HA File No. 90.17

Endangered and Threatened Snake Studies, Habitat Evaluations and Mitigation to offset Adverse Impacts of the Mule Road Extension, Berkeley Township, Ocean County, New Jersey

Submitted December 13, 1990 - To

Richard E. Lane, P.E., L.S. - County Engineer
Ocean County Engineering Department
119 Hooper Avenue - CN 2191
Tome River, New Jersey 08754

By

Robert T. Zappalorti and Gianluca Rocco
Herpetological Associates, Inc.
Plant and Wildlife Consultants
405 Magnolia Road
Pemberton, New Jersey 08068

Visit our WWW @ HerpetologicalAssociates.com

TABLE OF CONTENTS

ITEM		PAGE NO.
I.	Introduction	2
	Location of the Study Area	3
	Perspective and Scope	3
	Figure 1 - Map of New Jersey	6
	Figure 2 - Map of Ocean County	7
	Figure 3 - Location of the "Berkeley "Triangle" in Western Berkeley Township	8
	Figure 4 - Vegetation of the "Berkeley Triangle"/ Mule Road Corridor	9
II.	Materials and Methods	11
	Figure 5 - Method of Marking Snakes During this Study	17
	Figure 6 - Approximate Route of the Proposed Mule Road Extension (Alignment B)	18
III.	Results of the Investigation	20
	Figure 7 - Approximate Location of Wetlands where Pine Barrens Treefrogs were Confirmed During this Investigation	28
	Figure 8 - Approximate Location where Corn Snakes were Captured	29
	Figure 9 - Approximate Locations where Pine Snakes were Captured	30
	Figure 10 - Approximate Location of Known Natural Snake Dens/Winter Hibernacula and Man-made Dens/ Winter Hibernacula in the Davenport Basin/Mule Road Corridor	31
	Table 1 - Reptiles and Amphibians Confirmed in the "Berkeley Triangle"	32

TABLE OF CONTENTS

ITEM		PAGE NO.
	Table 2 - Frequency of Adult Pine Snakes Captured in Study Corridor Between 1987 and 1990	36
	Table 3 - Sex and Age of Pine Snakes Found Inside Two Natural Hibernacula Between 1987-1990	37
	Figure 11 - Activity Range of an Adult Female Corn Snake within the Davenport Basin Near Proposed Mule Road Extension	41
	Figure 12 - Activity Range of an Adult Male Corn Snake within the Davenport Basin Near Proposed Mule Road Extension	42
	Table 4 - Distance and Direction of Movements of Radio-tracked Female Corn Snake .	43
	Table 5 - Distance and Direction of Movements of Radio-tracked Male Corn Snake	45
	Table 6 - Activity Parameters for Two Radio-tracked Corn Snakes	47
	Table 7 - Corn Snake Records for the Study Area (1987-1990)	48
IV.	Discussion	52
V.	Assessment of the Project Impacts	59
	Alternative One	60
	Alternative Two	62
	Alternative Three	63
	Figure 13 - Proposed Section of the Mule Road Extension	64

TABLE OF CONTENTS

ITEM		PAGE NO.
	Figure 14 - Southern Terminus of Mule Road at Pinewald-Keswick Road	65
	Figure 15 - Proposed Mule Road Extension with Snake Tunnel under Pavement	66
	Figure 16 - Construction Detail of Proposed Mule Road Extension	67
	Figure 17 - Frequency of Observation of Snakes at Man-made Hibernacula	68
	Table 8 - Snakes Observed per Hour at Man-made Hibernacula	69
	Table 9 - Snakes Observed per Hour at Man-made and Natural Hibernacula . .	70
	Figure 18 - Existing Paved and Sand Roads in Greenwood Forest Wildlife Management Area, Lacey Township . .	73
	Figure 19 - Proposed Alternative Routes for Traffic to Reach Route 539 on Existing Gravel Roads in Lacey and Manchester Townships	74
	Table 10 - Rattlesnakes Killed on Various Roads by Vehicular Traffic Between 1981-1989	75
VI.	Mitigation and Recommendations	80
	Figure 20 - Man-made Concrete Block Snake Den/Hibernaculum	83
	Figure 21 - Top View of Hibernaculum Roof Made of Wolminized Plywood	84
	Figure 22 - Top View of Hibernaculum Chamber and Entrances	85

TABLE OF CONTENTS

ITEM	PAGE NO.
Figures 23-30 - Photographs of Road-Killed Snakes	86-89
Executive Summary	90
VII. References	91
Appendices	101

I. Introduction

INTRODUCTION:

This report summarizes an intensive habitat evaluation and herpetological survey of the proposed 1.5 mile (approximate) Mule Road extension in Berkeley Township, Ocean County, New Jersey (see location maps on the next three pages). Information was sought by the Ocean County Engineering Department (OCED) and/or the Ocean County Board of Chosen Freeholders on the distribution of "endangered" and "threatened" animals on or in the close vicinity of the proposed Mule Road extension.

Herpetological Associates, Inc. (HA), an environmental consulting firm specializing in the study of plants, birds, reptiles, and amphibians was commissioned on May 15, 1990 as a consultant. HA put together a team of naturalists to look at the wildlife within the general area of the Davenport Basin and conducted a sampling regime for reptiles and amphibians on the immediate study corridor. We also evaluated the adjacent land to the east and west of the Mule Road right-of-way owned by Berkeley Township, the Homeland Corporation (Hovsons, Inc.) and Leisure Technology, Inc.

HA provided the following scope of services under our contractual agreement with OCED.

1. A habitat evaluation of existing conditions along the route of the proposed Mule Road extension as "critical wildlife habitat" or "important wildlife habitat" (Pinelands Commission regulations).

2. An intensive sampling regime of the reptiles and amphibians that occur in the general vicinity of the study corridor (Pinelands Commission regulations).

3. Determine what portions of the Mule Road extension, if any, were habitat for Federal or State of New Jersey "endangered" or "threatened" species.

4. Develop a state-of-the-art road to protect snakes and other wildlife and an on-going mitigation and management plan for Mule Road in order to offset and minimize long-term and secondary adverse impacts to the "endangered" snakes.

5. Literature research for historic records, data analysis, and the writing of this report.

6. Determine home-range and habitat use by radio-telemetry of three corn snakes (Elaphe guttata) as it relates to the proposed Mule Road extension.

LOCATION OF THE STUDY AREA:

This study area is located in a "triangle" formed by Route 530 to the south; Davenport Branch to the west; the abandoned Pennsylvania Railroad (currently JCP&L Company right-of-way/Crestwood Interceptor sewerline) to the north; and the Holiday Heights section of Holiday City (Hovsons, Inc.) to the east. While the majority of the study corridor is owned by Leisure Technology (1,069 acres), portions of the woodlands to the east are owned by Berkeley Township and Hovsons, Inc. and/or the Homeland Corporation. Figures 1, 2, 3 and 4 illustrate the location of the Mule Road study corridor in New Jersey, Ocean County and western Berkeley Township. Figure 6 shows the length and route of proposed roads through the "Berkeley Triangle".

PERSPECTIVE AND SCOPE:

HA has been conducting herpetological surveys in the Davenport and Wrangle Brook Basins over the past 13 years for various clients; as well as doing independent scientific research in cooperation with Dr. Howard Reinert of Allentown College (Pennsylvania); Dr. Joanna Burger of Rutgers University (New Jersey); and Otto Heck of Trenton State College (New Jersey). In the past, HA has evaluated various parcels of land in the vicinity of the proposed Mule Road extension for the Ocean County Planning Board, Leisure Technology, Inc. and Hovson's Inc., et al. We have written reports and made recommendations to allow partial development of some of the property, while allowing for total protection of other sections we felt were "important wildlife habitat" or "critical breeding or hibernation areas". These past recommendations were made based upon the information and knowledge we had available at the time.

In recent years (1988-1990), HA was able to obtain and compile a vast amount of information on snake behavior in the Davenport Basin which has greatly added to our understanding of the habitat requirements of the corn and pine snake; especially during this current evaluation of the Mule Road extension and the radio-tracking studies of three corn snakes in connection with this project. We would therefore like to stress that the recommendations contained in this report should supersede all opinions set forth in the past with respect to "important snake habitat"; "areas that should be developed", and "areas that are critical habitat". We do not mean to imply that the information presented in other reports was inappropriate, or the habitat evaluations were wrong, but we suggest our past recommendations were made based upon the knowledge and information we had available which we believed to be factual

and correct. However, new information based upon radio-tracking studies of the corn snakes' home-range and habitat use has added greatly to our understanding of the subtle differences of habitat use which was not known in the past. Additionally, the activity area/home range is also larger than previously reported by HA in the past (Zappalorti and Johnson, 1982-B) which was based upon a single adult male corn snake. In our opinion, state-of-the-art techniques have been employed in this study to evaluate habitat and distribution of snakes. HA presents the results and recommendations with high confidence. Our mitigation plan and road design will provide the greatest amount of protection to the snakes and other wildlife in the Davenport Basin.

