
6-22	0-2	0-2				2-0	1-4	18-15										3-0				0-1			2-0	
6-25	0-1	0-1					0-1	9-15	3-0									2-0				1-1			0-1	0-3
date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf

Appendix V
Year #1

date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	
6-26	0-1					1-0	1-0	2-2																			
6-28		0-1	0-3			1-1	3-0	13-10										1-0		0-1							
6-30		0-2						0-6														0-1					
7-2	0-1					1-0	0-1	6-8										1-1									
7-4	1-0					1-0		20-5													0-2			0-1		1-8	
7-6			0-3		0-1	1-0		3-16										1-2		0-2	0-3			0-1		2-0	
7-8		0-1	1-1			0-1		7-3	0-2									2-1		0-1				0-1		1-1	
7-10			0-2			0-1		5-7	0-1									2-0							1-2	1-0	
7-12	0-1		0-1				1-0	4-12										0-2		0-1	0-2						
7-14		0-2						2-5										1-1									
7-18							0-1	1-3										0-2			0-1				0-1		0-1Pf
7-20			0-1					0-5	0-1									1-1									0-1Pf
7-22								3-5	1-0									1-1								0-1	0-2Pf
7-24		0-6	0-3					7-0	0-1											0-1					1-0	0-1	
7-27		0-10	0-10				2-0	31-5	0-2									3-1		1-0		0-1		0-2		0-1	
7-29		0-2	0-1		1-0			0-33	1-1																	0-2	
7-31							1-0	3-1	2-1									0-1								0-2	
8-2		0-2	0-1				0-1	14-5																			
8-5			0-2					8-10										2-0									
8-8		0-1	0-1					29-5																			1-0Pf
8-10								6-17										1-1		1-0							
8-12								1-4	1-1									1-1								0-5	
8-14								2-2										1-1							0-1	0-3	
8-16								0-3										0-1			1-0				0-1	1-8	
8-18		1-0				3-0		1-4										1-0							1-0	0-5	
8-20							1-0	7-2																		1-1	
8-22							1-0	12-6	1-0																	1-3	
8-26			0-1				0-2	12-4																	1-0		0-1Pf
8-28	1-0						0-2	1-12										2-0							0-1		
8-30							4-1	34-9	0-1									2-1		1-0	2-0				1-0	1-0	
9-1			1-0					12-7										3-0		3-0	2-0						
9-3					1-0		5-0	11-0										0-1		2-0	3-0	3-0					
9-5		0-1			1-0		0-2	3-8	0-1									9-0		3-0		1-0				3-0	2-0Pf
date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	

Appendix V
Year #2

Study Pond #1: Vertebrates trapped in drift fence buckets over a one-year period, 9/6/1996 - 9/7/1997. IN-migration data on left, OUT-migration on right. Specie At=*Ambystoma talpoideum*, mole salamander; Np=*Notophthalmus perstriatus*, striped newt; Nv=*Notophthalmus viridescens*, common newt; Eq=*Eurycea quadridigitata*, d salamander; Sh=*Scaphiopus holbrooki*, spadefoot; Bt=*Bufo terrestris*, southern toad; Bq=*Bufo quercicus*, oak toad; Gc=*Gastrophryne carolinensis*, narrowmouth toad; Ag= *gryllus*, cricket frog; Po=*Pseudacris ornata*, ornate chorus frog; Pc=*Pseudacris crucifer*, spring peeper; Lo=*Limnaoedus ocularis*, little grass frog; Hf=*Hyla femoralis*, pinew treefrog; Hg=*Hyla gratiosa*, barking treefrog; Hs=*Hyla squirella*, squirrel treefrog; Hc=*Hyla cinerea*, green treefrog; Rcp=*Rana capito*, gopher frog; Ru=*Rana utricularia*, leopard Rct=*Rana catesbeiana*, bullfrog; Ks=*Kinosternon subrubrum*, mud turtle; So=*Sternotherus odoratus*, stinkpot; Dr=*Dierochelys reticularia*, chicken turtle; Af=*Apalone ferox*, ea softshell turtle; Ps=*Pseudemys scripta*, pond slider; Ts=*Thamnophis sirtalis*, garter snake; Nf=*Nerodia fasciata*, banded water snake; Pf-*Pseudemys floridana*; Ap=*Agkist* *piscivorus*, cottonmouth; Cs=*Chelydra serpentina*. snapping turtle; Sp=*Seminatrix pygaea*, swamp snake..

date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap	Cs
1996																													
9-7					1-0			3-7										3-2		0-1	1-0						0-1		
9-9							0-1	5-13	0-1											0-1	1-0								
9-10		0-1					0-1	0-1														0-3				0-1			
9-13		0-1					1-0	0-4	6-0													0-1				0-1			
9-15								1-0	2-7																0-2				
9-17								0-2										0-1		0-3					1-0				
9-19								0-2	0-1									1-1							1-0				
9-21																													
9-23																													
9-25									1-0	1-0								1-0		0-1									
9-27																		0-1							1-0				
9-30							0-1	0-1		0-1								0-4		0-1		0-2							
10-1					1-0													4-0											
10-3																													
10-5																									1-0				
10-7									1-2									1-0											
10-9		16-0	13-0		23-0				0-2								34-0	10-0		4-0	1-0								
10-11		19-0	2-1		0-6				0-1									5-0											
10-13			1-0															0-1											
10-15			2-0		1-0				1-0								0-3												
10-17																													
10-19																				1-0									
10-24																													
10-27									1-0																				
10-29										2-0																			
10-31								1-0		2-0							1-0												
11-2																													
11-4																													
11-6																													
11-8					0-2		0-1										0-4	0-1							0-1				
11-10																													
11-12																													
11-14																	1-0												
11-16																													
11-18																													
11-20					1-0					0-1																			
11-22	3-0		4-0					0-1		2-0							0-1												
11-24			1-0		0-1					0-1							1-3												
11-26	29-0		9-0							1-1							0-2	1-2											
date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap	Cs

Appendix V
Year #2

date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap	Cs
11-29	4-13		3-3							0-1																			
12-2	21-2		10-5		0-1					1-1							0-1	0-2		0-1									
12-4	4-0		6-0							1-0								1-0											
12-6	16-0		11-0																										
12-8	188-0		6-0		0-5					1-1							1-0	2-0											
12-10	11-0	1-0	1-0																										
12-12	8-17	1-0	13-1							3-1			1-0					1-0											
12-14	101-4	12-0	5-0							1-2								0-1		0-1									
12-16	3-0	2-0	1-1							1-0																			
12-19	57-13	1-0	1-1		0-2					5-0								1-0											
12-21	1-20		3-0																										
12-23	1-1	0-2	1-1							1-0																			
12-26	28-6		3-1		0-1					1-1																			
12-28	1-3		8-1		0-1																								
12-30	1-0	2-0	4-2																			1-0							
1997																													
1-2	2-0		10-2				0-1			1-0															1-0				
1-4	0-2	4-4																											
1-6	0-1		2-0																										
1-8	0-44		2-2							0-4																			
1-10	142-67	1-0	4-0		0-1					4-0																			
1-12	1-2																												
1-14																													
1-16	25-17		2-0		1-0				2-0	5-0																			
1-18	1-0		0-1																										
1-20			1-0																										
1-22			0-2							1-0																			
1-24			1-0																										
1-25	0-53	2-0	1-0		1-1					4-3										0-1									
1-27			0-1																										
1-29	0-1		3-0							1-1																			
1-30	1-5	1-0	2-0																										
2-1	1-0																												
2-3		3-0	2-0							0-1																			
2-5									1-0	1-0	0-1											1-0							
2-8	0-8																												
2-10	0-1																												
2-12																													
2-14	14-111		1-0		7-4					2-0								7-4											
2-15	31-2	4-0	2-0		0-5					2-1							7-0				1-0								
2-17		5-0	1-0							1-0							0-1					2-0							
2-19		4-0	1-0								2-0							1-0											
2-21		1-0				1-0					1-0						1-0			2-0		2-0							
2-24	7-45	2-0	1-0		2-3				0-1	0-1							3-1			5-0		1-0							
2-26	8-0	2-0	1-0							1-0																			
2-28		3-0	2-0		1-0	1-0																							
3-2	0-1	1-0			0-1		1-0										0-1			2-0		2-0							
3-4	0-12								1-0								0-5			2-0									
3-6	1-18									0-1							1-2			1-0		1-0				1-0			
3-8	0-2																												
date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap	Cs

Appendix V
Year #2

date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap	Cs
3-10	0-1								1-0													1-0							
3-12																	1-0												
3-14	0-31				0-1		1-0										0-3	0-1		1-0		1-0							
3-16	1-1							1-0		0-1								1-0											
3-17					1-1	1-0		1-0	1-0	0-1								1-0		7-1	1-0				1-0				
3-18	1-9							1-0												1-0									
3-20	0-5																	0-1											
3-21	1-3				2-0															1-0					0-1				
3-24																													
3-26																						1-0							
3-28	0-2					2-0											0-1												
3-30	0-1						1-0										0-1	0-1		2-0		0-1							
4-1	0-12																	1-3				0-1							
4-3	0-1																	2-0											
4-5								1-0																					
4-7	0-2					2-0		4-0										0-8											
4-9									1-0									2-0											
4-11								0-1																					
4-12	2-5				1-0	1-0		2-0										1-19m		0-3									
4-13																		15-0											
4-15																		1-2											
4-17																		1-0											
4-20								1-0										0-1				0-1							
4-22						1-0												1-23				0-1							
4-23	0-4					2-1											0-9m	6-77m		2-1									
4-25	0-1		0-1			0-1		0-1									1-0	76-1											
4-27	0-3					7-0	4-0	1-0									1-59	4-239		3-0									
4-28	0-2				1-0	4-4	32-0	6-2									4-5	0-4		4-0		1-0							
4-30		3-0	1-0		0-1		42-0											2-0											
5-2							11-3										1-0					1-0							
5-4							10-0													1-0					1-0				
5-6							5-0	1-0									0-2												
5-8							2-1	2-0									0-4	1-1											
5-10							3-2	3-0																					
5-12						1-0	2-0																						
5-14	1-0					1-2		5-0									0-18	1-4											
5-16						1-1	1-18	4-1									1-109	0-28				1-0							
5-18						0-1	1-0										6-0												
5-20	0-1						1-9	0-1	0-1			0-1					0-150	0-224		0-1									
5-22							1-1										1-5	3-7		0-1									
5-24					1-0	2-0	101-1	8-0	0-1								0-2	0-1		1-1		1-0							
5-25		1-0				1-2	37-28	8-0									0-8	0-1		1-0									
5-26							25-13	7-0									0-5	1-0											
5-28							10-8	1-1												1-1									
5-30						0-1	0-3	5-1									0-10	2-2				1-0							
6-1					0-1	1-0	1-5	3-0	0-1								1-0			0-1									
6-3						0-1	1-0	2-0									0-8								1-0		1-0		
6-5	0-1						0-7	01									1-26	0-9											
6-7							1-2	0-1	0-2								0-2	0-1											
6-9									1-0								0-1												
date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap	Cs

Appendix V
Year #2

date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap	Cs
6-11							1-0	3-0	1-0								0-28	0-1		2-0								1-0	
6-12					1-0		2-3	5-1									0-8	0-4				1-0							
6-14						1-0	13-9	42-13														1-0							
6-16							3-1	7-3	1-0								0-10	1-0											
6-18				0-1			0-1	14-6	0-5								0-1	0-2			1-0								
6-20							2-1	7-0	0-2									1-0		1-0									
6-23							1-1	19-4	0-1								0-20	1-21		1-0						0-1			
6-26							3-4	22-7	0-2								0-1	3-0		0-1		1-0							
6-28							1-1	9-5	0-2									1-1											
6-30							0-2	8-8	0-1								0-7	2-21		2-0									
7-2							0-1	18-5	0-2								0-13	3-18		1-0		1-0							
7-4							4-0	8-5										1-2											
7-6						2-0		1-6																					
7-8	1-0			0-1		1-1	0-2	2-2					0-1					0-3											
7-9						1-0												1-0											
7-11						3-1	0-1	3-2					1-0	0-1			0-2	1-1											
7-14						1-0		2-0	1-0											1-0									
7-17						0-2			0-1									0-1											
7-19																													
7-21						3-0	2-0	13-7									0-1	1-0		0-1	1-1								
7-23							1-0	0-2												1-0		1-0							
7-28							1-2	1-2	0-2								0-2	1-0		3-1									
7-31								0-2	0-1									1-0		2-0									
8-1						0-2		1-2	0-1									2-3		1-1									
8-3							1-2																						
8-5							5-0	1-0										0-1		2-0						0-2			
8-7							1-1	2-1										2-1								1-0			
8-9						2-0	2-0																						
8-11							0-2										0-1	1-3								1-0			
8-13																	0-1	0-2											1-0
8-15																													
8-17								0-1										0-2											
8-19		0-1e						2-4					0-1				0-2	0-6											
8-21						2-0											0-4	1-2											
8-25								0-1																					
8-27						3-0		2-1									1-1												
8-29						0-1		0-30m														2-0							
9-1		0-1m				0-1	0-1	0-19m										1-4				1-0							
9-3		0-1m						5-1									0-1	1-0											
9-6				2-0		1-1		4-2	2-0				0-1					3-1											
1997																													
date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap	Cs

Appendix V
Year #3

Study Pond #1: Vertebrates trapped in drift fence buckets over a one-year period, 9/8/1997 - 9/4/1998. IN-migration data on left, OUT-migration on right. Species are At=*Ambystoma talpoideum*, molesalamander; Np=*Notophthalmus perstriatus*, striped newt; Nv=*Notophthalmus viridescens*, commonnewt; Eq=*Eurycea quadridigitata*, dwarf salamander; Sh=*Scaphiopus holbrooki*, spadefoot; Bt=*Bufo terrestris*, southern toad; Bq=*Bufo quercicus*, oak toad; Gc=*Gastrophryne carolinensis*, narrowmouth toad; Ag=*Acris gryllus*, cricket frog; Po=*Pseudacris ornata*, ornate chorus frog; Pc=*Pseudacris crucifer*, spring peeper; Lo=*Limnaoedus ocularis*, little grass frog; Hf=*Hyla femoralis*, pinewoods treefrog; Hg=*Hyla gratiosa*, barking treefrog; Hs=*Hyla squirella*, squirrel treefrog; Hc=*Hyla cinerea*, green treefrog; Rcp=*Rana capito*, gopher frog; Ru=*Rana utricularia*, leopard frog; Rct=*Rana catesbeiana*, bullfrog; Ks=*Kinosternon subrubrum*, mudturtle; So=*Sternotherus odoratus*, stinkpot; Dr=*Dierochelys reticularia*, chicken turtle; Af=*Apalone ferox*, eastern softshell turtle; Ps=*Pseudemys scripta*, pond slider; Ts=*Thamnophis sirtalis*, garter snake; Nf=*Nerodia fasciata*, banded water snake; Pf-*Pseudemys floridana*; Ap=*Agkistrodon piscivorus*; Cs=*Chelydra serpentina*; Sp=*Seminatrix pygaea*.