Preliminary plans for the proposed Mule Road extension in western Berkeley Township were reviewed by the New Jersey Pinelands Commission. The question was raised as to whether or not the road would present any potential long-term adverse impacts to "endangered" or "threatened" snakes and their environment. HA was charged with an analysis and evaluation of the existing habitat and wildlife species. This report deals only with the suitability of the study corridor in its present condition, as habitat for them as well as what species were found on the site. Radio-telemetry was used to obtain information on corn snake habitat use and home range requirements. Assessment of adverse impacts of the proposed Mule Road extension on the local pine and corn snake population was based on radio-tracking data, historical and recent capture records, HA's knowledge of the Davenport Basin, and the habitat requirements and behavior of the two protected species. Our main objective was to identify critical habitat of "endangered" and "threatened" species along the Mule Road alignment and develop a road design to prevent snakes and other wildlife from being killed on the road.

Based on HA's knowledge of nongame wildlife in southern New Jersey, past surveys conducted under a research contract with the Endangered and Nongame Species Program, Division of Fish and Game and Wildlife (NJDEP), advice from our team of naturalists and our literature search, we suggest the Davenport Basin is critical habitat for the following "endangered" and "threatened" nongame wildlife species:

Common Name	Scientific Name	Current NJ Status
REPTILES:		
1. Pine Snake	Pituophis melanoleucus	Threatened
2. Corn Snake	Elaphe guttata	Endangered
AMPHIBIANS:		
3. Pine Barrens Treefrog	Hyla andersonii	Endangered

(Source: Anderson, 1976; Anderson, et al, 1978; and Updated Herpetological Survey for NJDEP, Zappalorti and Johnson, 1982-A; and NJDEP, 1980).

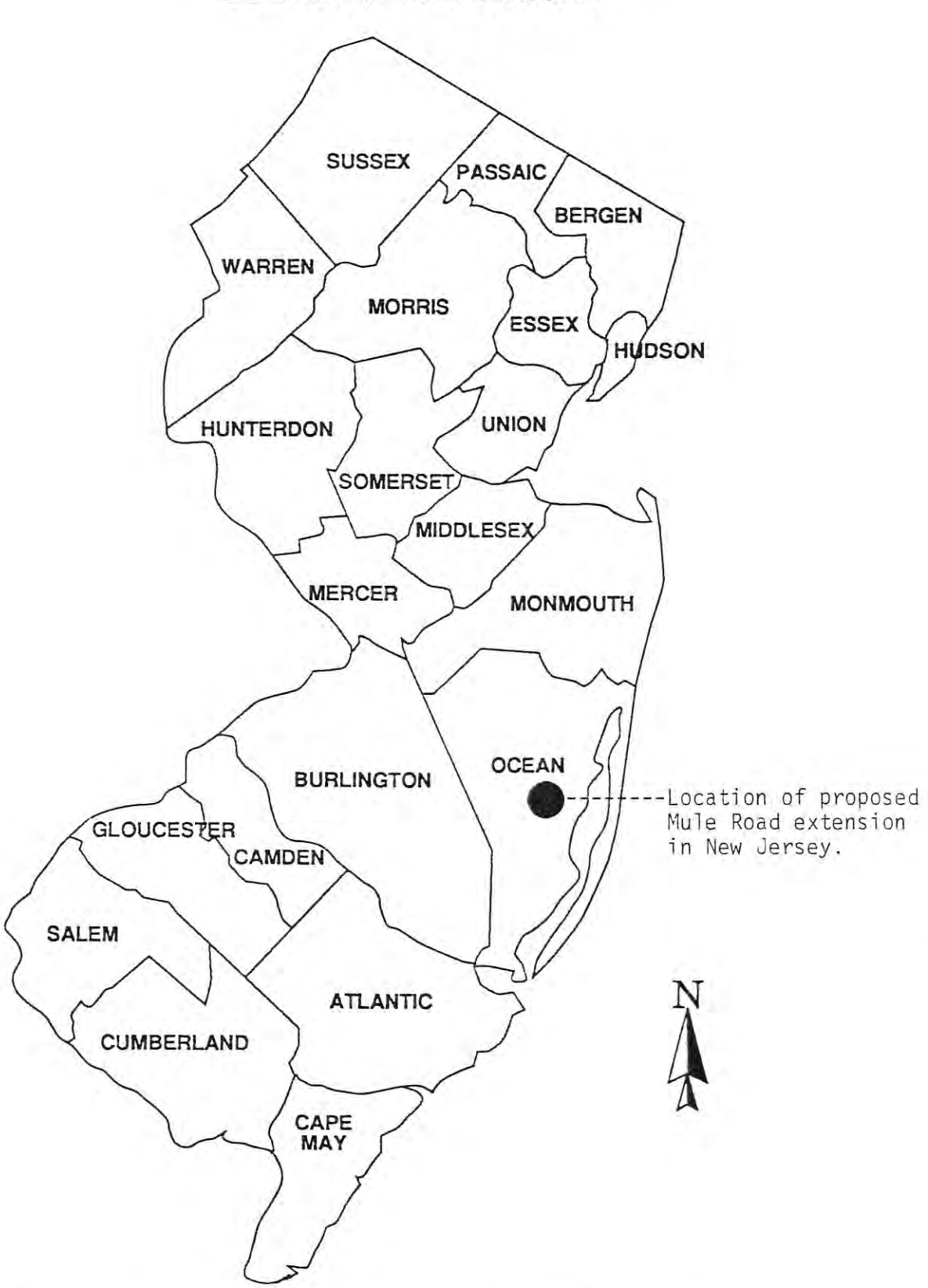
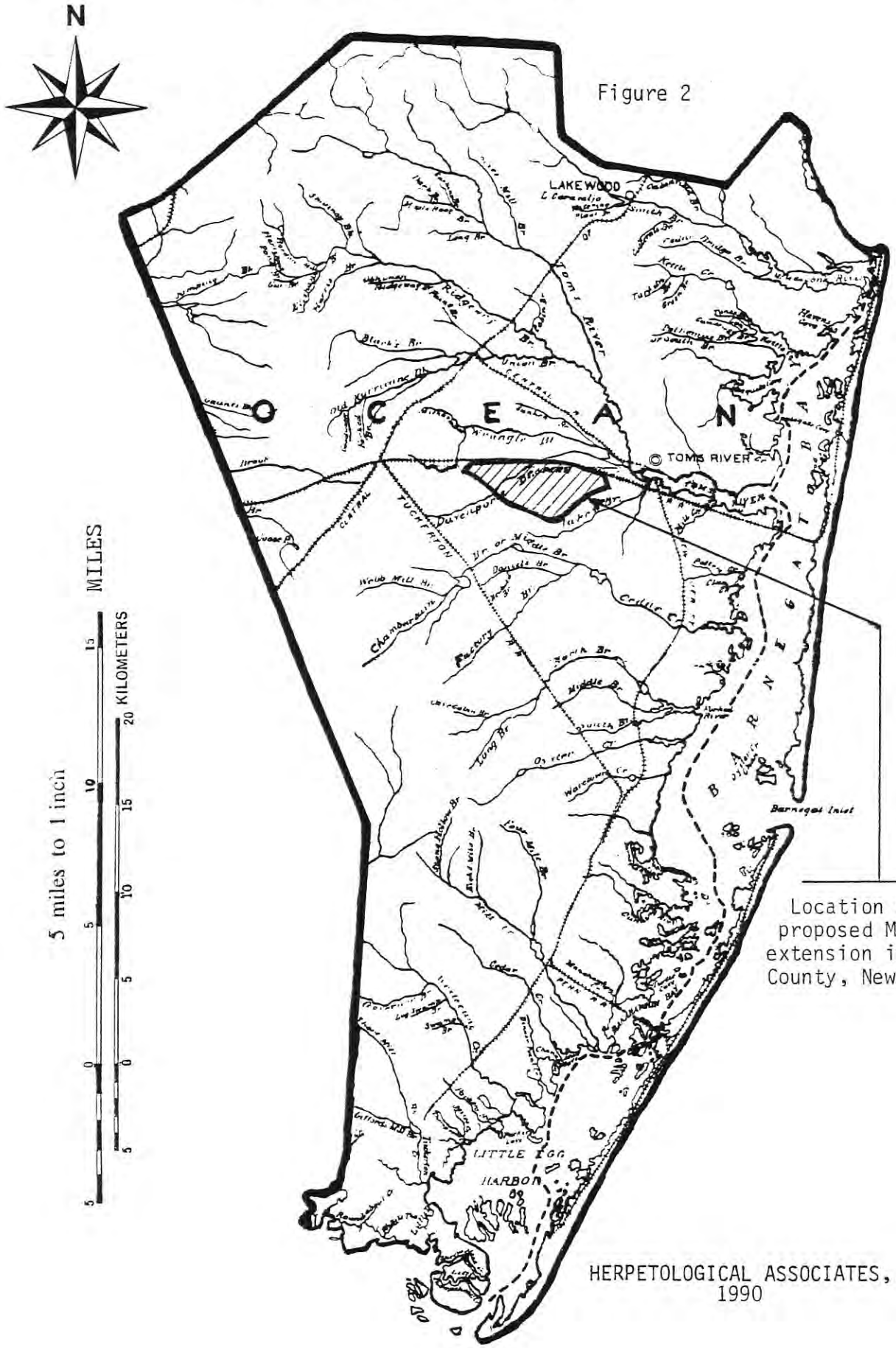


Figure 1. Location Among 21 New Jersey Counties

Source: Herpetological Associates, Inc., 1990

OCEAN COUNTY, NEW JERSEY

Figure 2



HERPETOLOGICAL ASSOCIATES, INC.
1990

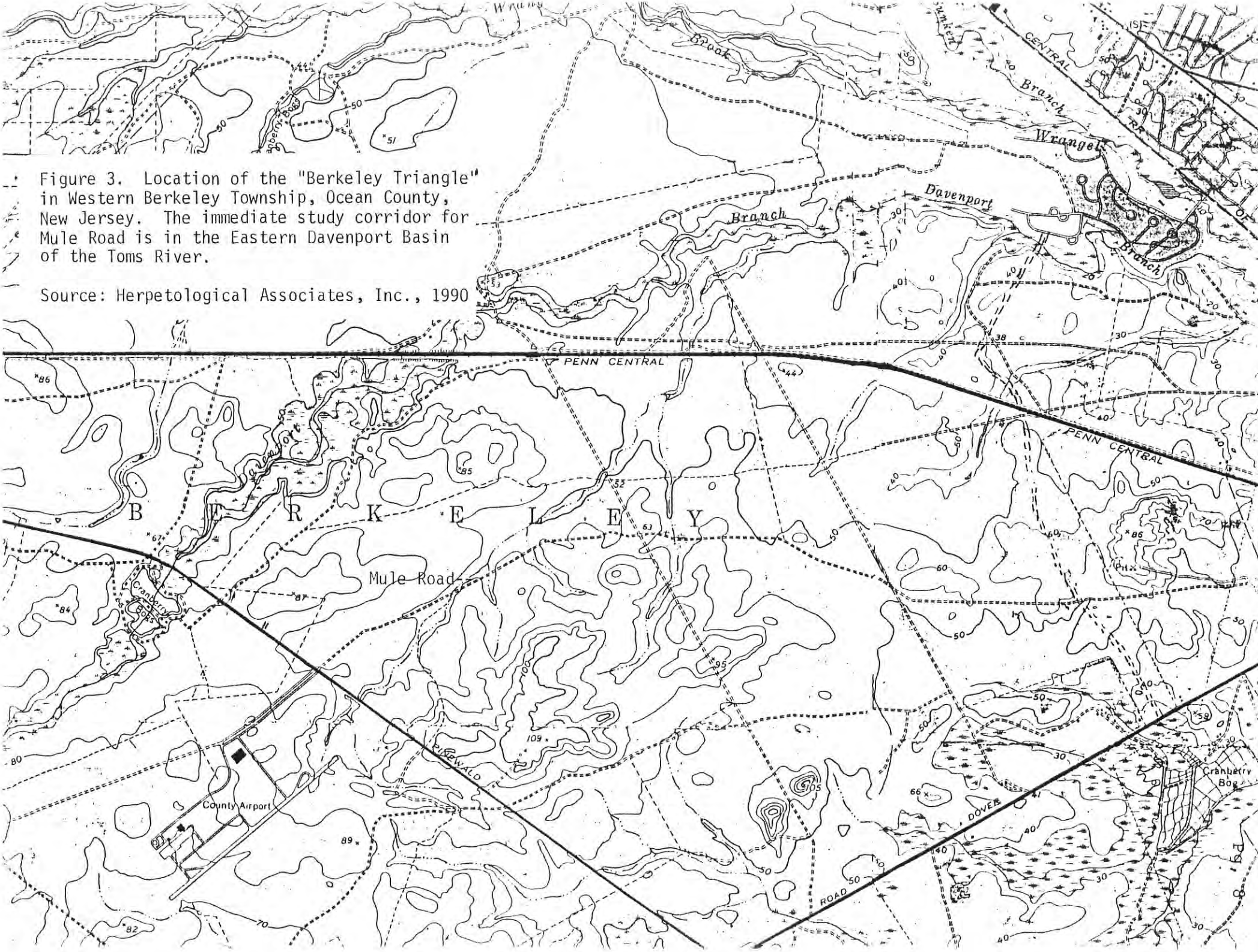


Figure 3. Location of the "Berkeley Triangle" in Western Berkeley Township, Ocean County, New Jersey. The immediate study corridor for Mule Road is in the Eastern Davenport Basin of the Toms River.

Source: Herpetological Associates, Inc., 1990

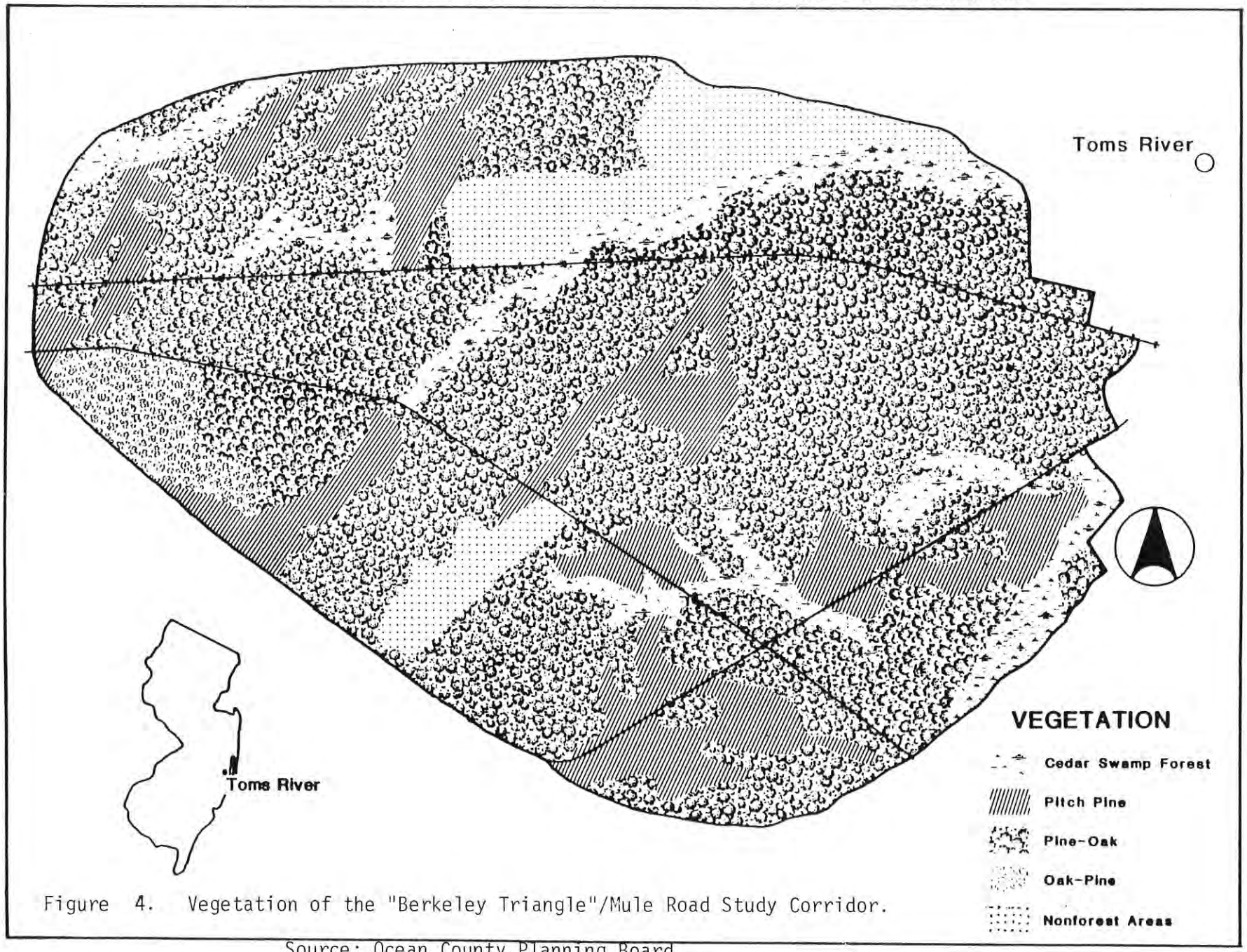


Figure 4. Vegetation of the "Berkeley Triangle"/Mule Road Study Corridor.

Source: Ocean County Planning Board

II. Methodological Approach

MATERIALS AND METHODS:

HA staff ranged between 1-3 persons on a given day (average 2 persons), and spent a total of 75 days in the field. Surveys began on May 15, 1990 and continued through November 28, 1990. Robert T. Zappalorti, William Callahan, Pete Mooney, Jim Dowdell, and Gianluca Rocco conducted the herpetological and radio-tracking studies throughout the Mule Road study corridor in the eastern Davenport Basin. Additionally, HA's executive director and staff spent 10 days conducting meetings, a literature search, analyzing various data, developing the management and mitigation plan and writing this report. Radio-tracking of three corn snakes was also carried out within the study corridor in order to obtain information on habitat use and home range.