date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap	Cs
1997																													
9-8						1-1		13m-1					2-0					1-0											
9-11						3-0		21m-2					2-0					0-2								0-1			
9-14						1-2		8-3					1-2	0-1				1-3								1-0			
9-16		0-5m						1-20m					1-5m					1-10m											
9-18						1-0		24-1					0-1																
9-19		0-1		1-0				15-0																					
9-22								16-2										0-2											
9-24		0-3		1-0			1-0	10-2	1-0					0-1				0-1											
9-25						0-1	0-1	6-3										1-0											
9-26		0-15						0-3	0-1									1-2			0-1								
9-29		0-6		1-0				7-1	3-0				1-0	0-1															
10-1		0-1		2-0			1-0	17-1	1-0				0-1	0-3															
10-4		1-0		2-0		1-0		17-0					1-0																
10-6		1-1		2-0				5-0	1-0				1-0																
10-8	2-0	6-5	0-1			2-0		5-2					1-0																
10-11				1-0				8-0						0-1															
10-14		0-2						3-0										0-3	0-2										
10-15						1-0		7-1		1-0			1-0					2-1	1-0										
10-17						1-0		6-0							1-0														
10-19								1-0																					
10-21								1-0																					
10-23								4-0	1-0																				
10-26		0-71	0-3		1-0		0-3	0-3	0-1										0-1	0-1	0-1	0-9							
10-27		0-41	0-17		1-0	1-1	0-2	0-1	2-1									4-1			0-1	0-1							
10-29		1-1	1-14	1-0				0-1	1-0									1-0			1-0								
10-31		1-3	1-8				0-1		0-1										1-0	0-1									
11-1	1-5	0-32	0-36			0-2	0-1		1-2									14-4	1-0	1-0									
11-3		1-13	0-34		0-1		1-1		2-1									6-2	1-0										
11-5		1-0	0-4					0-1	1-0										1-0										
11-7	1-2	2-7	2-13	1-0																									
11-9			0-1																										
11-12			0-3											0-1								1-0							
11-13	24-8	0-9	1-24		0-1			0-3										7-1		0-1									
11-14	1-2	0-10	1-24		1-1	1-0		0-3	3-0									12-4	6-0			0-1							
11-17		3-3	1-8															2-0											
11-19	1-0		0-2					1-0	0-1																				
11-21		3-0	0-3																			0-1							
11-24	1-0	1-0	1-0					1-5												0-1		0-5							
11-27		1-0	0-1						1-0																				
11-30	20-9	3-6	5-10		1-0	0-1		0-3	0-2									1-0	2-0	0-4		0-1							
date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap	Cs

Appendix V
Year #3

date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap	Cs
12-2	0-1	1-0	1-5																	0-1									
12-4	9-0		3-6		0-1																								
12-6	2-0	0-1	0-4																										
12-9	44-0		0-2						0-1	1-0																			
12-10	3-3	0-1	2-6				0-1												1-0										
12-12	1-0		3-1															1-0		0-1		0-1				0-1			
12-14	4-0																												
12-16	2-1																												
12-18																													
12-22	4-2	0-2	1-0		0-1	0-1	0-1		1-0					1-0				2-0		0-4	0-1	0-1							
12-24	26-4	0-6	2-2				0-1			2-1								3-1	1-0	0-3	0-1								
12-27	42-4	0-2	3-2					0-1		1-0								2-1	0-1										
12-29	1-0	1-0																1-0											
1998																													
1-1									0-1																				
1-4		1-1	1-0																1-0										
1-6		2-0	1-0					1-0	1-1	0-1								1-0		1-0	0-1	0-1							
1-7	4-23	1-4	1-2			1-0		0-1	1-2	0-1								0-2		0-1		1-0							
1-8	28-4				9-0	3-1	0-1		0-4	1-0							1-0	3-1		1-0									
1-12	4-3		1-1			0-2												1-1											
1-14	11-1	1-2								2-1								2-1											
1-15	29-4	0-1	1-0		0-5				0-1	2-0								4-1											
1-19	39-2	1-0	2-0							0-1								1-0											
1-21	0-2	1-0	1-0						2-0																				
1-23	41-14	1-0	0-1		0-1					3-0								3-0											
1-26	3-3	4-0	2-0						0-1	1-1								2-1											
1-27	14-5		1-0							0-1																			
1-30	3-1	1-0							1-0																				
2-3	126-53	6-0			3-2	1-0	0-1			10-0							12-0	5-0		1-0									
2-4	23-15	10-0	4-0		0-2				1-0	3-1							2-3	7-0											
2-6	1-2	1-0								0-1								0-1											
2-9	0-1		1-0						0-1																				
2-11	0-1	1-1	1-0							1-0							1-0												
2-13	0-2	4-0							0-1	0-1								2-0											
2-16	12-81	1-0						0-1	1-0	0-3							3-0	6-2		0-1									
2-17	35-28				0-2	0-1			2-0	1-0							11-4	11-4		2-2									
2-20	10-14	3-0								1-2							2-1	6-0											
2-23	37-24	2-0	2-0							1-1							0-3	1-0											
2-25	2-3								1-0									0-1											
2-27	9-95	2-0							2-1	0-3							1-6	5-10	1-0	3-0									
3-2	2-9					2-0	2-0		5-2	0-1							2-1	6-0		1-0					0-1	1-0			
3-4	0-2								1-1									1-0											
3-6	2-50							4-0	1-0								0-3												
3-8	9-39	1-1	1-0		3-0	0-2	0-1		2-2								2-7	1-6		1-0	1-0								
3-9	12-9				30-3	3-0		0-2	0-1								7-1	5-5	2-1	2-0		2-0							
3-11	3-1	1-0		0-1	1-26	1-1		0-1	0-1										1-0										
3-14					1-3				1-0				1-0																
3-16		1-0				0-1			2-0									2-2											
3-19	3-33	1-0	2-0		0-6	11-1		0-2	0-5								0-4	3-4	1-0	1-0		1-0							
3-20	3-10		1-0		1-2	0-5		0-1									0-1	2-3				1-0							
date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap	Cs

Appendix V
Year #3

date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap	Cs
3-22	2-2																	0-1				1-0							
3-23				0-1				0-2										0-1											
3-24	1-1					0-1														1-0		1-0							
3-27	0-7					3-1		1-0												1-0		3-0							
3-30	0-12					2-4		2-6	1-0								0-3			2-0		5-0							
4-1	7-6					2-1		2-1									3-1			2-0		3-0							
4-3	1-6					1-1		0-1	1-1								0-2	0-7		1-0		1-0							
4-6	1-5					1-1		0-1	1-0								0-1	1-1				1-0							
4-8	1-33				0-1	2-1		0-4	0-1									1-7	0-1	1-0	0-1								
4-10	1-7				1-0	0-1		0-1	1-0									1-2											
4-13									1-0																				
4-15	0-1																												
4-17	1-3							3-0										0-3		1-0									
4-20	0-17								1-0											0-1	1-0	0-3							
4-22	0-1							1-0									1-0												
4-24									0-1																				
4-27							2-0			1-0							1-0												
4-29						1-0			1-0	0-2																			
5-1						0-1				0-1										1-1									
5-4	0-2					1-0		1-0		0-4			1-0							1-1	1-0								
5-6	1-0						1-0	4-0										0-1		1-0									
5-8	1-3					3-1		2-0		0-1										1-0									
5-11	2-2							1-0												0-1		1-0							
5-13								1-0												1-0									
5-15	0-1							5-0		0-1	1-0															0-1			
5-18						0-1		4-0		0-2										0-2						1-0			
5-20	1-0							3-0										0-3											
5-22	0-1							1-1									1-0	1-0											
5-25								3-1						1-0				0-9											
5-27							1-0	3-0									1-0	5-3								0-1			
5-29								1-2						0-1				1-4											
6-1								3-0									0-3	1-12											
6-3								2-0						0-1			1-1									0-1			
6-5	1-0							5-0									1-5	0-2		1-0									
6-8	0-1						0-2	2-1	3-1		1-0						0-1												
6-10						1-1	0-1		1-0						1-0		0-6	0-1				1-0							
6-12	0-1						1-0	1-0									1-14	0-4			1-0								
6-15							1-0	2-0					1-0	1-0			0-1												
6-17								5-0						2-0			0-2												
6-19		0-4	0-2			1-0		1-82		0-1							0-9	3-57											
6-22		0-4	0-1				0-1	24-3	8-0								1-1	4-0											
6-24		1-4	1-1		1-0	0-1	1-0	0-35	1-6								0-2	2-44				0-1							
6-26	0-1	0-12	0-1				3-0	0-1	1-3											0-1		0-2					0-1		
6-29		0-13	0-14	1-1			2-1	5-4	1-14					1-1				0-4											
7-1		0-2	1-2				1-0	1-1	2-1									0-1											
7-3		0-5	0-5	1-0				2-0	0-4									0-10											
7-6			0-1				2-0															0-1							
7-8			2-0					2-0										0-1				0-2							
7-10	0-1	0-12	0-30				1-0	1-0									0-2	0-34		0-3		0-1							
7-13		0-15	0-18					1-5									0-1	3-1		0-1						0-2			
date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap	Cs

Appendix V
Year #3

date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap	Cs
7-14		0-11	0-15			0-1	80-7	12-0	0-1									0-6				0-1							
7-16		0-19	1-46	0-2		0-1	21-56	6-7	0-2									0-3		1-1									
7-18		0-4	0-10	0-1			0-9	0-5	0-2								1-0	0-1								1-0			
7-20		1-12	0-11				1-7											2-8		0-1						1-1			
7-22	0-1	0-3	0-5															4-0		1-0									
7-24		0-16	0-22				0-2	1-1										0-10											
7-27		0-12	0-14				0-2	1-0	0-3													1-0							
7-29		1-6	0-11				2-1	3-4	0-1								0-2	0-11		1-1						0-1			
7-31		0-3	0-7	0-1			1-3	6-2	0-2									1-3		0-1	2-0	2-0							
8-3		0-1	0-1			1-0	0-1	0-3	0-1											1-0									
8-5			0-1			1-0		0-4																	0-1	0-1			
8-7																													
8-10		0-1	0-3				0-1	0-1										1-1											
8-13		0-1	0-1				0-1	1-1	1-0									1-0		0-1	1-0	1-0				1-0			
8-15		0-2	0-1			1-0			0-1									0-1											
8-17		0-1																1-2											
8-19		0-2						1-0										0-2								1-0			
8-21		0-3						0-1										0-2											
8-24																		2-0											
8-26						2-0	1-0																		0-1	0-1			
8-28							1-0	0-1																					
8-31		0-1		2-1				1-0																					
9-4		0-3			14-0	1-0		0-1										1-0		2-0									
date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap	Cs

Appendix V
Year #4

Study Pond #1: Vertebrates trapped in drift fence buckets over a one-year period, 9/7/1998 - 9/5/1999. IN-migration data on left, OUT-migration on right. Species are At=*Ambystoma talpoideum*, mole salamander; Np=*Notophthalmus perstriatus*, striped newt; Nv=*Notophthalmus viridescens*, common newt; Eq=*Eurycea quadridigitata*, dwarf salamander; Sh=*Scaphiopus holbrooki*, spadefoot; Bt=*Bufo terrestris*, southern toad; Bq=*Bufo quercicus*, oak toad; Gc=*Gastrophryne carolinensis*, narrowmouth toad; Ag=*Acris gryllus*, cricket frog; Po=*Pseudacris ornata*, ornate chorus frog; Pc=*Pseudacris crucifer*, spring peeper; Lo=*Limnaoedus ocularis*, little grass frog; Hf=*Hyla femoralis*, pinewoods treefrog; Hg=*Hyla gratiosa*, barking treefrog; Hs=*Hyla squirella*, squirrel treefrog; Hc=*Hyla cinerea*, green treefrog; Rcp=*Rana capito*, gopher frog; Ru=*Rana utricularia*, leopard frog; Rct=*Rana catesbeiana*, bullfrog; Ks=*Kinosternon subrubrum*, mud turtle; So=*Sternotherus odoratus*, stinkpot; Dr=*Dierochelys reticularia*, chicken turtle; Af=*Apalone ferox*, eastern softshell turtle; Ps=*Pseudemys scripta*, pond slider; Ts=*Thamnophis sirtalis*, garter snake; Nf=*Nerodia fasciata*, banded water snake; Pf-*Pseudemys floridana*; Ap=*Agkistrodon piscivorus*; Cs=*Chelydra serpentina*; Sp=*Seminatrix pygaea*.

date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap	Cs
1998																													
9-7		1-0			1-1	0-1		0-1										5-6	0-1			1-0							
9-9		0-1																3-2								0-1			
9-11		0-1	0-1																	1-0						1-1			
9-14																				1-0									
9-16																				1-0						0-1			
9-18																		0-4											
9-21		0-22	0-1		0-1		0-1											2-0		0-1									
9-23		0-14	0-2																		0-1								
9-25		0-5																0-1								1-0			
9-28		0-17																											
9-30		2-43	0-1																	0-1									
10-2		1-52	2-4														0-2			0-1						0-1			
10-5		0-140	0-11														0-1			1-0									
10-7		0-61	0-12														0-1	0-1											
10-9		1-31	0-6														1-0												
10-12		0-14	0-7																										
10-14		2-2	0-2																										
10-16		0-2	0-1																										
10-19		0-4																0-1											
10-21		0-1																				1-0							
10-23		0-1																											
10-26			0-1																										
10-28			0-1																										
10-30			1-0																										
11-2		0-1																											
11-4		0-1	0-6															0-6				0-1							
11-6			0-2																										
11-9																		0-1											
11-11		0-10	0-15															1-3											
11-13		0-301	0-583																										
11-16	0-6	1-113	5-298	0-1														0-3											
11-18	0-1	59-69	139-717														0-2												
11-20		0-15	1-170																										
11-23	0-3	0-3	1-75															0-1											
11-25	1-3	0-18	0-25															1-1											
11-27	0-1	0-2	0-36														1-0	0-1											
date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap	Cs

Appendix V
Year #4

date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap	Cs
11-30	0-1		0-3														1-0	0-1											
12-2			0-4																										
12-4		0-2	0-5															1-0											
12-7			0-1																										
12-9	0-1	0-1	0-5																										
12-11	0-2	0-1	1-23			1-0																							
12-14	0-2	0-16	1-79														1-3												
12-16	0-1	0-1	0-12														0-1												
12-18		0-2	0-1																										
12-21		1-1	1-4														1-0					0-1							
12-23		0-2	0-4																										
12-25	0-37	0-29	0-158														0-1												
12-28	0-8	0-11	1-6																										
12-30	1-2	0-5	0-6																			0-1							
1999																													
1-1																													
1-4	2-14	0-7	0-1															0-1											
1-6	3-4	0-2	0-2																										
1-8	0-11	0-1	0-2															0-1		0-1									
1-11	0-5	0-2	0-4																	0-1									
1-13	2-3	0-3	0-1																	0-1		0-1							
1-15	2-2		0-5																										
1-18	0-2	0-1	0-1																	0-1						1-0	0-1		
1-20	0-2	1-5																											
1-27	1-6		0-2																										
1-29	1-1		1-0															0-1		0-1									
2-1	0-2		1-1															0-1											
2-3			1-1							1-0																			
2-5	1-0	0-1			1-0													0-2											
2-8																													
2-10	0-1							0-1																					
2-12								1-0												0-1		0-2							
2-15																		0-1											
2-17	0-1																	0-1											
2-19	0-32	0-3	0-18		1-0													1-1		0-1									
2-22	0-13	1-5																		0-1									
2-24	0-7	0-1	0-5																										
2-26	0-1																												
3-1	0-6		0-3															0-1	0-1			0-1							
3-3	2-6	0-1	0-2																										
3-5		0-1	0-1																										
3-8	0-2	0-14	0-27																										
3-0	0-2	1-7	3-54																										
3-12	0-4	0-4	0-22																										
3-15	1-104	0-7	0-21		0-1	1-0												0-1		1-2									
date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap	Cs

Appendix V
Year #4

date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap	Cs
3-19	3-10	0-1	1-6															1-0								1-0			
3-22	4-1		2-1			1-0																							
3-24	0-2		0-2																										
3-26	3-3	0-3	2-2					1-0										0-1											
3-29	2-3	0-2	2-2					1-0																					
3-31	0-1	2-0	1-1				1-0																						
4-2		0-1	0-1																										
4-10		2-7	1-17					4-0	0-1		1-0									0-9	0-6	1-5			0-2	0-1	0-1		
4-16		0-2	0-9																	1-5	0-3	0-3							
4-19		1-0	1-3			1-0														1-1									
4-21			1-2																	0-1	0-1								
4-23																			0-1			0-1							
4-26								1-0												1-2									
4-28																				0-1									
4-30	0-3	0-2	1-15					0-1												0-5	0-3	1-0				0-1			
5-3		0-2	0-9						0-4																				
5-5			0-1																	0-1									
5-7	0-1		0-13																	2-1									
5-10		0-1																											
5-12																					0-1								
5-14			0-1				0-1													1-2	0-1								
5-17																				1-0									
5-19																													
5-21																													
5-24																									0-1				
5-26																													
5-28																				1-1		1-0							
5-31								2-0	1-0																				
6-2						2-0														1-1	0-1								
6-4			0-1																	0-1		0-1							
6-7					1-0				0-1											3-1		0-1							
6-9								0-2												1-1									
6-14								2-1												0-4	0-2								
6-16								1-0												0-1									
6-18								2-2												1-0									
6-21								3-1													1-0								
6-23								1-0																					
6-25						0-3		0-1																					
6-28						3-0	2-0	4-0																					
6-30							4-0	6-0												1-0									
7-2								2-3												2-1									
7-5								3-3												3-1	0-1								
7-7								4-8																					
7-9								1-1												0-2									
7-12								1-2												0-1									
date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap	Cs