The study area was surveyed for herpetofauna by using several proven techniques. Following is a description of these methodologies:

TIME CONSTRAINED TECHNIQUE:

A specific habitat is selected (e.g. pine-oak forest, wetland, etc.) and an intensive time constrained search (a time limit is set for each search) within the selected habitat is initiated. Plant and human debris, logs, stones or any other suitable cover is overturned to check for hidden herptiles. Open areas are visited to look for basking or surface active herpetofauna.

RANDOM OPPORTUNISTIC SAMPLING:

No specific habitat is selected and searches are carried out randomly in all potential habitats within a predetermined area e.g., suitable refugia along the Mule Road alignment were overturned and thoroughly inspected for concealed snakes. Searches within a particular site are repeated randomly several times to ensure that specimens collected adequately reflect the herptile community found in the area being studied.

To augment our chances of locating snakes, particularly in densely vegetated or entirely barren areas, approximately twenty large wooden boards were placed flat on the ground along the alignment and in strategic locations (near hibernacula) to provide shelter for snakes and rodents. The boards were periodically checked while searching an area. The method is particularly fruitful for long term surveys.

As part of HA's own research, two winter dens near the roadway alignment were excavated on an annual basis between 1986-1990. The results of these excavations were included in the analysis of the historical records. This method of locating dormant snakes is very useful because it eliminates collector bias, enables large numbers of snakes to be captured in a relatively short time, and effectively samples a given area. The continuation and persistent use of excavated dens by resident snakes (and newcomers alike), is suggestive evidence of the passive effects of this practice.

DIURNAL AND NOCTURNAL ROAD CRUISING:

Road driving is a popular method used by herpetologists to sample an area for herptiles. This techniques involves driving a vehicle at slow speed along a paved or dirt road at various times of the day or night. Specimens observed crawling, walking or hopping across the road can be easily captured. This method often yields herptiles that would otherwise not be collected due to their secretive nature and ability to remain hidden for long periods of time amid dense vegetation. Road cruising is particularly fruitful after a heavy rainfall. Vehicles traveling along roads frequently kill animals attempting to cross. Fauna dead on the road (D.O.R.) act as good "indicators" and can inform an investigator as to what species occur naturally in an area that is being studied. D.O.R. specimens can provide important information about activity patterns, migration routes and habitat utilization of herptiles (Reynolds and Scott, 1982; Karns, 1986; and Rodda, 1990).

PINE BARRENS TREEFROG SAMPLING AND HABITAT EVALUATION:

In New Jersey, most species of frogs and toads breed at night between March and August when temperature and humidity fall within the need of a particular species. Sampling for Hyla andersonii is best done after sundown and during their breeding activity, which occurs sometime in May and June, depending upon environmental conditions such as temperature, precipitation and relative humidity. During this period, males actively vocalize to defend a territory and to attract receptive females. The voice of the Pine Barrens treefrog is a nasal, duck-like "quonk-quonk-quonk" repeated at a rate of about 25 times per 20 seconds (Conant, 1975). The calls are quite distinct and are audible for 50 meters or more from the breeding pond. Although calls are not an accurate means of estimating population size (only males vocalize and not all participate), the latter can certainly serve to document the presence of a particular species. In absence of vocalizing individuals, orally mimicking their voice or playing pre-recorded choruses of treefrogs, will sometimes induce responses. Oral mimicking was employed at the study site and control areas.

The ponds off Davenport Road - Hovnanian/Audubon Sanctuary and the water retention basin in the Holiday Heights section of Holiday City South in western Berkeley Township (a confirmed Pine Barrens treefrog breeding area) were used as the "control" area to compare with the wetlands along the study corridor (Zappalorti and Johnson, 1982-A).

ADDITIONAL DATA COLLECTED ON SNAKES:

Each pine or corn snake was taken to the lab and permanently marked by branding dorsal scales on the posterior portion of the body (Figure 5) with an electric soldering iron (modified from Clark, 1971). Body measurements were taken using a squeeze box and cartometer (modified from Quinn and Jones, 1974). Sex was determined by probing (Schaffer, 1934) and/or, by counting subcaudal scales. Some gravid females were held in the laboratory until the eggs were laid. The reproductive condition of adult female snakes was assessed visually or by palpation of the posterior ventral region of the body (bulging eggs). Eggs were artificially incubated in the laboratory at appropriate temperatures (24 to 30 degrees centigrade). Hatchlings were sexed by the "hemipenis popping method" described by Gregory (1983). Hatching corn or pine snake eggs in the laboratory provides researchers with vital information about sex ratios of the young; reproductive success; size of hatchlings and reproductive cycles. More important, it protects the incubating eggs (that would have been laid in the field) from mammalian and human predators (illegal snake collectors).

METHODS FOR RADIO-TRACKING STUDY:

Three adult corn snakes captured on/or near the Mule Road/JCP&L right-of-way corridor, were surgically implanted with AVM instrument Model SM1 transmitters using a technique described by Reinert and Cundall (1982). A 30-40 cm teflon-coated whip antenna was attached to the transmitter. The complete transmitter unit (transmitter, battery, antenna and dental acrylic/beeswax potting material) weighed 4-5 grams. Each transmitter unit produced a unique pulsed frequency signal in the 150-151 MHz range. The signals were received with an AVM instrument model LA 12-DS receiver and a hand held Yagi antenna. The transmitters had a functional field range of 200 to 1,000 feet, depending upon local topography and where the snake happened to be when it was relocated; i.e., basking on the surface, in a log, or below the surface in a stump-hole, etc. An attempt was made to relocate each individually implanted corn snake in the field at least once every other day from September 6, 1990 (The radio-tracking

study continued through the end of November 1990 when the snakes went into hibernation). Approximately 540 man-hours were spent conducting field work, this included searching for other unregistered snakes and radio-tracking implanted snakes. About 8 man-hours were spent in the laboratory surgically implanting snakes. A total of 548 man-hours were spent on this phase of the study.

Nine climatic variables were recorded immediately upon relocation of a monitored snake (e.g.; relative humidity both at the snake and 1.5 meters above it; surface temperature at snake and 3 cm. above it; ambient air temperature in shade; soil temperature at snake; soil moisture at snake; and light intensity [candles] at snake and within two meters of it). We also recorded 15 structural habitat characteristics after the snake had moved away. A color slide photograph was taken at the center of the snakes relocation site (within one square meter) using a 35mm single lens reflex camera (Reinert and Zappalorti, 1988).

Vegetational zones of the study area were differentiated on the basis of visually dominant plant species present (Reinert and Kodrich, 1982). General habitat characteristics at each relocation site were also noted in the same manner.

The distance between each relocation site was measured in the field with a "Rolotape" measuring wheel, Model No. 415 and/or Keson fiberglass 100 foot measuring tape. All recapture points were field marked with surveyor's flagging tape and directional movements were checked with a Silva System No. 7 NL compass. Ernst Hofmann of HA staff, prepared a grid map of the study area at a scale of one inch equals 400 feet. Duplicate copies were supplied by OCED and the Ocean County Planning Board. The authors plotted each corn snake relocation site on the grid map and/or the Toms River and Keswick Grove USGS topographical maps.

Weather conditions were recorded at each initial capture site and subsequent relocation sites. Cloacal temperatures were taken at most initial captures, but not at the radio-tracking relocation sites in order to prevent disturbance to the snakes. We attempted to follow the movements and behavior of the snakes with a minimum amount of disturbance. The snakes were visually observed from a distance (sometimes with binoculars) and notes were made on their activities and behavior.

RATIONALE FOR RADIO-TRACKING:

Due to the highly controversial nature of this project and the need to justify the added cost of the elevated snake-proof roadway, HA decided to implant radio transmitters into three adult corn snakes. Data collected assisted HA in assessing the impacts of the road by providing: 1) an unbiased sample of the habitat used by three adult corn snakes; 2) the size of their activity range; 3) the location of previously unknown winter dens along the study corridor.

LITERATURE SEARCH:

When trying to identify critical habitat for an "endangered" or "threatened" species, it is advantageous to know what species were historically known from the study area, or at least, from the general vicinity of the township or county. During HA's work for NJDEP over the past 13 years, museums, zoos, universities and zoologists from New York, New Jersey, Pennsylvania and elsewhere were contacted to obtain voucher specimen records from New Jersey.

Information from local naturalists and amateurs was also used to compile a comprehensive data bank of the locations of "endangered" and "threatened" herptiles in southern New Jersey in general and Ocean County in particular.

The existence of a zoo or museum specimen or historical record does not necessarily mean that the species of concern is still present on site, but it is a good indicator that suitable habitat did exist at one time and may still be present as long as an area has not been seriously altered or polluted.

Information from records of pine and corn snakes at the study site (collected by HA between 1986-1990 for its own non-profit scientific research and investigations) was assembled into a data bank with a Zenith Z-180 PC by using DBASE III Plus program. Different variable combinations were later retrieved to assess distribution (occurrence and location of snakes along the study corridor), population structure (age, sex and reprodutive conditions) and habitat use (nesting areas, hibernacula).

When a snake was captured, numerous variables were recorded (see sample data sheet in the appendix). For the purpose of this study, only the following were used:

I.D.: Field or identification number.

SEX: Male or female.

DATE: The month, day and year the snake was captured.

LOCATION: Where the snake was captured. All capture sites were categorized into one of the following:

CRSMM - Crestwood JCP&L right-of-way corridor between man-made dens nos. 1-6.

CRSND - Crestwood Natural Den

DVNNA - Davenport Nesting Area

DVNND - Davenport Natural Den

DVNND #2 - Davenport Natural Den No. 2

DVNND #3 - Davenport Natural Den No. 3

DVNND #4 - Davenport Natural Den No. 4

MLERD - Mule Road right-of-way (does not include portion near DVNNA).

CONDITION: Age and reproductive condition of specimens

N - Neonate (pine snake SVL less than 50 cm.; corn snake SVL less than 30 cm.)

S - Subadult (pine snake SVL between 51 cm.- 100 cm.; corn snake SVL between 31 cm.- 50 cm.)

A - Adult (pine snake SVL greater than 100 cm.; corn snake SVL greater than 50 cm.)

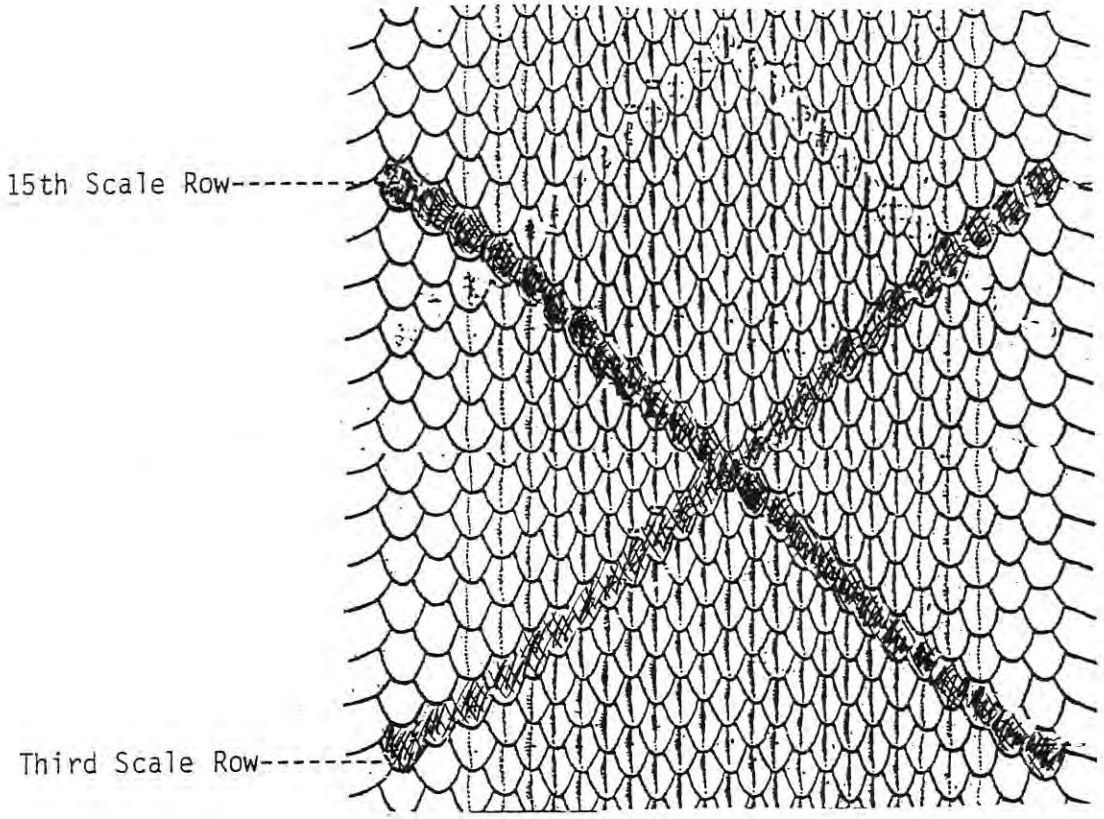
G - Gravid female

BEHAVIOR: Only three categories were used:

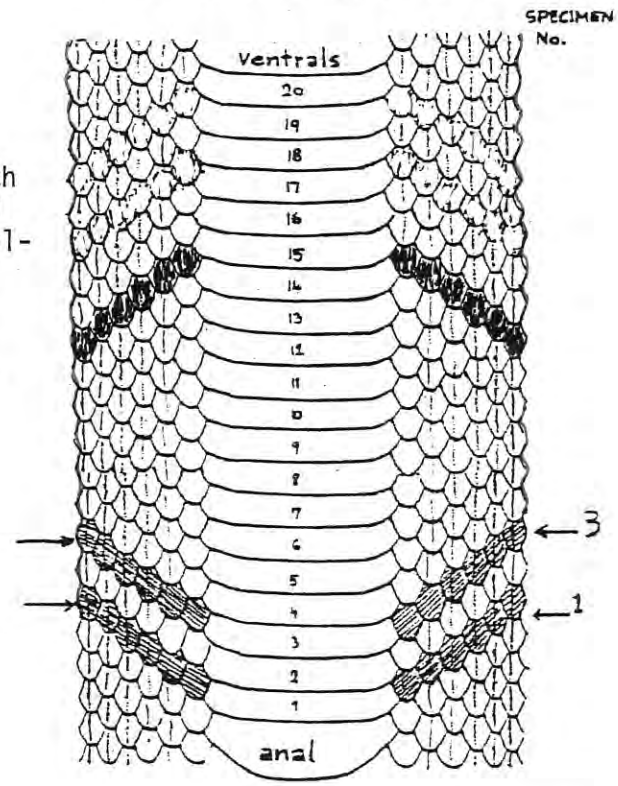
Hibernat - Specimen captured inside hibernaculum in the winter.
Nesting - Gravid female digging a burrow or found in/or near one
Active - All other behaviors (e.g., basking, traveling, resting, etc.)

OTHER: Miscellaneous observations.

M - Specimen was previously captured at X location. Indicates movement.
LAB-H - Neonate was hatched in laboratory.
Dead - Specimen found dead.



Dorsal View Showing "X" Brand



Ventral View Showing Base of "X"

Figure 5. Method of marking the snakes during this study (modified from Clark, 1971). The snakes were cauterized with a soldering iron on dorsolateral scale rows. The scale row is followed across the entire dorsal surface, from ventral scale to ventral scale, thus forming an "X" mark (Zappalorti & Hofmann, unpublished data, 1989).