Appendix V
Year #4

date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap	Cs
7-14								3-0																					
7-16						1-0		1-1																					
7-19								0-1																					
7-21						1-0														1-1	0-1								
7-23								0-5	0-1											0-1									
7-26								0-4																					
7-28								0-3												0-1						0-1			
7-30								0-1																	1-0				
8-2								1-2												0-1					0-1				
8-4								2-1																					
8-6																													
8-9							0-1	0-28																					
8-11							0-1	0-5																					
8-13							0-1	0-11																					
8-16								0-3																					
8-18							0-2	2-1																					
8-20								0-4																		1-0			
2-23							0-1	1-0																					
8-25																													
8-27																													
8-30						1-0		0-1																					
9-1																													
9-3								1-0																					
date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap	Cs

Appendix V
Year #5

Study Pond #1: Vertebrates trapped in drift fence buckets over a one-year period, 9/6/1999 - 9/6/2000. IN-migration data on left, OUT-migration on right. Species are At=*Ambystoma talpoideum*, mole salamander; Np=*Notophthalmus perstriatus*, striped newt; Nv=*Notophthalmus viridescens*, common newt; Eq=*Eurycea quadridigitata*, dwarf salamander; Sh=*Scaphiopus holbrooki*, spadefoot; Bt=*Bufo terrestris*, southern toad; Bq=*Bufo quercicus*, oak toad; Gc=*Gastrophryne carolinensis*, narrowmouth toad; Ag=*Acris gryllus*, cricket frog; Po=*Pseudacris ornata*, ornate chorus frog; Pc=*Pseudacris crucifer*, spring peeper; Lo=*Limnaoedus ocularis*, little grass frog; Hf=*Hyla femoralis*, pinewoods treefrog; Hg=*Hyla gratiosa*, barking treefrog; Hs=*Hyla squirella*, squirrel treefrog; Hc=*Hyla cinerea*, green treefrog; Rcp=*Rana capito*, gopher frog; Ru=*Rana utricularia*, leopard frog; Rct=*Rana catesbeiana*, bullfrog; Ks=*Kinosternon subrubrum*, mud turtle; So=*Sternotherus odoratus*, stinkpot; Dr=*Dierochelys reticularia*, chicken turtle; Af=*Apalone ferox*, eastern softshell turtle; Ps=*Pseudemys scripta*, pond slider; Ts=*Thamnophis sirtalis*, garter snake; Nf=*Nerodia fasciata*, banded water snake; Pf-*Pseudemys floridana*; Ap=*Agkistrodon piscivorus*; Cs=*Chelydra serpentina*; Sp=*Seminatrix pygaea*.

date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap	Cs
1999																													
9-6								0-1																					
9-8								1-0																					
9-10							0-1	0-9																					
9-13								1-0																					
9-15								1-0																					
9-17																													
9-20								0-2																					
9-22								0-1																					
9-24																													
9-27								0-1																					
9-29																													
10-1																													
10-4								0-1																					
10-6																													
10-8																													
10-11								0-2																					
10-13																													
10-15																													
10-18																													
10-20																													
10-22																													
10-25																													
10-27																													
10-29																													
11-1																													
11-3																													
11- 5																													
11-8																													
11-10																													
11-12																													
11-15																				1-0									
11-17																													
11-19																													
11-22																													
11-24																													
11-26																													
date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap	Cs

Appendix V
Year #5

date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap	Cs
11-29																													
12-1																													
12-3																													
12-6																													
12-8																													
12-10																													
12-13																													
12-15					1-1																								
12-17																													
12-20			1-0		0-1																								
12-22			6-0																										
12-24			2-0																										
12-27																													
12-31																													
2000																													
1-3			1-0																										
1-5	1-0		4-0																										
1-7																													
1-10					1-0																								
1-12					1-0																								
1-14			1-0		1-0																								
1-17																													
1-19																													
1-21																													
1-24					1-0																								
1-26																													
1-28																													
1-31			1-0																										
2-2																													
2-4																													
2-7																													
2-9																													
2-11			1-0																										
2-14					6-2				1-0																				
2-16					2-0															1-0									
2-18																													
2-21					3-0																								
2-23																													
2-25																													
2-28																													
3-1																													
3-3																													
3-6																													
3-8																													
3-10																				0-1	0-1	0-1							
date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap	Cs

Appendix V
Year #5

date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap	Cs
3-15																					1-0								
3-17					1-0																								
3-20					6-0															0-2		0-1							
3-24																													
3-27																													
3-29																													
3-31						1-0																							
4-3																													
4-5																													
4-7																						0-2							
4-10																													
4-12																													
4-14																													
4-17																													
4-19																													
4-21																													
4-24																									1-0				
4-26																													
4-28																													
5-1																													
5-3																													
5-5																													
5-8																													
5-10																													
5-12																													
5-15																				0-5		0-2							
5-17						1-0																							
5-24																													
5-26						1-0																							
5-29																													
5-31																													
6-2																													
6-5																													
6-7																													
6-9																													
6-12																													
6-14																													
6-16																													
6-21																													
6-23						2-0																							
6-26						2-0	1-0		0-1											0-1									
6-28								0-2																					
6-30						2-0	1-0											1-0											
7-3						4-0																							
7-5																													
date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap	Cs

Appendix V
Year #5

date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap	Cs
7-7						1-0																							
7-10						2-0	5-0																						
7-12						1-0	3-0																						
7-14						1-0	2-1																						
7-17																													
7-19																													
7-21																				2-0									
7-24						1-1		0-1												1-0									
7-26					1-0			1-2																					
7-28								0-1																					
7-31																													
8-2						0-1	1-0	0-2																					
8-4						1-0	1-0	1-0												0-1									
8-7						1-0	1-1	1-0														1-0							
8-9						0-1		1-0																					
8-11					1-0	1-0	1-0																						
8-14						2-0																							
8-16						7-0		2-0																					
8-18								2-1																					
8-21						1-0		1-2														0-1							
8-23						1-0		0-1																					
8-25								0-2																					
8-28						0-1																							
9-1					4-4																								
9-4					6-0																								
9-6					81-3															1-0									
date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap	Cs

Appendix V
Year #6

Study Pond #1: Vertebrates trapped in drift fence buckets over a one-year period, 9/8/2000 - 9/?/2001. IN-migration data on left, OUT-migration on right. Species are At=*Ambystoma talpoideum*, mole salamander; Np=*Notophthalmus perstriatus*, striped newt; Nv=*Notophthalmus viridescens*, common newt; Eq=*Eurycea quadridigitata*, dwarf salamander; Sh=*Scaphiopus holbrooki*, spadefoot; Bt=*Bufo terrestris*, southern toad; Bq=*Bufo quercicus*, oak toad; Gc=*Gastrophryne carolinensis*, narrowmouth toad; Ag=*Acris gryllus*, cricket frog; Po=*Pseudacris ornata*, ornate chorus frog; Pc=*Pseudacris crucifer*, spring peeper; Lo=*Limnaoedus ocularis*, little grass frog; Hf=*Hyla femoralis*, pinewoods treefrog; Hg=*Hyla gratiosa*, barking treefrog; Hs=*Hyla squirella*, squirrel treefrog; Hc=*Hyla cinerea*, green treefrog; Rcp=*Rana capito*, gopher frog; Ru=*Rana utricularia*, leopard frog; Rct=*Rana catesbeiana*, bullfrog; Ks=*Kinosternon subrubrum*, mud turtle; So=*Sternotherus odoratus*, stinkpot; Dr=*Dierochelys reticularia*, chicken turtle; Af=*Apalone ferox*, eastern softshell turtle; Ps=*Pseudemys scripta*, pond slider; Ts=*Thamnophis sirtalis*, garter snake; Nf=*Nerodia fasciata*, banded water snake; Pf-*Pseudemys floridana*; Ap=*Agkistrodon piscivorus*; Cs=*Chelydra serpentina*; Sp=*Seminatrix pygaea*.

date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap
2000																												
9-8					23-42	1-1														2-0								
9-11					0-22	0-4		0-1																				
9-13					0-13	3-0																						
9-15					0-8																							
9-18					1-13	11-0	1-0	3-6																				
9-20					0-2	0-1		0-2																				
9-22					54-8															2-0								
9-25					73-135												0-1			3-0		1-0						
9-27					0-7																							
9-29					3-52	1-0														1-0								
10-2					1-9															0-1								
10-4						1-0		2-0																				
10-9					1-1																							
10-11					0-1																	1-0						
10-13																												
10-16																												
10-18																												
10-20																												
10-23																												
10-26																												
10-27						0-1																						
10-30					0-2593																							
11-1					290-2680																							
11-3					553-2031																							
11-6					210-460																							
11-8					251-7546																							
11-10	1-0				2873-20400																							
11-11			0-1		260-437																							
11-13					526-174																							
11-14	20-0		4-0		389-11490-2			1-2																				
11-15	5-0				110-366																							
date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap

Appendix V
Year #6

date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap
11-17	37-1				148-985																							
11-20	1-1		1-0		0-36																							
11-22			1-0																									
11-24					0-2																							
11-27	52-0				9-463	1-7		0-1										0-1										
11-29	5-0				0-1													1-0										
12-1	1-0																											
12-4																												
12-8																												
12-11	6-1				8-92													0-1				0-1						
12-13			2-0			0-20												2-0										
12-15	2-2		1-0			0-11													1-0	0-1								
12-18	3-6				1-3																							
12-20	0-3																			0-1								
12-22	1-0																											
12-29	8-4		1-0		0-3	0-1												1-0										
2001																												
1-1																												
1-3	0-2																											
1-5																												
1-8																		1-1										
1-10																												
1-12	0-2																											
1-15																												
1-17																												
1-19			0-1															2-0										
1-22	0-19				2-1	1-0												1-0										
1-24	0-4																											
1-26	0-1																	1-0										
1-29	1-0																											
1-31	1-2																	0-2										
2-2	0-1																											
2-5	0-3		0-1		0-1													0-2										
2-7	0-1																											
2-9					0-1																							
2-12			1-0																									
2-14	0-1																	1-0										
2-16	0-2							1-0										1-2		0-1								
2-19	0-8				0-1													1-0										
2-21	3-21		2-1		1-0	1-1												1-1	0-1									
2-23	0-14		1-3					0-1										0-3										
date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap

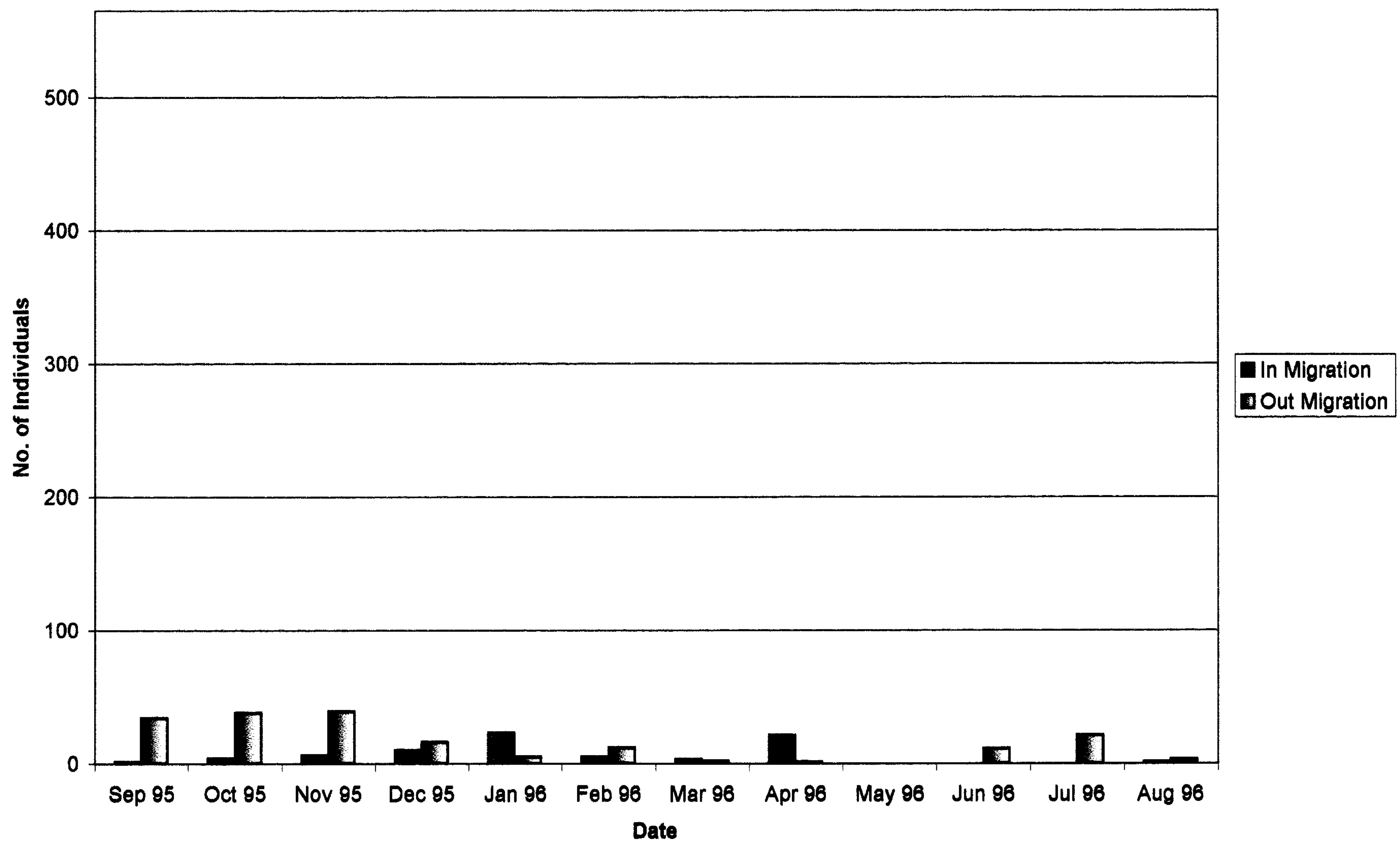
Appendix V
Year #6

date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap
2-26	0-6																	0-1										
2-28	0-13		0-1		0-1	0-4		0-1												2-2								
3-2	0-9		0-1		2-0	0-1	1-0											0-1										
3-5	1-3					1-0																						
3-7																												
3-9																												
3-12	1-1					0-1												1-0										
3-14	3-0																											
3-16	2-2																0-1	0-1		0-1		1-0						
3-19	12-0																											
3-21	20-2	2-0															1-0			1-0								
3-23	5-0																1-0											
3-26	3-0	2-0																										
3-28	1-0		1-0																									
3-30	3-2		1-1				0-2																					
date	At	Np	Nv	Eq	Sh	Bt	Bq	Gc	Ag	Po	Pc	Lo	Hf	Hg	Hs	Hc	Rcp	Ru	Rct	Ks	So	Dr	Af	Ps	Ts	Nf	Pf	Ap