Source: Herpetological Associates, Inc., 1989

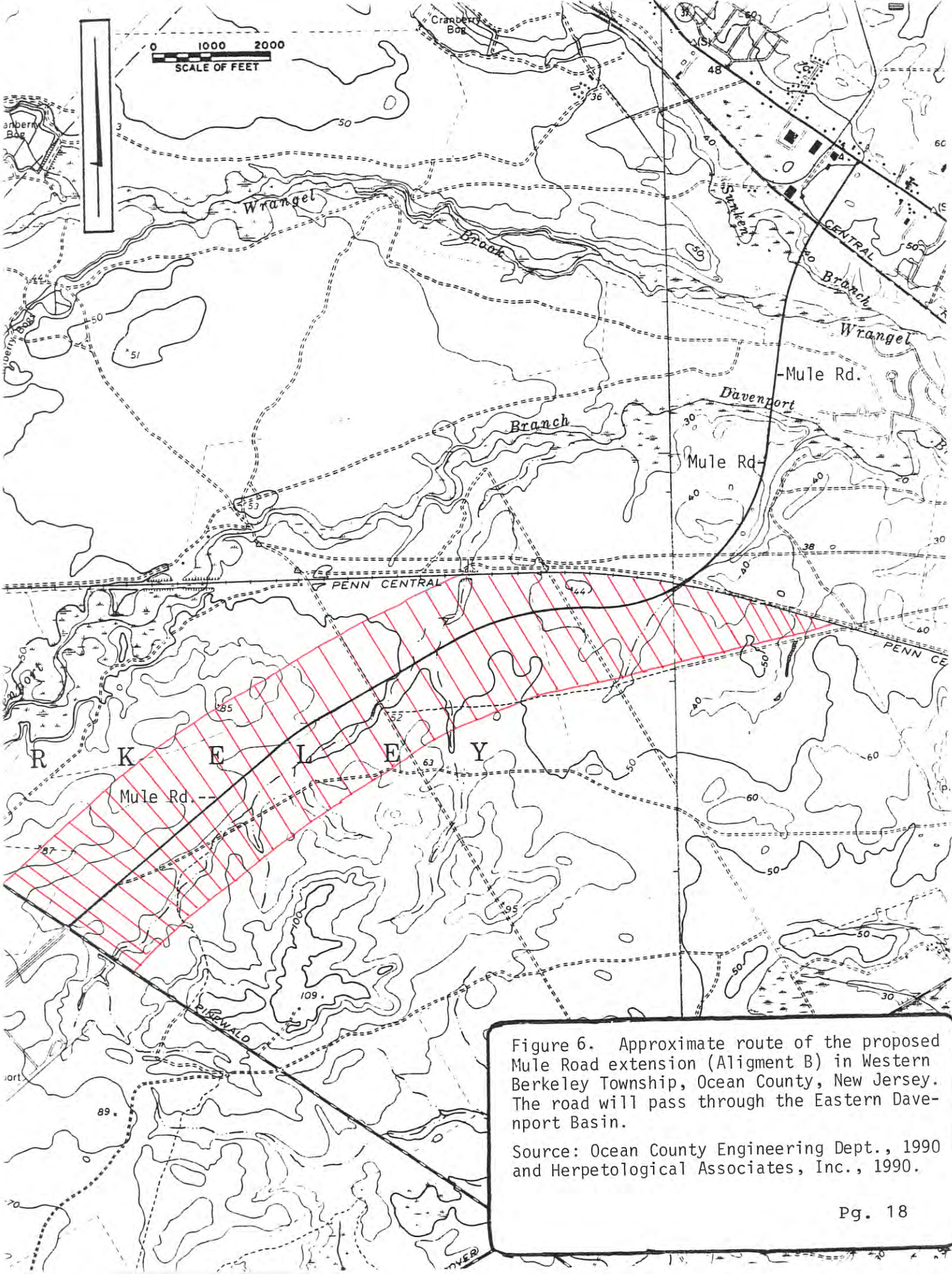


Figure 6. Approximate route of the proposed Mule Road extension (Aligment B) in Western Berkeley Township, Ocean County, New Jersey. The road will pass through the Eastern Davenport Basin.

Source: Ocean County Engineering Dept., 1990 and Herpetological Associates, Inc., 1990.

III. Results of Investigation

RESULTS OF HABITAT EVALUATION:

DESCRIPTION OF EXISTING CONDITIONS:

HA conducted a thorough ground survey of all appropriate sections along the study corridor of the proposed roadway to evaluate various habitats within the Davenport Basin. The southern terminus or entrance of the proposed roadway is located on Route 530 at the Ocean County Airpark. The alignment overlays the first 1,000 feet of the existing Mule Road (an old sandy, ungraded road that is currently being used for deer hunting access and as a convenient illegal dump site) and then veers off to the left to maintain its northeast course (see Figure 6). The surrounding habitat of the first 4,000 feet of the road is composed of upland pine-oak (P-O) forest (Pitch pine, Pinus rigida; and blackjack oak, Quercus marilandica). The alignment eventually traverses an open, sandy area and splits into alignments A and B. Illegal dumping is evident from the large amount of trash scattered throughout the area. Vegetation surrounding this clearing is mostly successional and could be the result of clear cutting for firewood. Shallow wetlands and a swale of pitch pine lowland forest lie about 300-400 feet south of the road and for some distance it meanders parallel to the road.

Both alignments cut through P-O forest, bisect the Davenport nesting area (alignment B to a lesser degree) and gradually merge with the JCP&L Company right-of-way to connect with the existing portion of the Mule Road within the "Holiday City South" development. The "Davenport Nesting Area" is confirmed critical habitat to both pine and corn snakes (Zappalorti and Johnson, 1982-A and B; Burger, et al, 1988; Burger and Zappalorti, 1988; and Burger and Zappalorti, 1989).

RESULTS OF HISTORICAL LITERATURE SEARCH:

The abundance of pine and corn snakes in the vicinity of the abandoned town of Crossley is vividly described in C.F. Kauffeld's "Snakes and Snake Hunting", 1957. His descriptions date back to the 1930's and most likely represent one of the earliest accounts of the two species in the Davenport Basin and Wrangle Brook Basins.

In cooperation with HA, the Ocean County Planning Board's report "Critical Habitat Requirements of Two Threatened Species in the Davenport Basin", 1982-B, provides records and sightings of the two species before and after 1970. Pre-1970 sightings on, and near, the Crestwood Interceptor/ JCP&L Company right-of-way corridor include three pine snakes and one corn snake. Later records (1970-1982) show the presence of a relatively large number of both species, particularly east and west of the common right-of-way. Unfortunately, some of the habitat in the east side has been either destroyed or lost to partial housing development (Holiday Heights section of Holiday City) or encroached upon (see Figure 9), further reducing the available habitat. However, it should also be pointed out that Hovsons, Inc. (Hirair and Anna Hovnanian) donated 460 acres of important corn and pine snake habitat to the New Jersey Audubon Society in 1987. This wildlife sanctuary is located about 2,000 feet southeast of the proposed Mule Road. The study corridor and surrounding area was historically known to be inhabited by significant populations of both corn and pine snakes (Kauffeld, 1957 and Zappalorti and Johnson, 1982-A).

Recent records confirm the existance of both species. Between 1986 and 1990 a total of 106 individual pine snakes were captured, marked and released along (and near) the Crestwood Interceptor/ JCP&L Company's right-of-way. Eighty-four of these specimens were from the vicinity of Mule Road right-of-way and the Davenport Nesting Area. During that same period, HA collected and released 96 individual corn snakes of which 55 had been hatched in the lab (to minimize predation of eggs and hatchlings) as part of a non-profit, self-supported "head start" program. Of the total, 46 individuals were associated with the Mule Road study corridor.

Various projects in this area in the last four years enabled HA to accumulate a respectable amount of information from data recorded at each snake capture site. Captures and recaptures (same snake is found more than once) generated 150 pine snake and 53 corn snake sightings (see Table 7 and the list of records of pine snakes in the Appendix).

PINE SNAKE:

The sample of 84 individuals (sex of two snakes not recorded) consisted of 39 males (47%) and 43 females (52%) of various ages. Almost fifty percent (45%) of all pine snakes marked and released were recaptured at least once, but only 31% were recaptured twice or more (range 1-6). Eighteen males (46% of all males) and 20 females (46% of all females) were recaptured at least once, but the latter accounted for 61% of all the recaptures in this study. Adult females (often gravid) had generated 82% of the female recaptures, or one third of all sightings (34%).

Between 1987 and 1990, 37 adult male and 51 adult female observations (figures include individuals and their recaptures) were recorded in the study area. Twenty-nine adult males were found inside hibernacula during winter/ early spring excavations, but only eight were found active (any activity which was not hibernation e.g., basking, traveling, resting, etc.). Males were recaptured seldom and usually while in hibernation. Adult male I.D. No. 8709 was recaptured three times (the most any male was recaptured), but always inside a den hibernating. One specimen (counted as active) was recaptured frozen a short distance from the den apparently fooled by an unusually warm spell in March of 1990.

Twenty-two adult females were captured in hibernation, and 29 were observed active. Of the latter, 18 were gravid (see Table 2). No significant difference in the frequency of captures was found amongst the three categories of active snakes ($X = 4.28$; $P > 0.05$, [2]), but gravid females contributed considerably (40%) to the total number of captures recorded.

Pine snakes over 100 cm. in snout-vent length (SVL) were considered mature adults; snakes between 50 cm. and 100 cm. SVL, subadults, and less than 50 cm. SVL, neonates. Approximately (some recaptured snakes outgrew their initial "subadult" or "neonate" category) 52% of the individuals captured were adults, but during the four years of snake monitoring at the Davenport nesting area and along the JCP&L Company right-of-way (only snakes that were found within 2,000 feet of the Mule Road right-of-way were included in the analysis), 88 adult (58%), 18 subadult (12%), and 44 neonate (29%) sightings were recorded. Neonates and subadults were usually captured in winter (by excavating dens) or in late fall and late spring not far from a winter den. Not a single individual from this age group was ever captured between the months of May and August suggesting: 1. a very secretive lifestyle in the first years of life, and 2. a high mortality due to predators and/or from freezing during their first winter.

On September 5, 1989, following the successful incubation of several pine snake eggs, nine neonates were marked and released at the Crestwood man-made den no. 6 (the original location where the eggs were found). On October 23 and 26, 1990, approximately seven weeks later, two of the neonates were found basking near the entrance of the Davenport natural den. The straight line distance between the two sites is about 1,650 feet. One of the neonates hibernated in this den since she was recaptured again in the early spring of the following year.

Between 1987 and 1990, HA captured 18 gravid pine snakes in the eastern Davenport nesting area/Mule Road and/or the JCP&L Company study area/corridor (9 females, some recaptured several times). Two females were found gravid for four consecutive years, and one female for three, suggesting that pine snakes in the New Jersey Pine Barrens can reproduce every year. Clutch size varied between 4 and 14 eggs. Females engaged in nesting behavior (crawling in open sandy areas while probing, tongue flicking and/or excavating a burrow) were seen in late June to early July (June 25-July 13).

Gravid females frequently returned to the nest in the same area as the year before, but not always. Female ID No. 8743 was observed nesting in 1987 and 1988 at the Davenport nesting area, but in 1989 and 1990, she chose the Crestwood/ JCP&L Company right-of-way corridor (see appendix). One female used the Davenport nesting area for four consecutive years. More data is needed to determine overall nest site fidelity in pine snakes. Although the JCP&L right-of-way was used by several females to nest, seventy-eight percent (78%) of the observed gravid females used the Davenport nesting area as a nesting site.