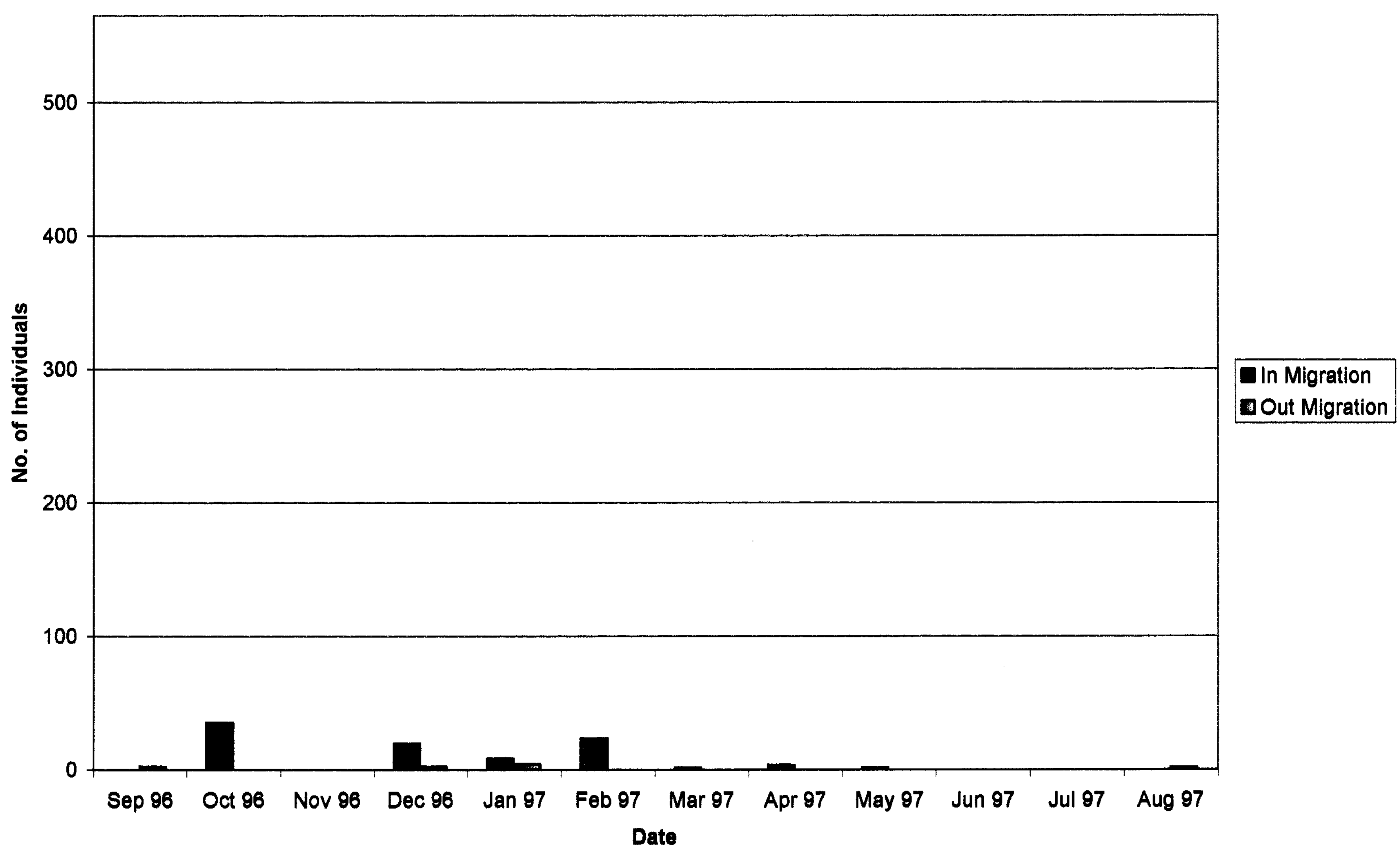
Appendix VI.

Monthly Movements of the Striped Newt (*Notophthalmus perstriatus*) in and out of Study Pond #1, Munson Sandhills, Leon County, Florida, for the Six-year Period September 1995 – September 2001.

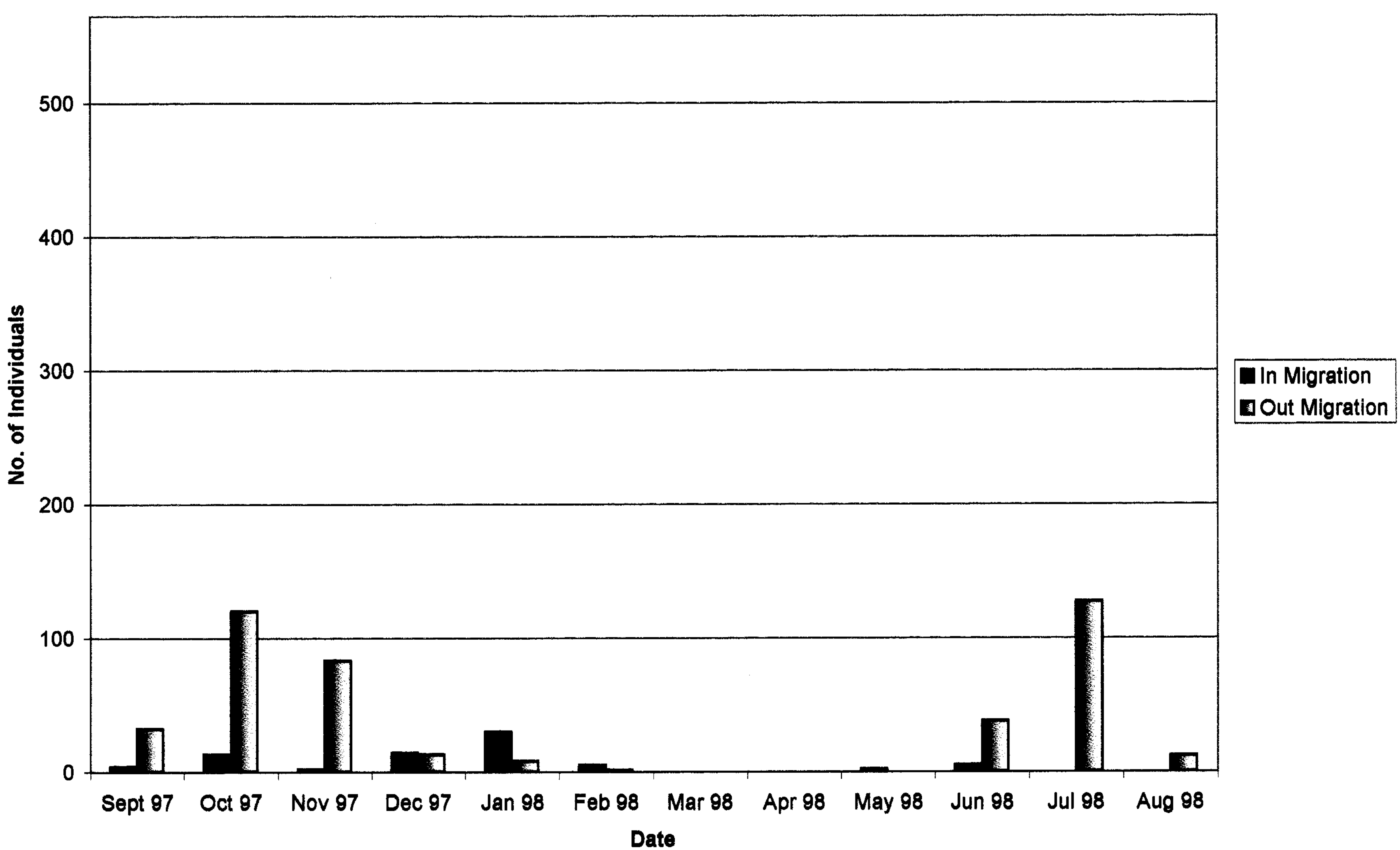
Monthly Movement of the Striped Newt in and out of Study Pond #1, Year 1



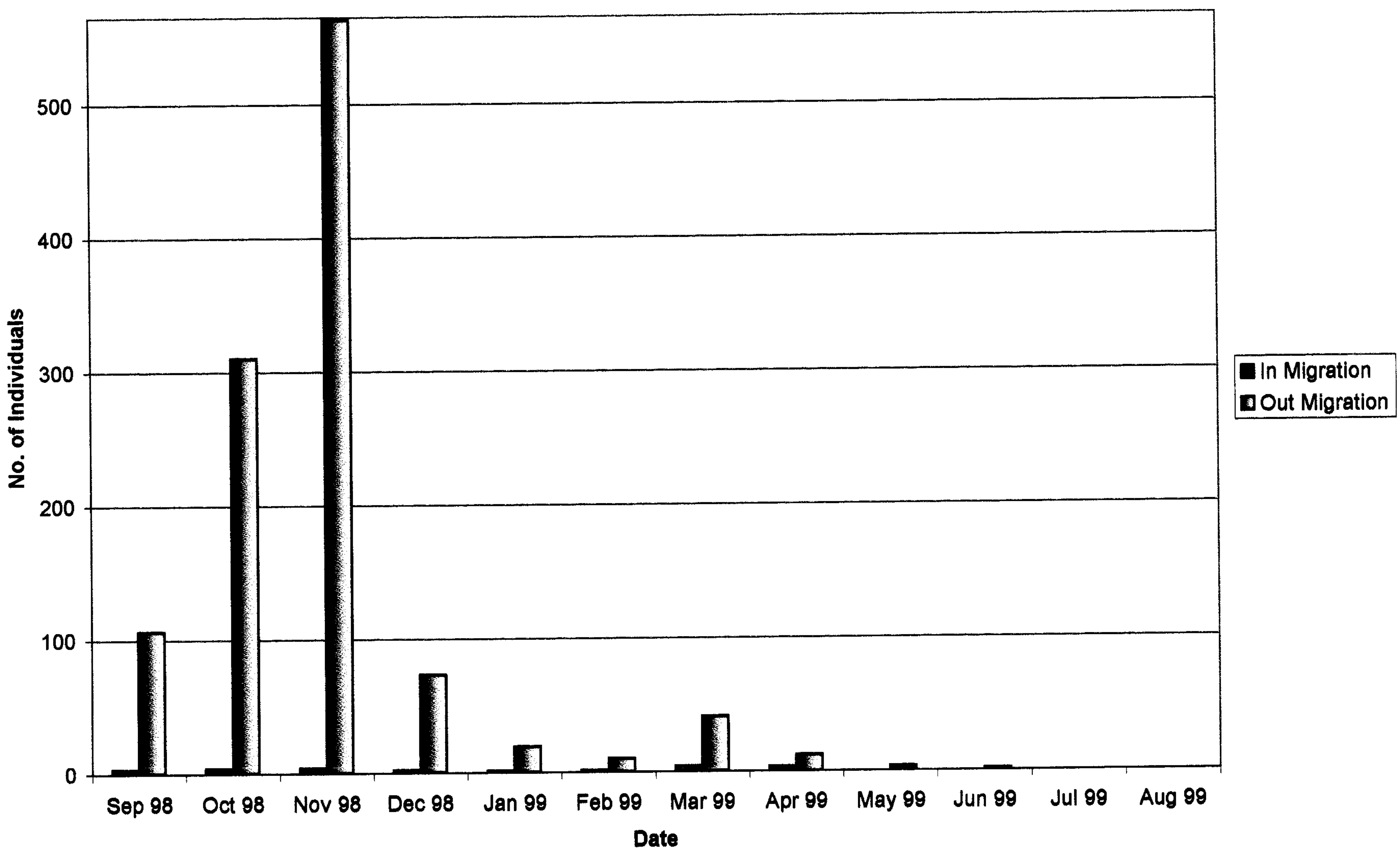
Monthly Movements of the Striped Newt In and out of Study Pond #1, Year 2



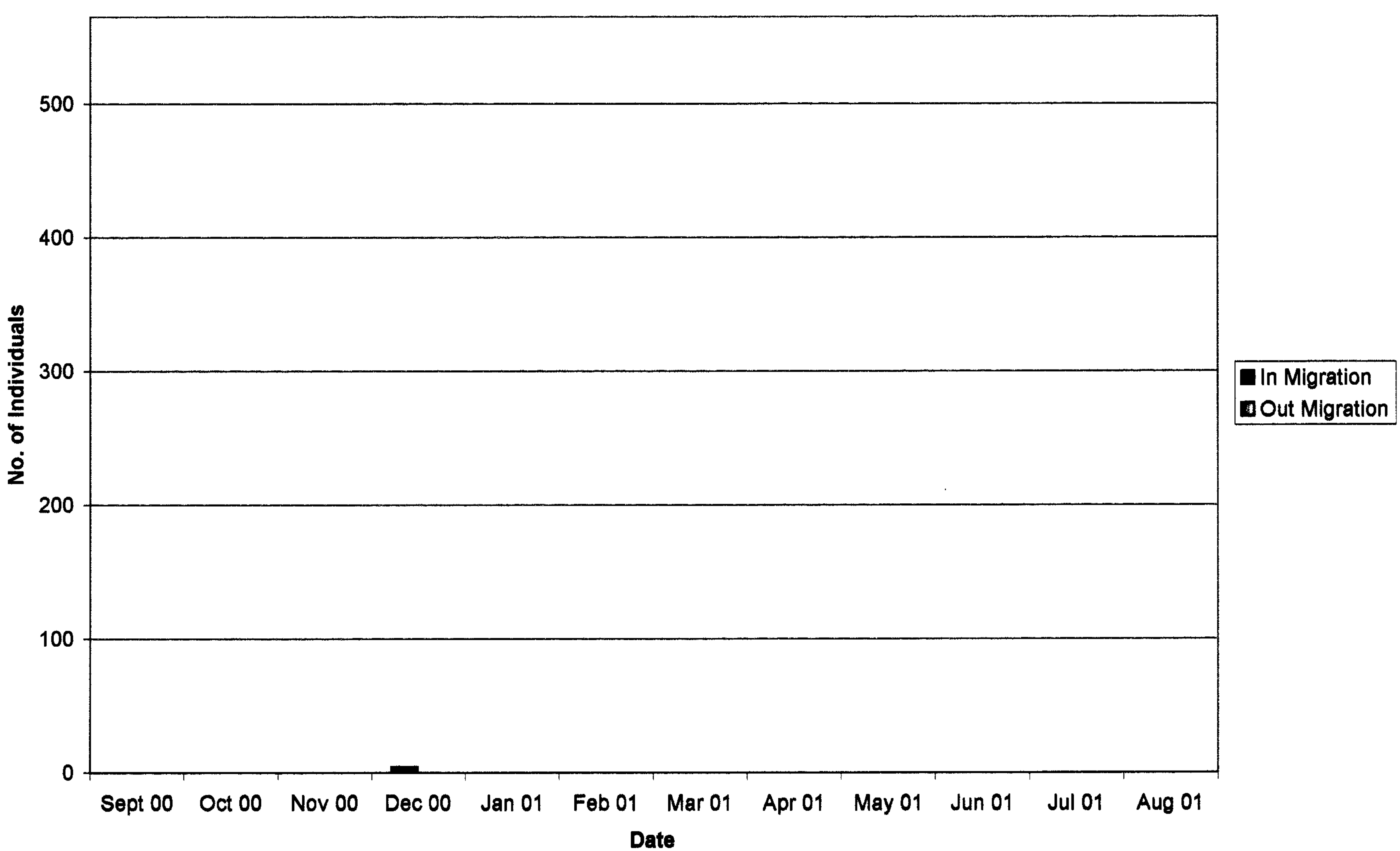
Monthly Movement of the Striped Newt In and out of Study Pond #1, Year 3



Monthly Movement of the Striped Newt in and out of Study Pond #1, Year 4



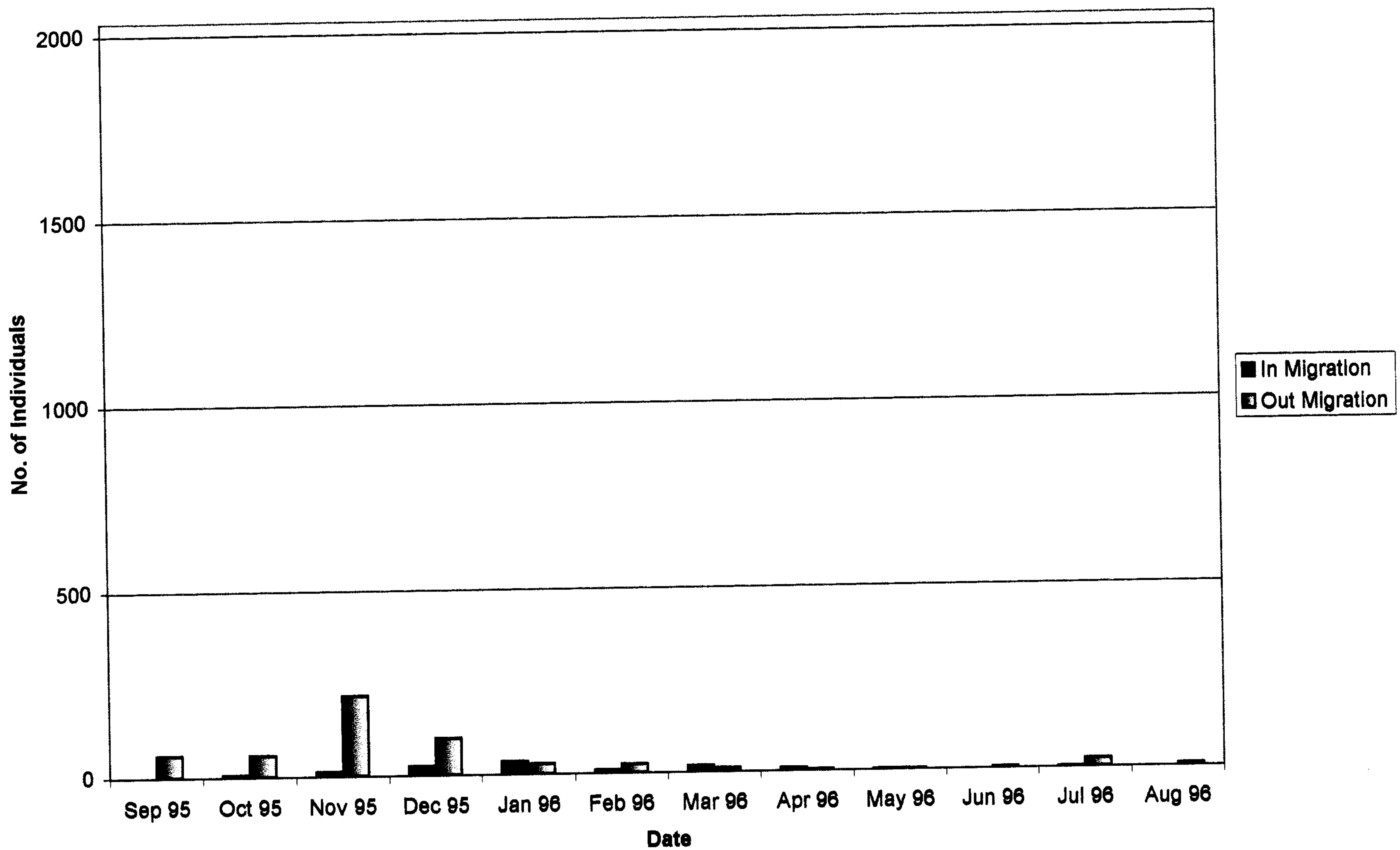
Monthly Movement of the Striped Newt In and out of Study Pond #1, Year 6



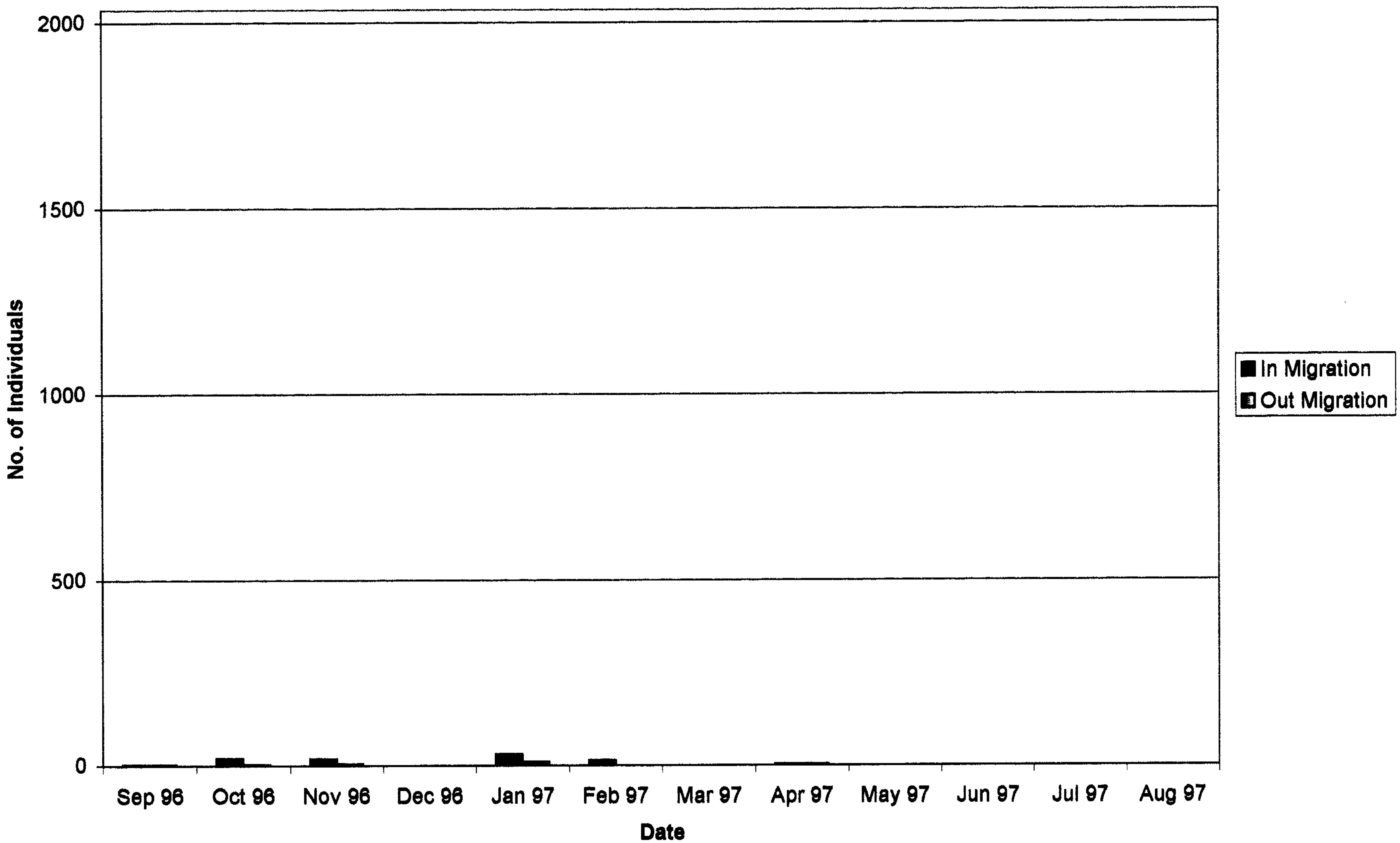
Appendix VII.

Monthly Movements of the Common Newt (*Notophthalmus perstriatus*) in and out of Study Pond #1, Munson Sandhills, Leon County, Florida, for the Six-year Period September 1995 – September 2001.

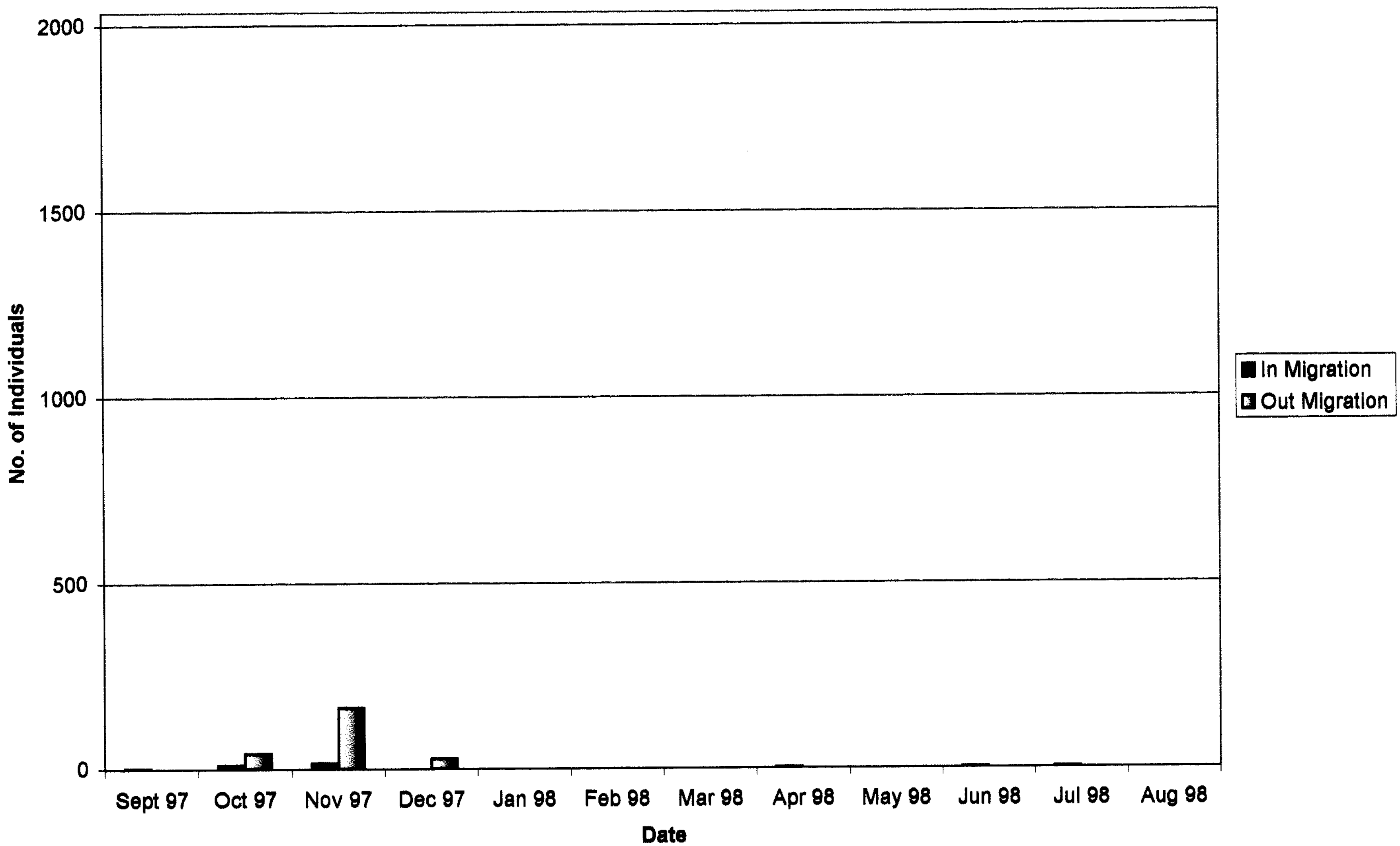
Monthly Movement of the Central Newt in and out of Study Pond #1, Year 1



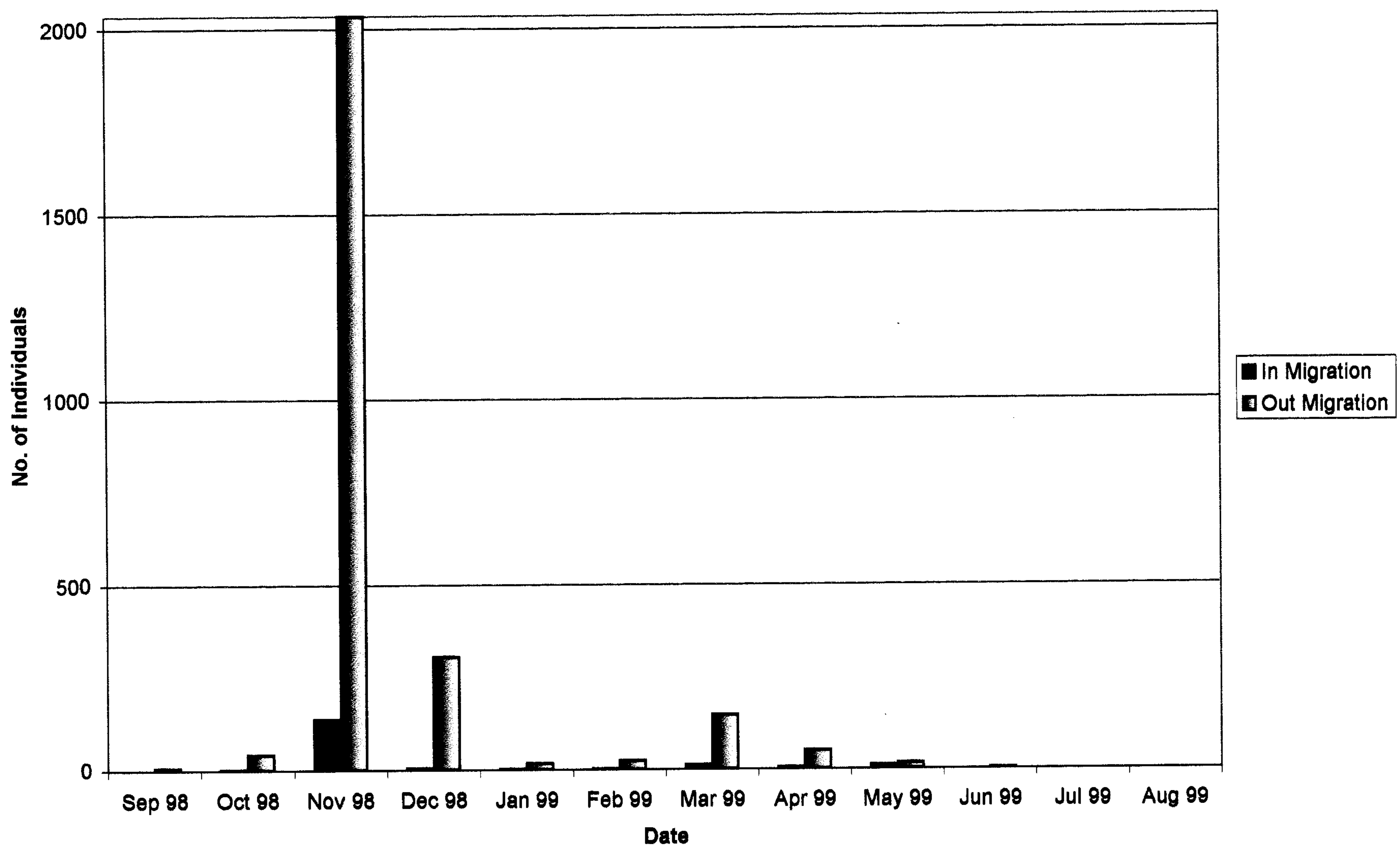
Monthly Movements of the Central Newt In and out of Study Pond #1, Year 2



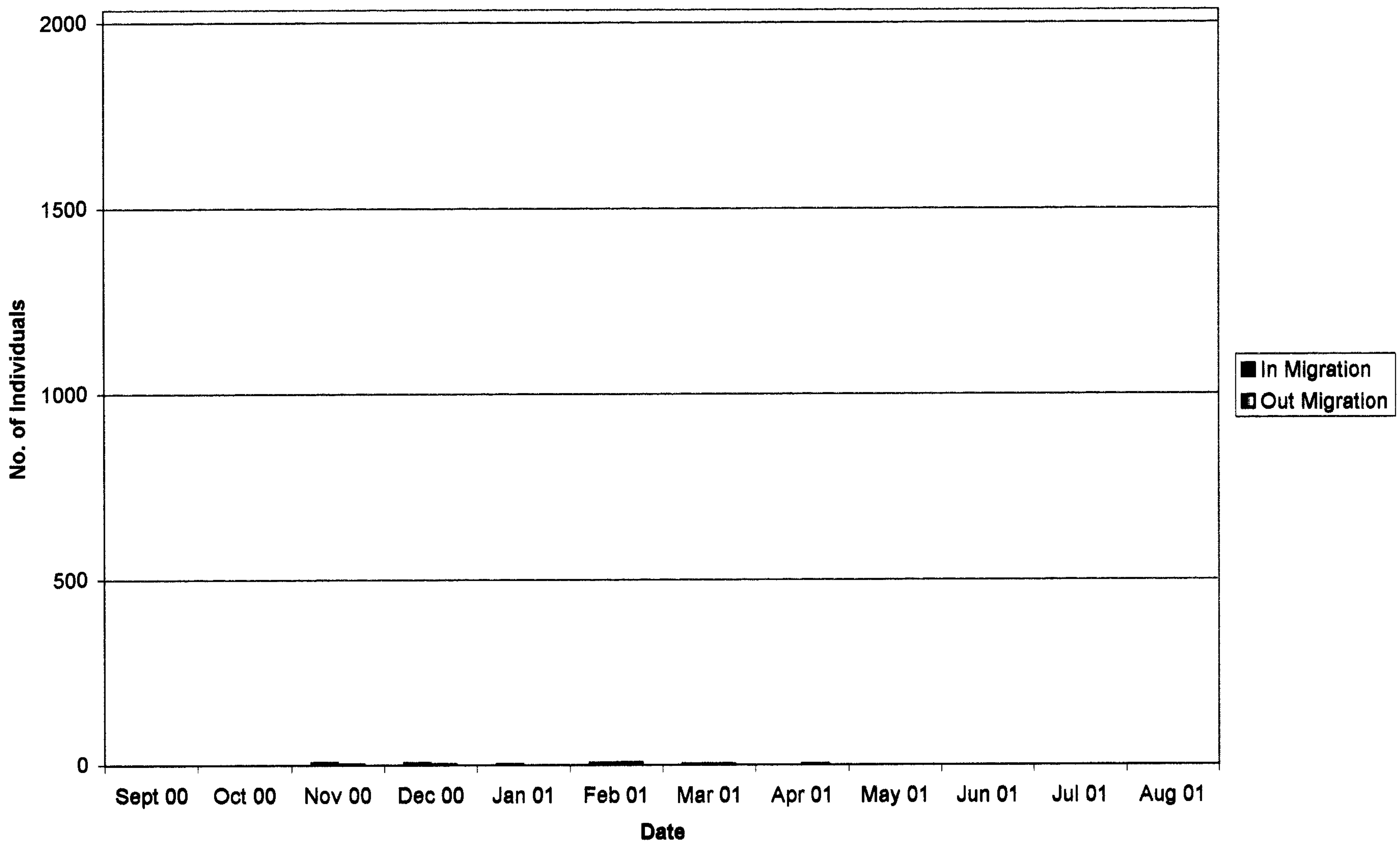
Monthly Movement of the Central Newt In and out of Study Pond #1, Year 3