The Davenport nesting area was a critical habitat for hibernation too (Table 3). Fifty-two individuals were observed using this open habitat either to hibernate, nest or for other purposes (thermoregulate, forage, rest, etc.) which means almost half (49%) of all the pine snakes observed in the Davenport Basin were captured in this sandy, open area. The Davenport natural den is centrally located within the nesting area (see Figure 10) and between 1986 and 1990, forty-eight individuals were observed inside (excavated in 1989 and 1990) or within 25 feet of its entrance. Only 30% of the snakes known to use the den were recaptured at least once inside, or near it (Table 3).

The Crestwood natural den was used by a total of 19 pine snakes. Forty-two percent were recaptured at least once (hibernaculum was excavated in 1987 and 1988), but in the following years several individuals changed dens and hibernated in the Davenport natural den.

A comparison of both den populations reveals obvious differences in age and sex ratios. The Davenport natural den hosts mostly adult females and juveniles, the former on the other hand, is largely frequented by adult males and almost no juveniles (see Table 3).

The man-made dens along the Crestwood/JCP&L right-of-way have yet to be excavated, but sporadic surveys and searches near the dens yielded 28 captures (excludes the release of laboratory-hatched neonates). Open areas along this artificial "edge" were used as nesting sites by several gravid females.

CORN SNAKES:

Between 1987 and 1990, twenty-one (21) Elaphe guttata were captured along the Crestwood corridor and the Davenport nesting area. On September 6 and 8, 1990, the proto-integument (first shedding of a snake, Graves, et al, 1986) of ten (10) neonates were found near man-made den no. 3. The shed skins document an additional 10 individuals. After shedding the proto-integument, fifteen (15) lab hatchlings (eggs incubated in the lab) were released near the Davenport natural den no. 2 on September 6, 1990. The gravid parent (90.06) was captured at this den earlier in the season.

Data for each corn snake is presented in Table 7. Eight (8) specimens were adult females (two gravid); four were adult males, and a male and a female were subadults. The rest were neonates. Due to the cryptic and secretive nature of the species, not many recaptures were generated. Only adult male 89.15 was captured three times. Most individuals were captured when "active" (thermoregulating, crawling, resting, etc.) and only two neonates were found hibernating inside a den (Davenport natural den and Crestwood natural den). Eleven (11) captures were within 25 feet of man-made den no. 3 (excludes the 10 shed skins). Since neonates, a gravid female, and neonatal sheds have been found here, the den mound may be used as a nesting area by corn snakes. So far, a specific nesting site for this species has not been identified in the study area. Radio-telemetry has helped confirm the exact location of four previously unknown corn and pine snake hibernacula, and the use of pitch pine lowlands, possibly to maximize foraging. Future research employing radio-transmitter implanted gravid females may assist HA in locating specific nesting sites in the east Davenport Basin.

In 1987 a corn snake was captured on the right shoulder of the present Mule Road (the site was less than .25 of a mile north of Route 530 or 5,000 feet south of the JCP&L Company right-of-way). This record represents the southernmost sighting of a corn snake in the Davenport Basin.

RESULTS OF HERPETOLOGICAL SURVEY:

The findings of our 540 man-hour survey (May 15 to November 28, 1990) along the proposed Mule Road study corridor are shown in Table 1. Pine Barrens treefrogs (Hyla andersonii) were present in two locations in the vicinity of the right-of-way. Wetlands 1 and 2 are situated, respectively, 400 feet and 1,200 feet, southeast of the alignment B (see Figure 7). Several vocalizing males were heard at these sites on various occasions during May-July 1990. Hyla andersonii tadpoles have not been observed in the existing pools. Pitch pine, sheep laurel, highbush blueberry, Sphagnum moss and other typical Pine Barrens treefrog "indicator plants" abound in these wetlands. No other wetlands or pools were found within 1,000 feet of both sites.

Our intensive herpetological survey of the study corridor also yielded 15 pine snakes (those captured after July 15 are not included in the analysis of records) and 11 corn snakes (see Figure 8 and 9). With the exception of five pine snakes, most of the above specimens were captured at the "Davenport Nesting Area" and along the Crestwood Interceptor/JCP&L Company's right-of-way at the man-made snake dens. The former, as will be discussed later, is believed to be "critical habitat" for a large number of these "endangered" and "threatened" snake species.

Five pine snakes were gravid (pregnant) or had just recently laid eggs (an adult female was found near a burrow with eggs). Several were observed nesting prior to their capture. On June 25, 1990, a "recaptured" (a snake that has been previously captured and marked) female was found nesting at the Davenport nesting area in an open, sandy spot, not far from alignment B (+/-200 feet southeast). Initially, the subject was observed vigorously exploring its surroundings (sustained, rapid tongue flicking, probing) and crawling very slowly in what seemed no specific direction. The erratic movements eventually brought the female to a freshly dug burrow where she proceeded to enter it and continue its excavation by using her pointed snout and body loops to remove the sand (Burger and Zappalorti, 1986 and Burger and Zappalorti, in press). Her efforts were ended when she had to be captured and bagged. The 20 minute event (videotaped by the senior author, RTZ) documents the use of the area and provides further proof of its importance as critical nesting habitat.

Several days afterwards, another gravid female was seen a few meters away from a second burrow basking amidst the low hanging branches of a small pitch pine. After seizing this animal, HA excavated the burrow and found two chambers: one containing a clutch of pine snake eggs and the other empty, probably soon to be filled with the eggs of the female found basking nearby. Multiple clutches are frequently found in the same burrow (Burger and Zappalorti, 1986). Only one gravid corn snake was collected in the study corridor in 1990 during our survey. The latter specimen was found at the Davenport Natural Den No. 2 (Figure 8) underneath a piece of rusty sheet metal together with an adult male of the same species (following our position, both were implanted with radio-transmitters).

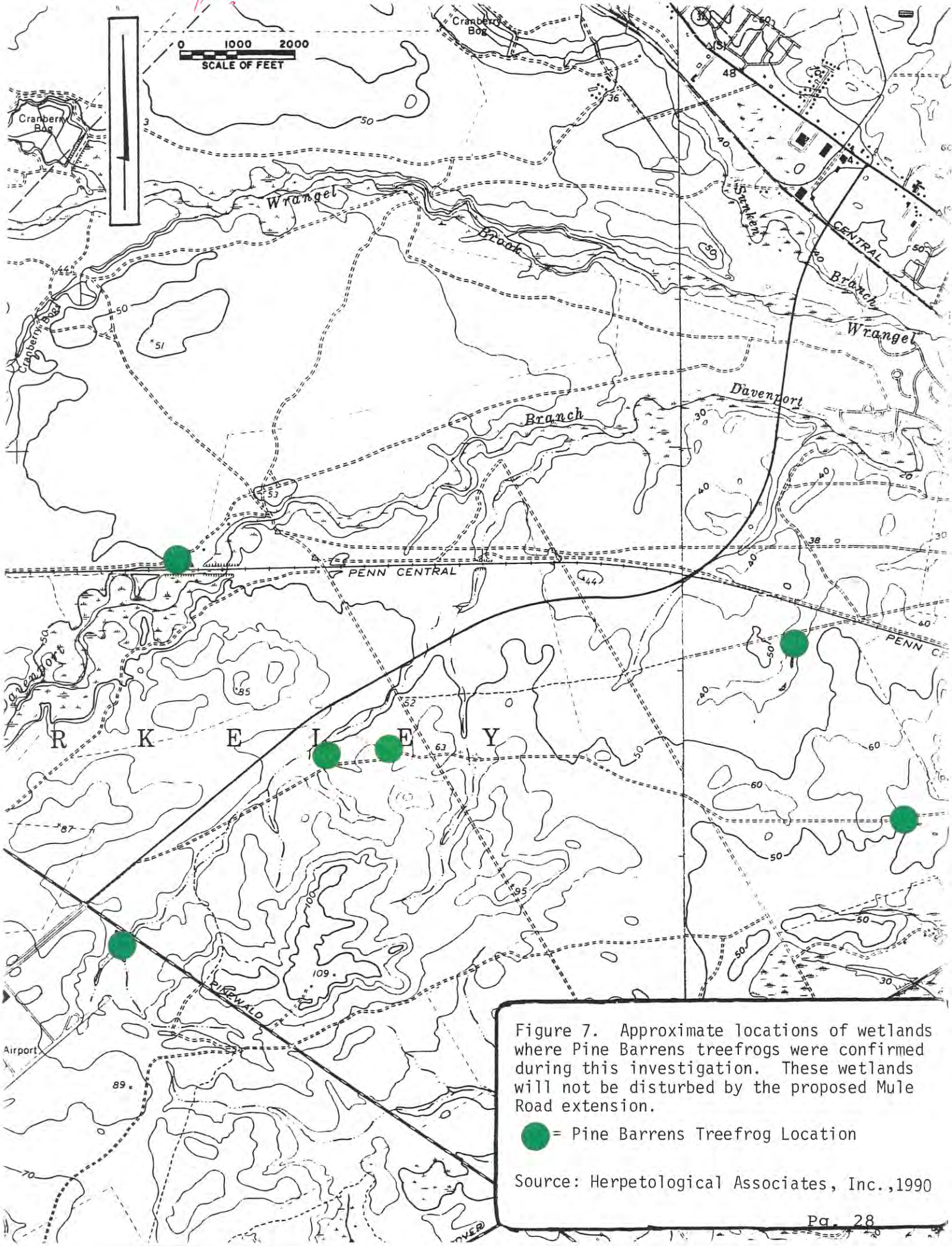


Figure 7. Approximate locations of wetlands where Pine Barrens treefrogs were confirmed during this investigation. These wetlands will not be disturbed by the proposed Mule Road extension.