Monthly Movement of the Central Newt In and out of Study Pond #1, Year 4



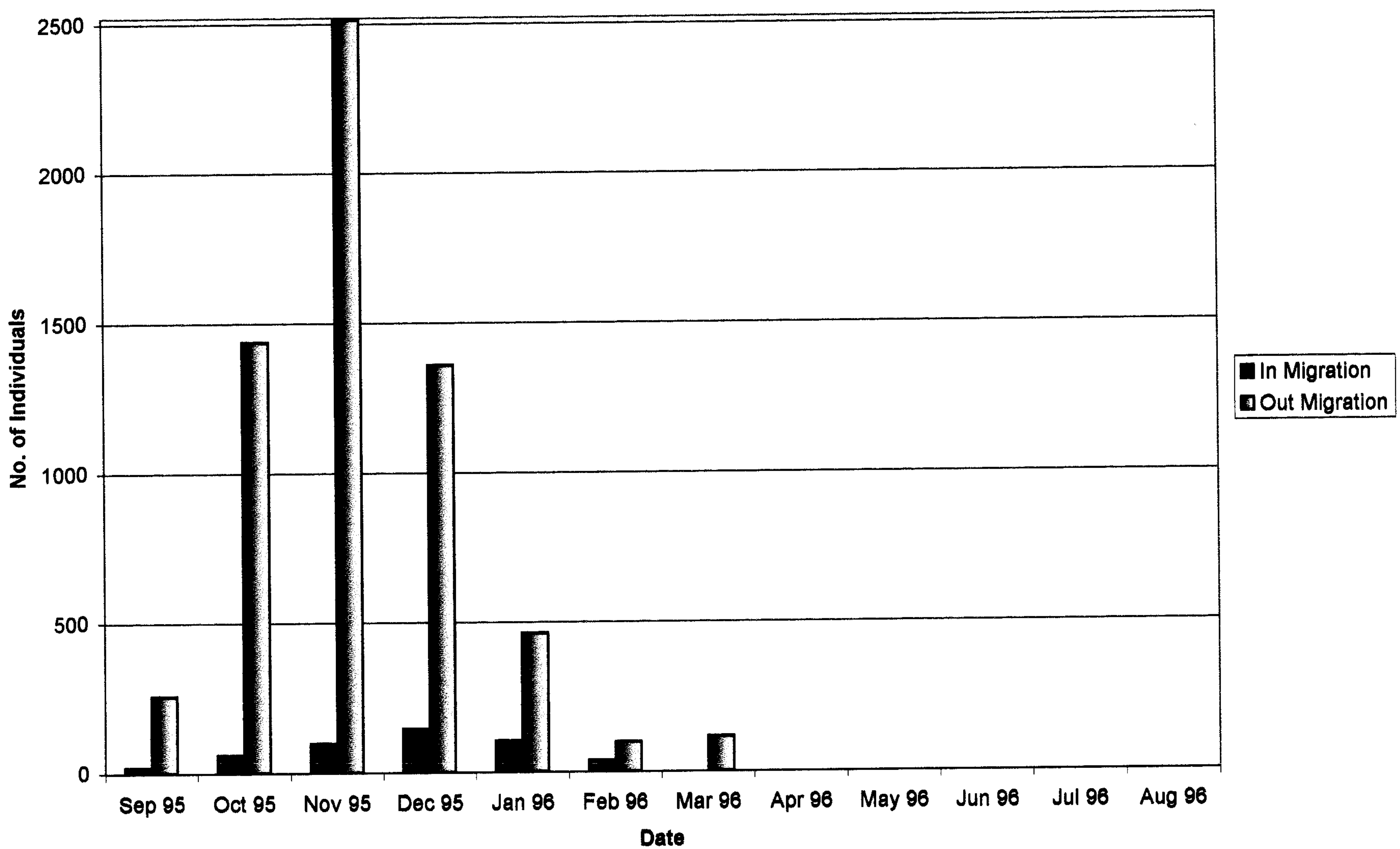
Monthly Movement of the Central Newt in and out of Pond #1, Year 6



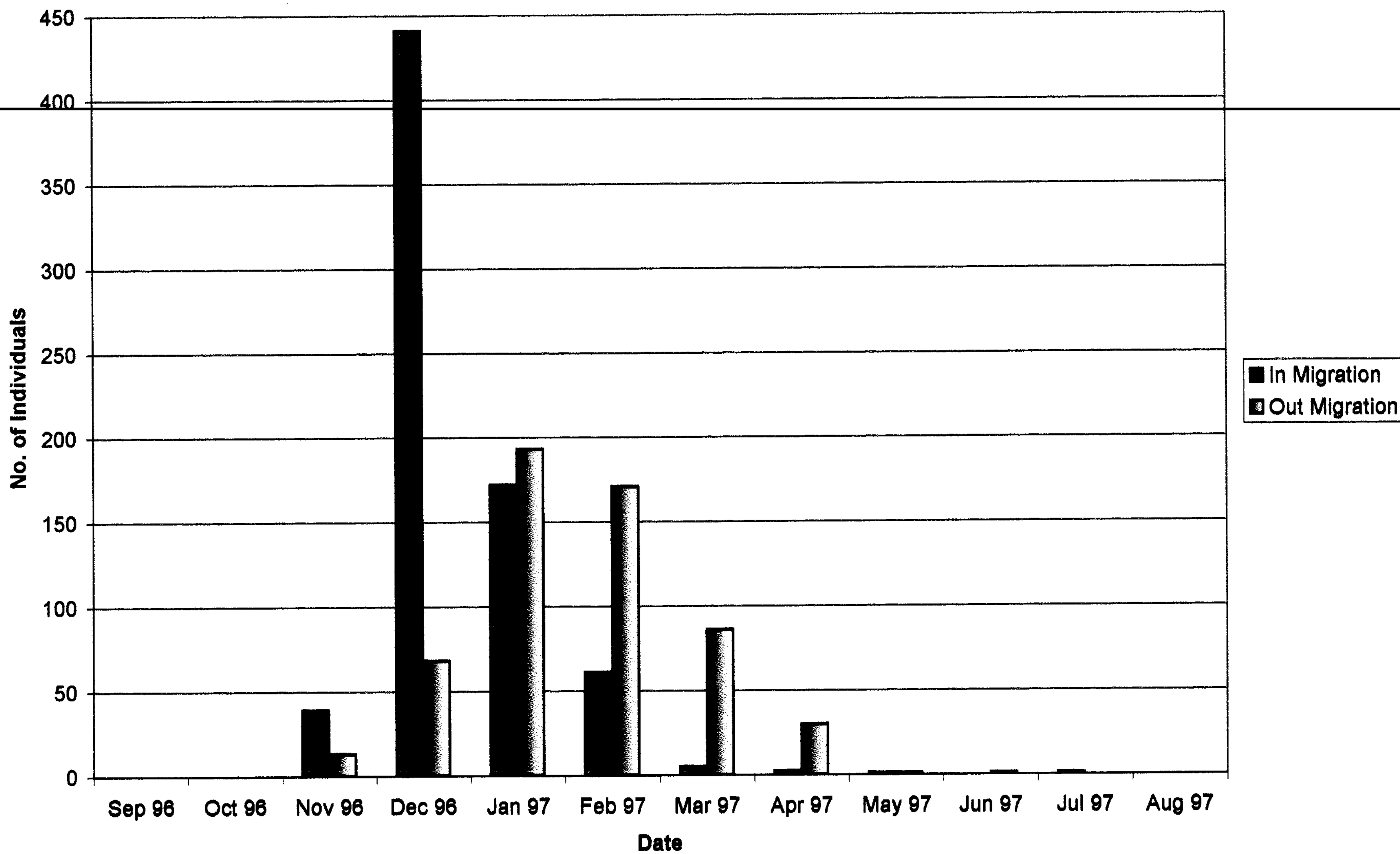
Appendix VIII.

Monthly Movements of the Mole Salamander (*Ambystoma talpoideum*) in and out of Study Pond #1, Munson Sandhills, Leon County, Florida, for the Six-year Period September 1995 – September 2001.

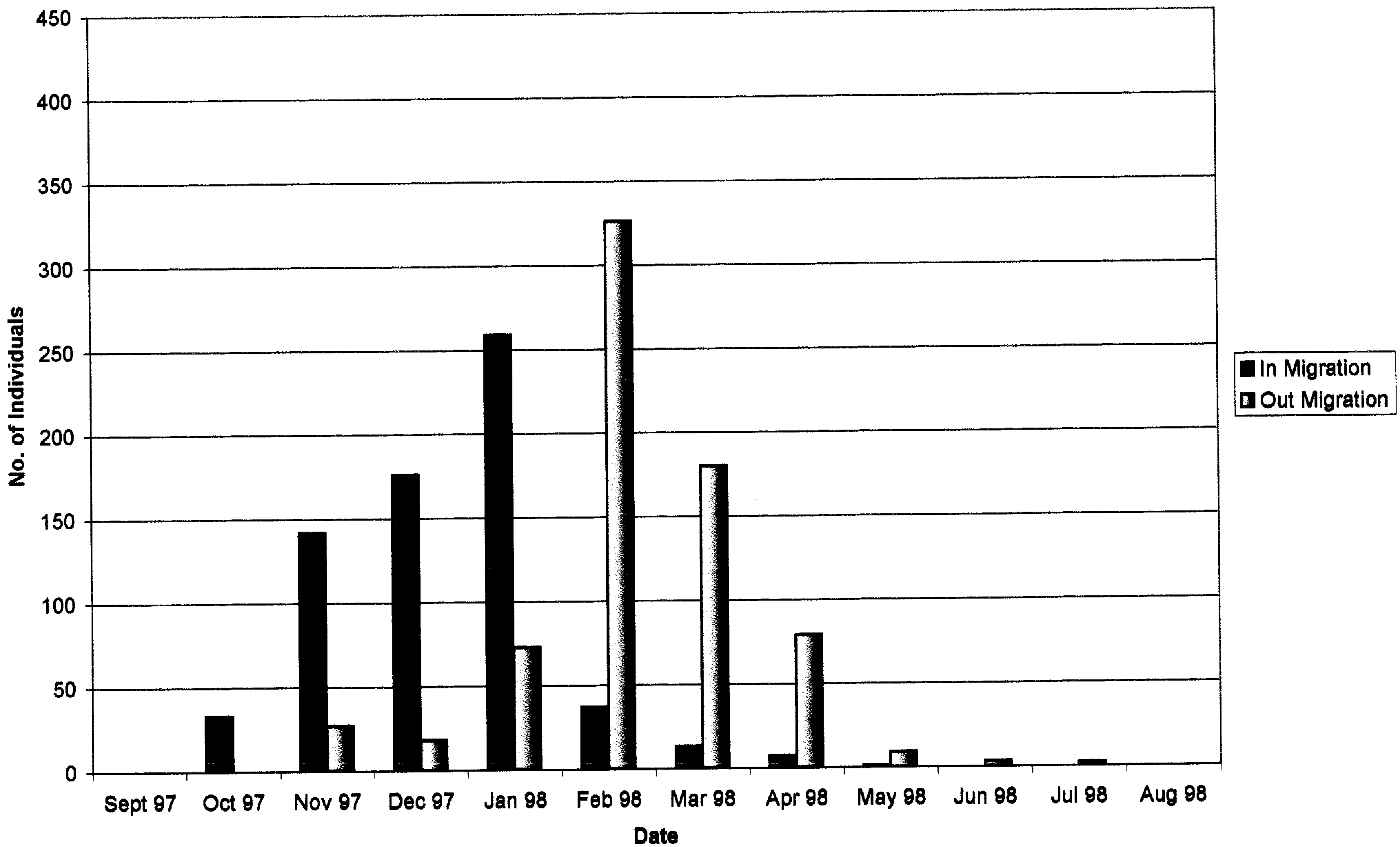
Monthly Movement of the Mole Salamander in and out of Study Pond #1, Year 1



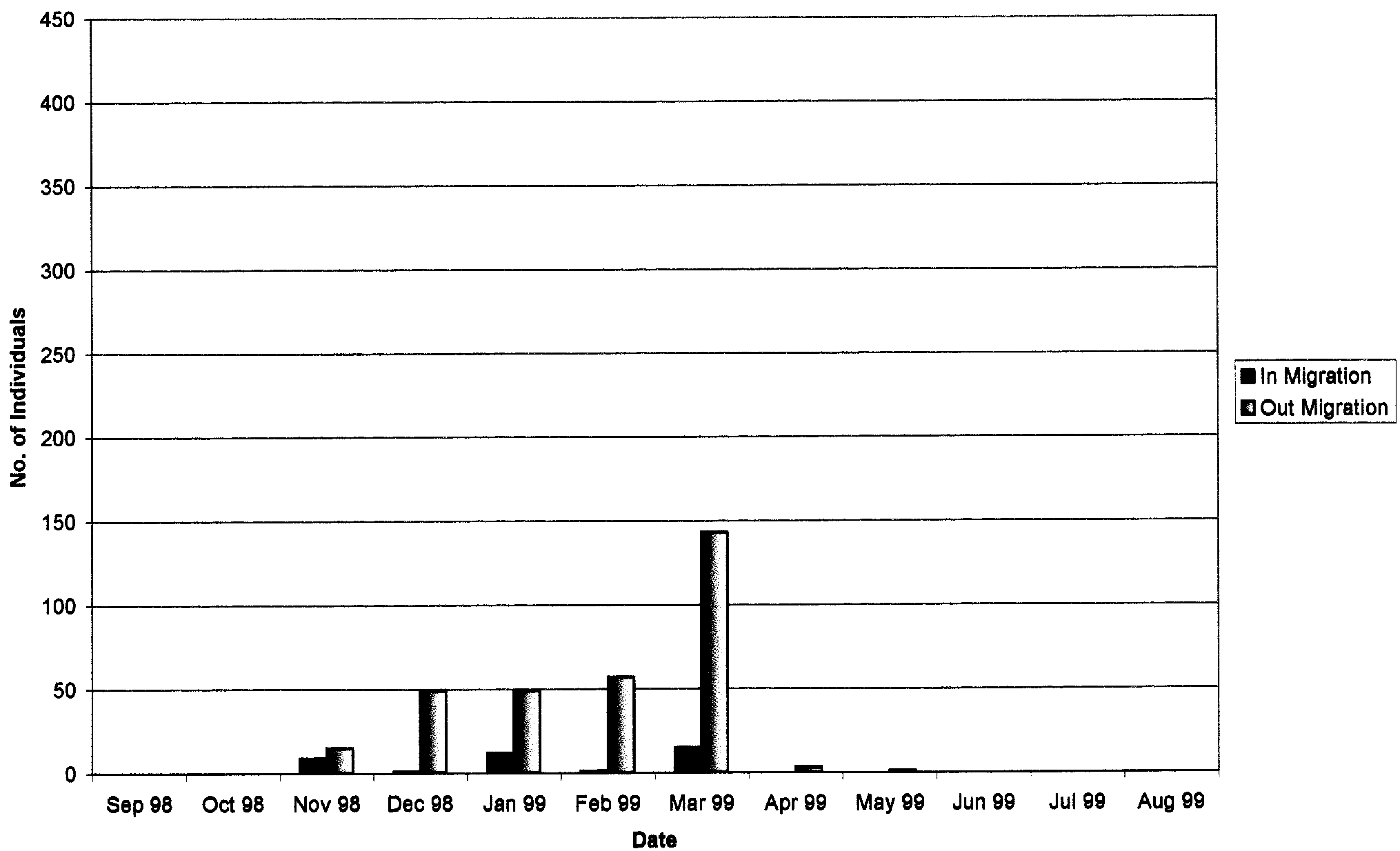
Monthly Movement of the Mole Salamander in and out of Study Pond #1, Year 2



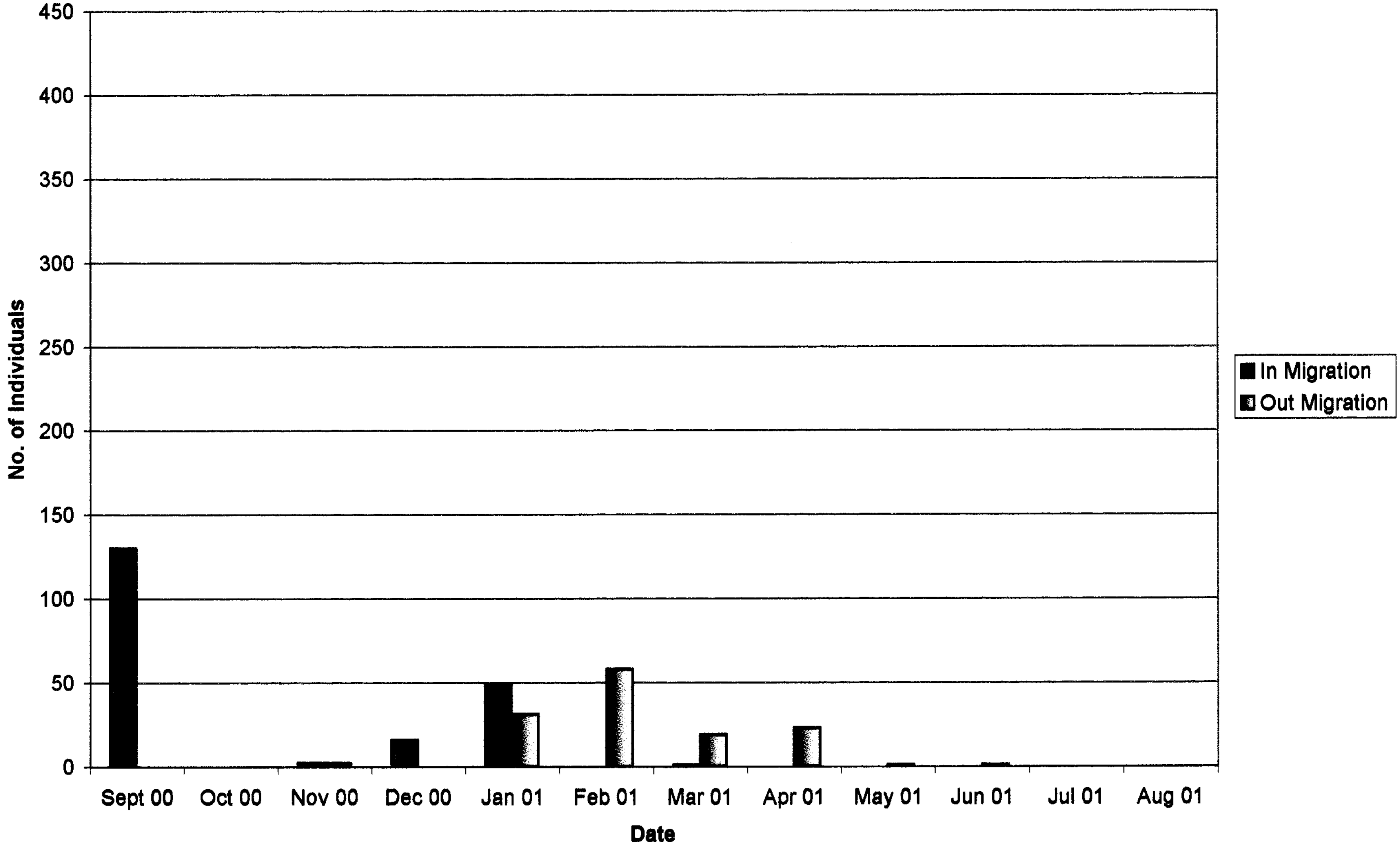
Monthly Movement of the Mole Salamander in and out of Study Pond #1, Year 3



Monthly Movement of the Mole Salamander in and out of Study Pond #1, Year 4



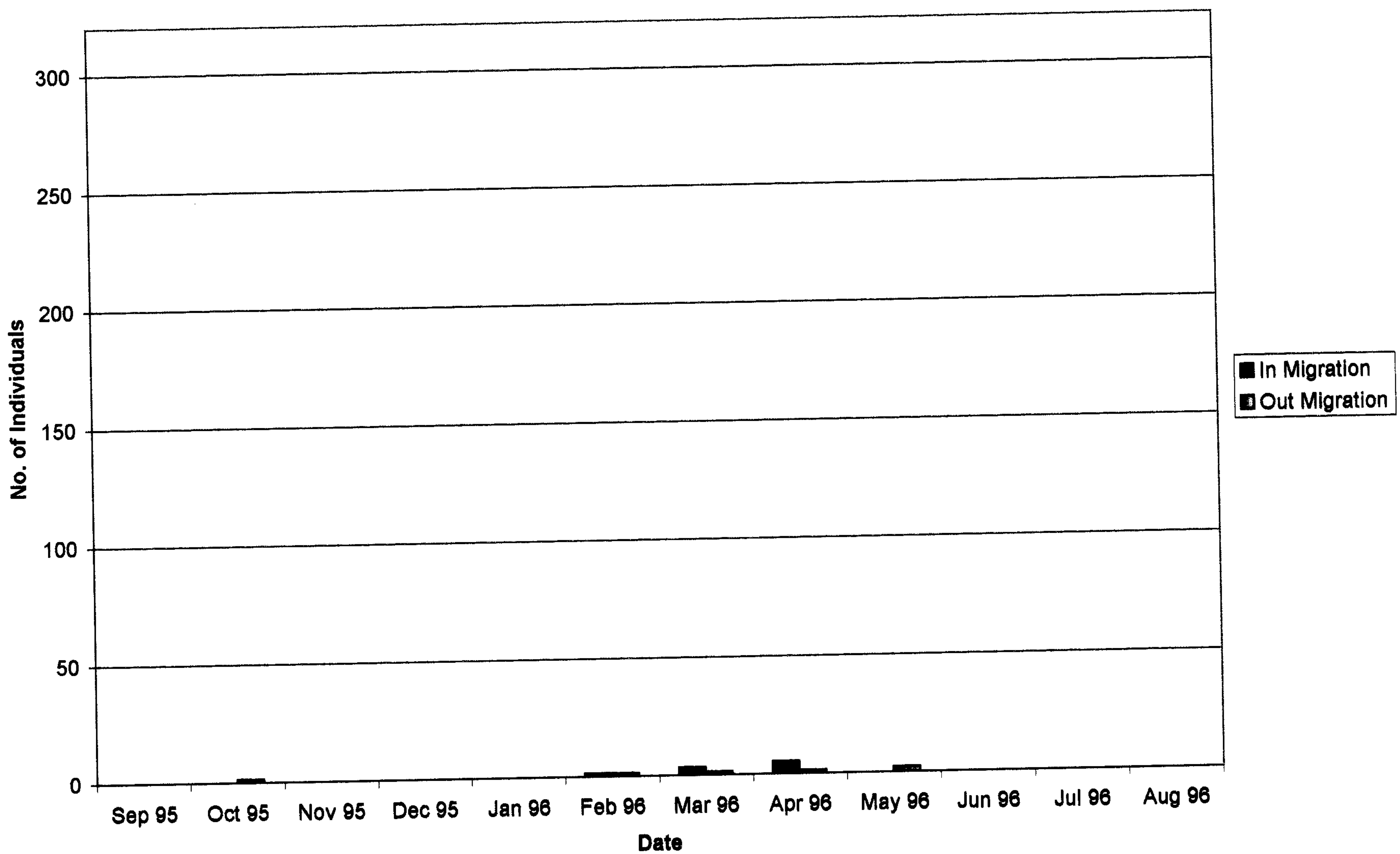
Monthly Movement of the Mole Salamander in and out of Study Pond #1, Year 6



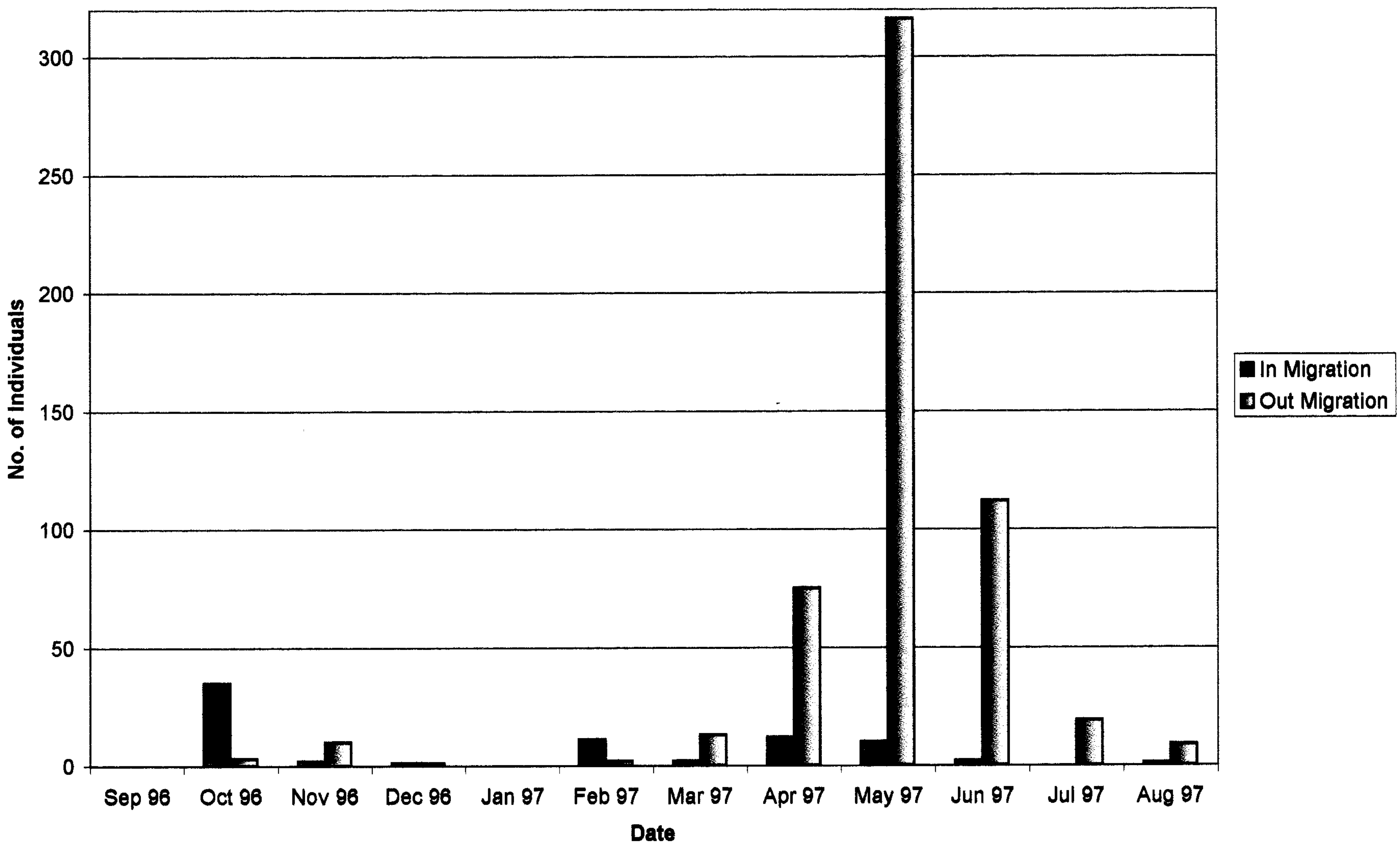
Appendix IX.

Monthly Movements of the Gopher Frog (*Rama capito*) in and out of Study Pond #1, Munson Sandhills, Leon County, Florida, for the Six-year Period September 1995 – September 2001.

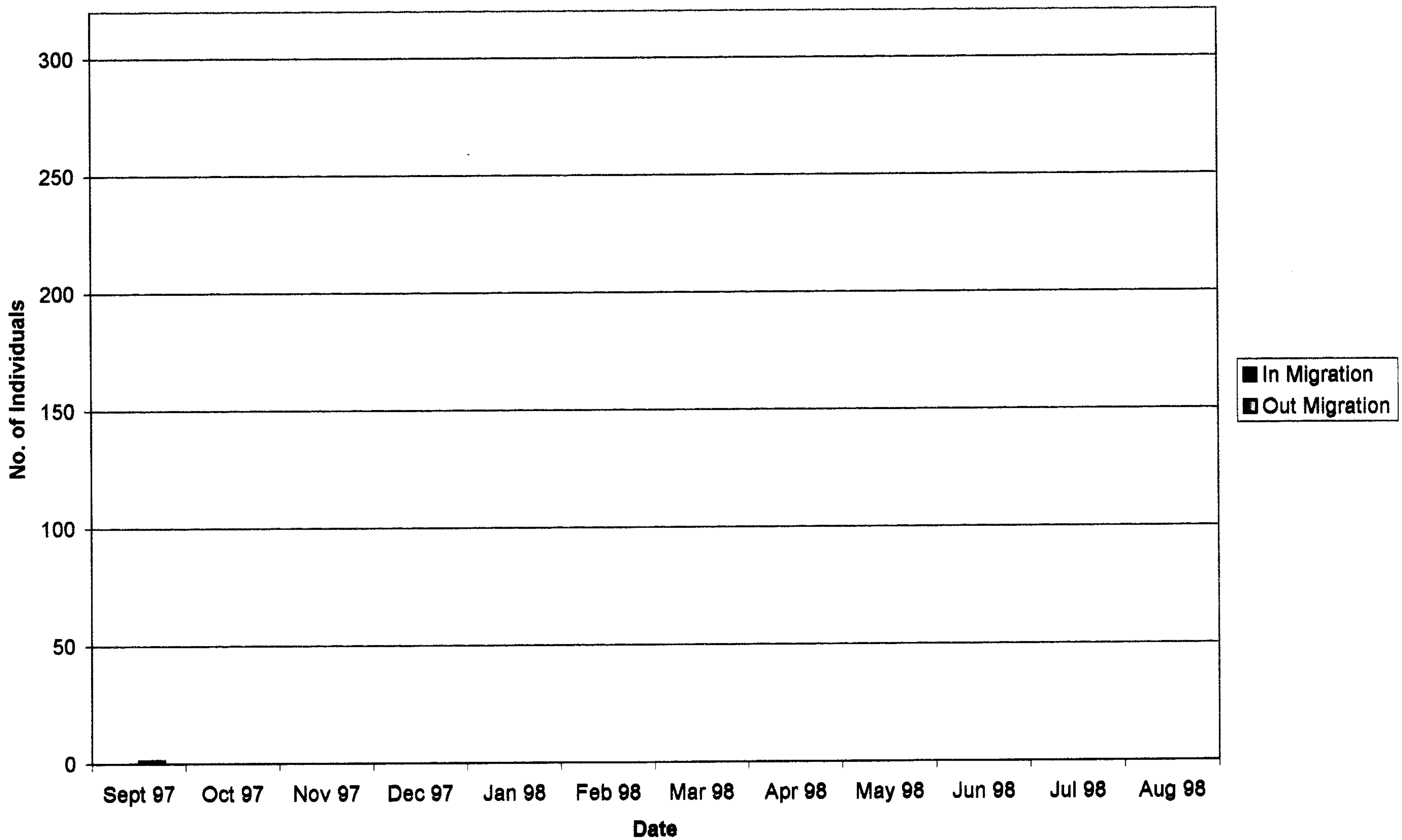
Monthly Movement of the Gopher Frog in and out of Study Pond #1, Year 1



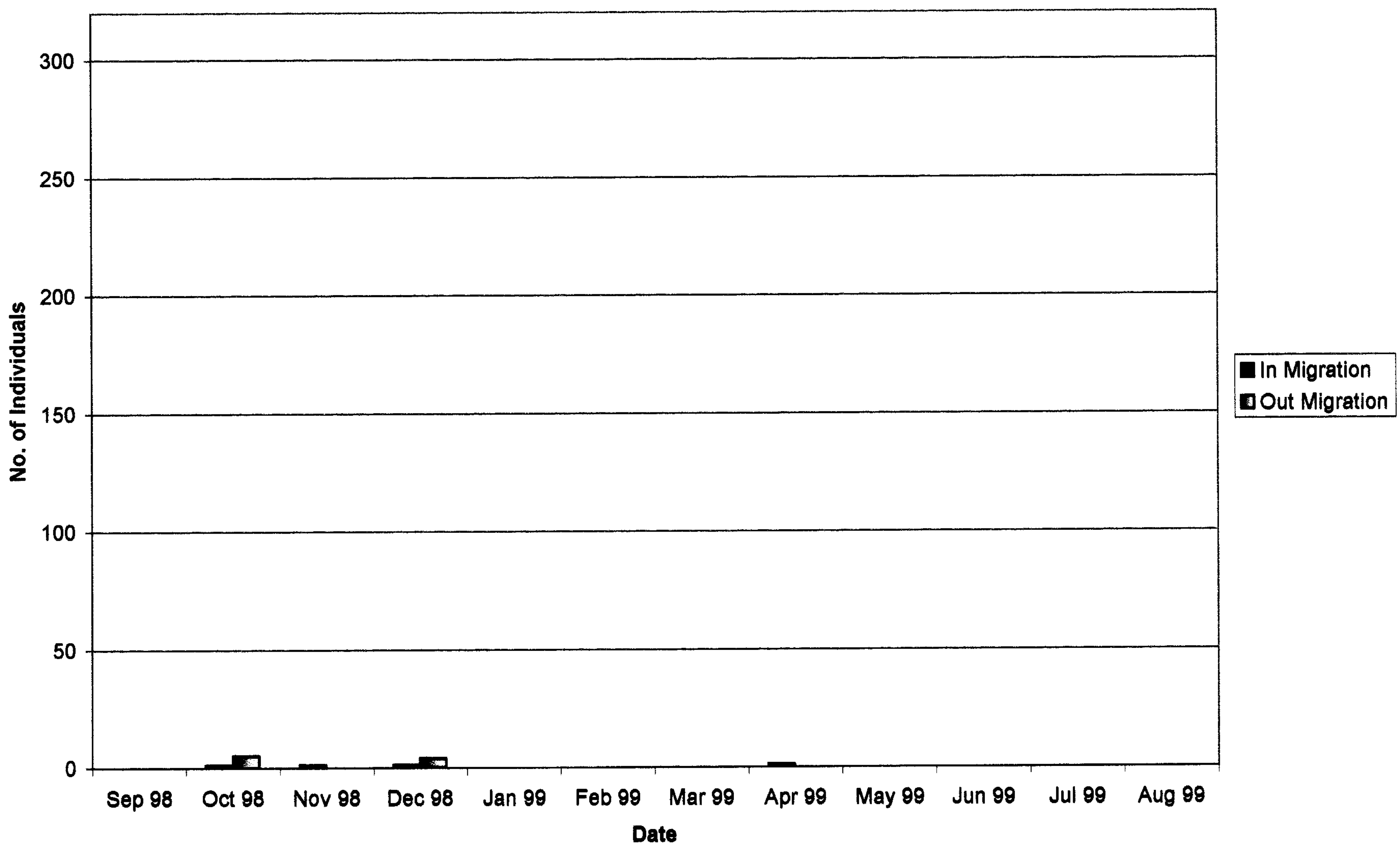
Monthly Movement of the Gopher Frog in and out of Study Pond #1, Year 2



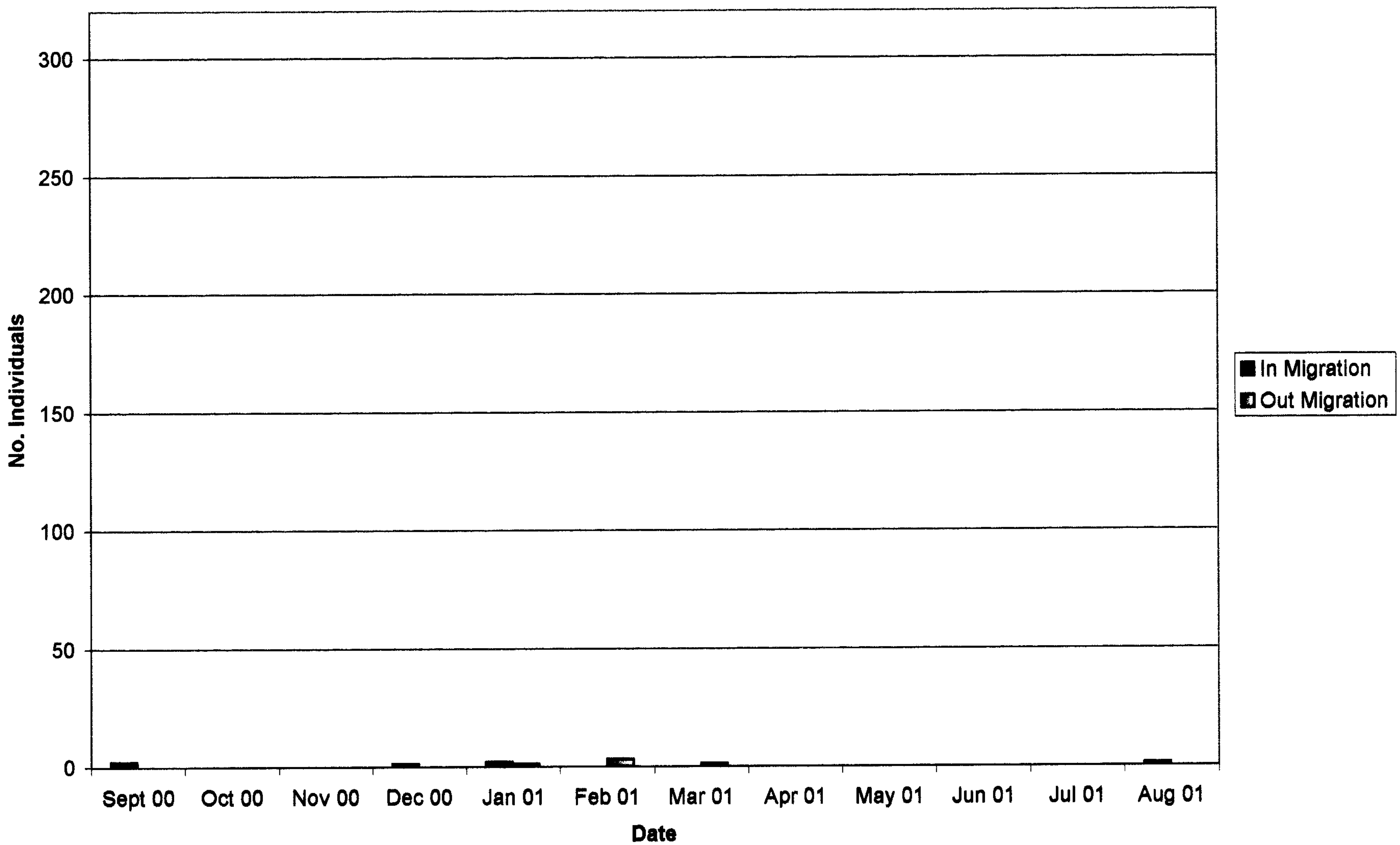
Monthly Movement of the Gopher Frog in and out of Study Pond #1, Year 3



Monthly Movement of the Gopher Frog in and out of Study Pond #1, Year 4



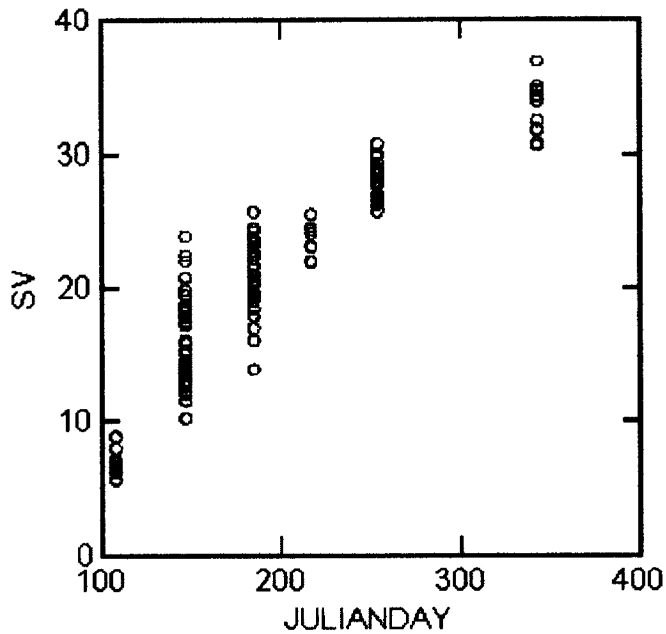
Monthly Movement of the Gopher Frog In and out of Study Pond #1, Year 6



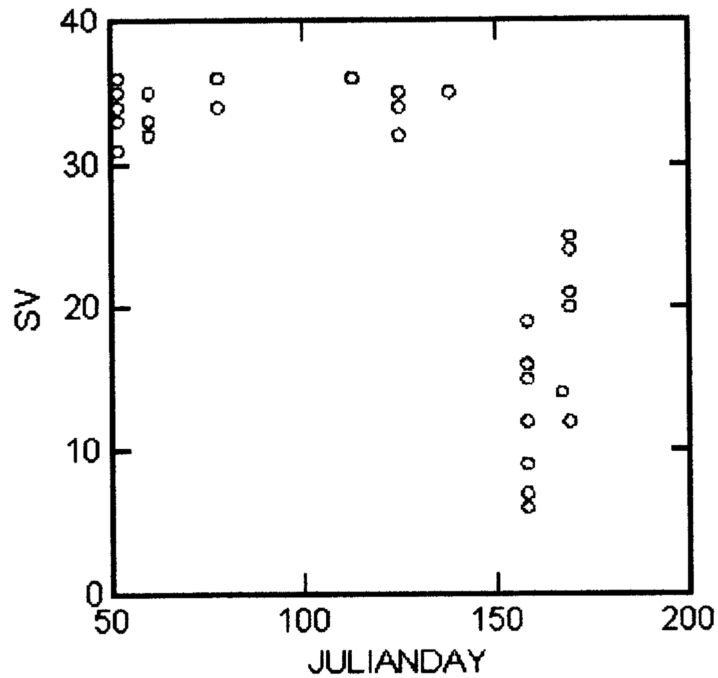
Appendix X.

Larval Growth of the Striped Newt (*Notophthalmus perstriatus*) in Study Pond #1
for the years 1973, 1993 – 1997

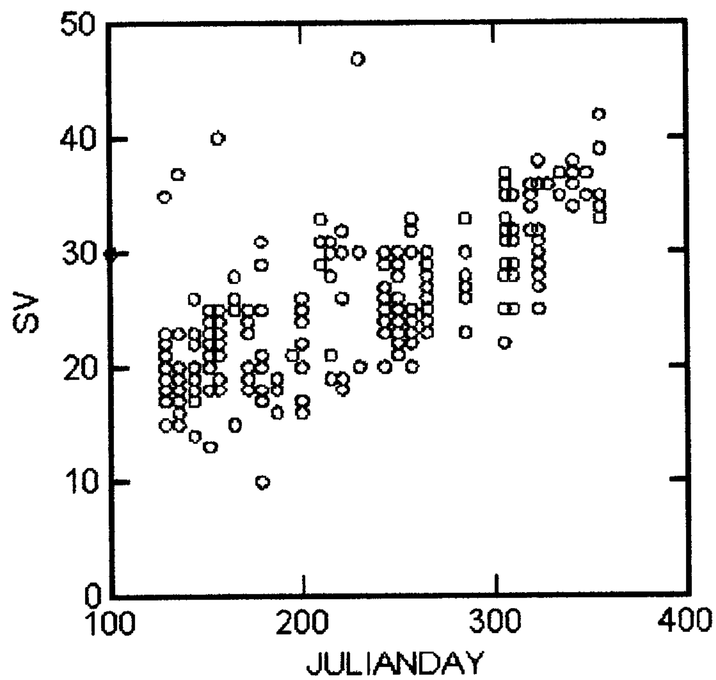
Growth of larvae of the striped newt (*Notophthalmus perstriatus*)
in Study Pond #1 for 1973



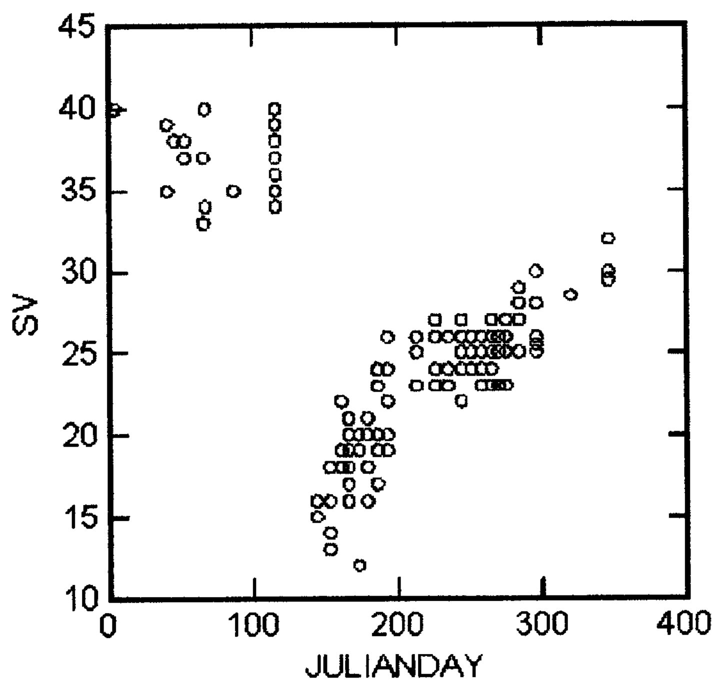
Growth of larvae of the striped newt (*Notophthalmus perstriatus*)
in Study Pond #1 for 1993



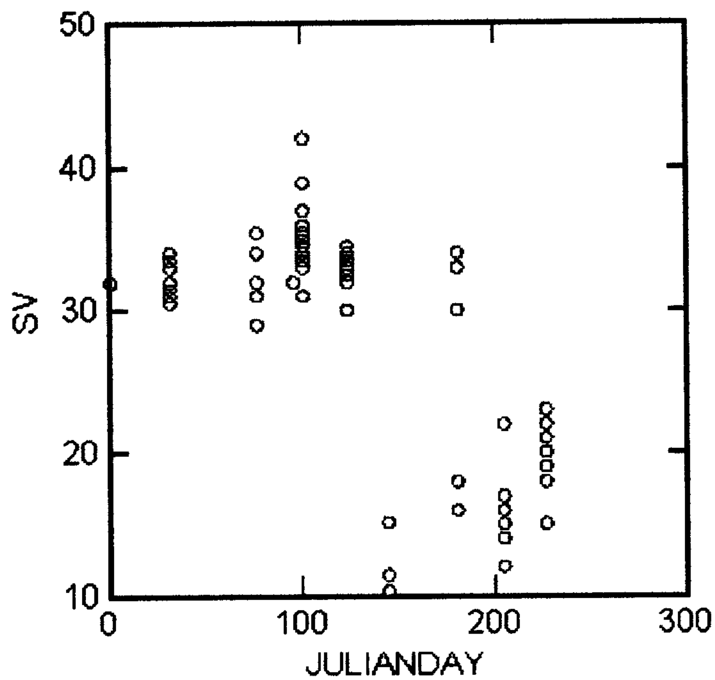
Growth of larvae of the striped newt (*Notophthalmus perstriatus*)
in Study Pond #1 for 1994



Growth of larvae of the striped newt (*Notophthalmus perstriatus*)
in Study Pond #1 for 1995



Growth of larvae of the striped newt (*Notophthalmus perstriatus*)
in Study Pond #1 for 1996



Growth of larvae of the striped newt (*Notophthalmus perstriatus*)
in Study Pond #1 for 1997