● = Pine Barrens Treefrog Location

Source: Herpetological Associates, Inc.,1990

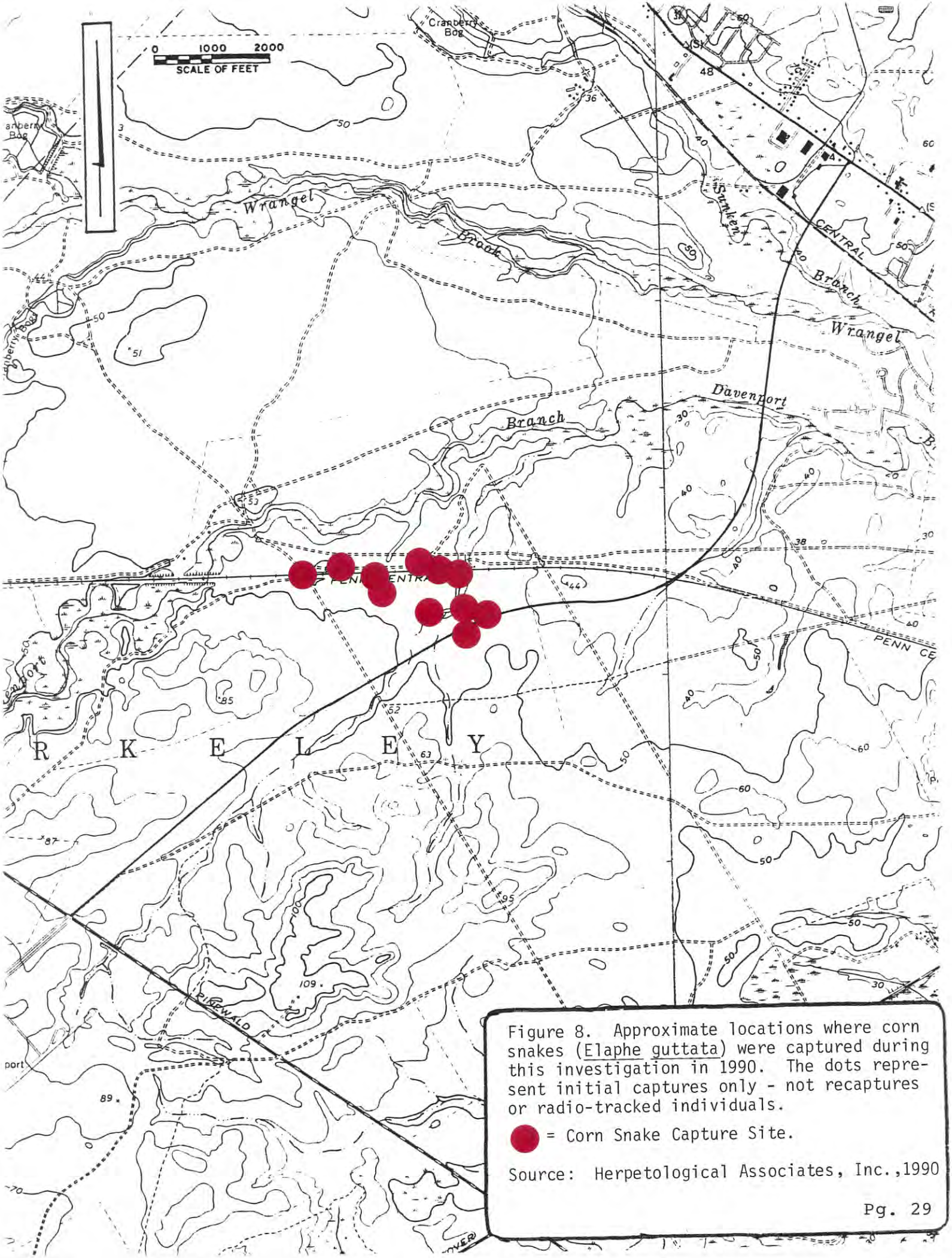


Figure 8. Approximate locations where corn snakes (Elaphe guttata) were captured during this investigation in 1990. The dots represent initial captures only - not recaptures or radio-tracked individuals.

● = Corn Snake Capture Site.

Source: Herpetological Associates, Inc.,1990

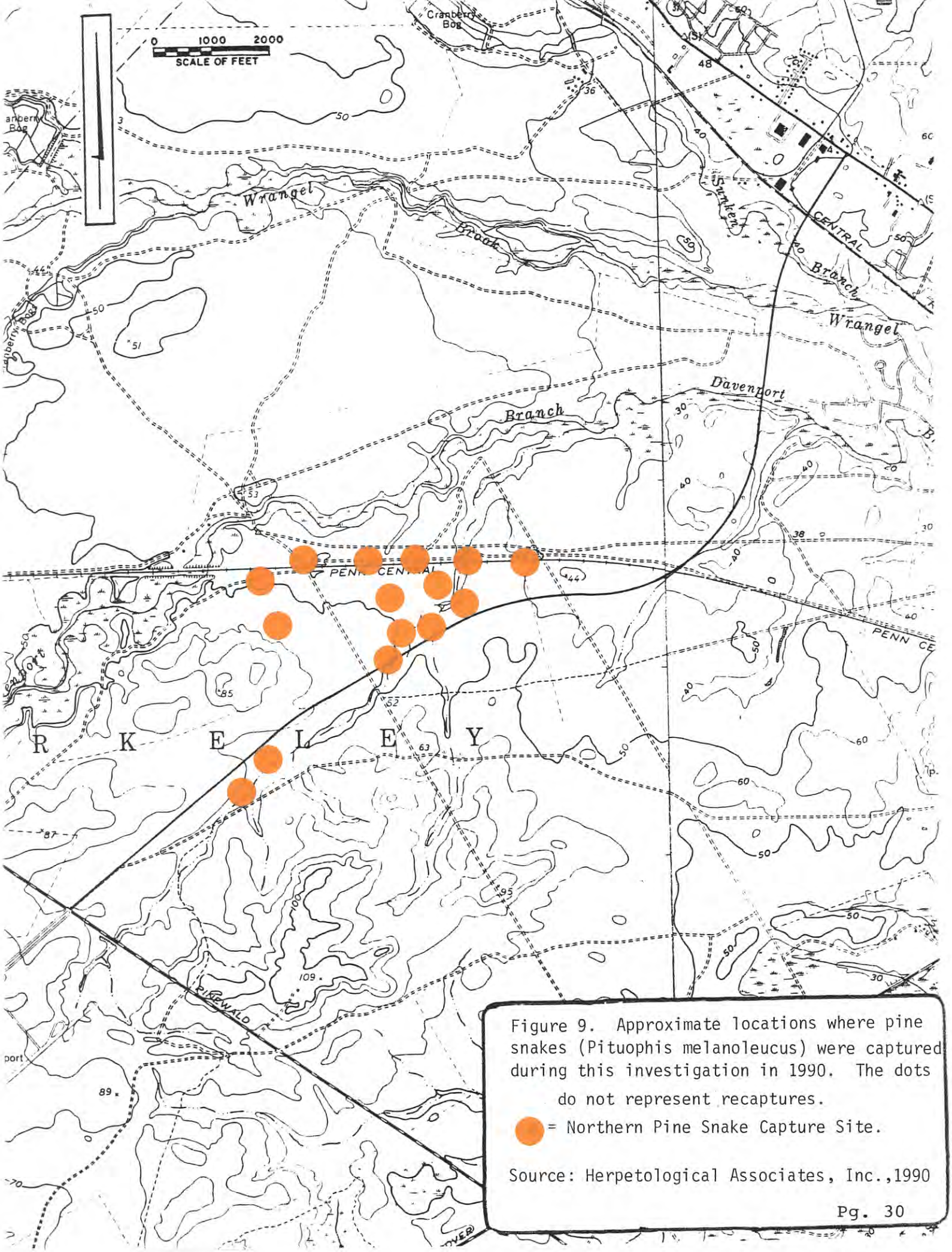


Figure 9. Approximate locations where pine snakes (Pituophis melanoleucus) were captured during this investigation in 1990. The dots do not represent recaptures.

● = Northern Pine Snake Capture Site.

Source: Herpetological Associates, Inc.,1990

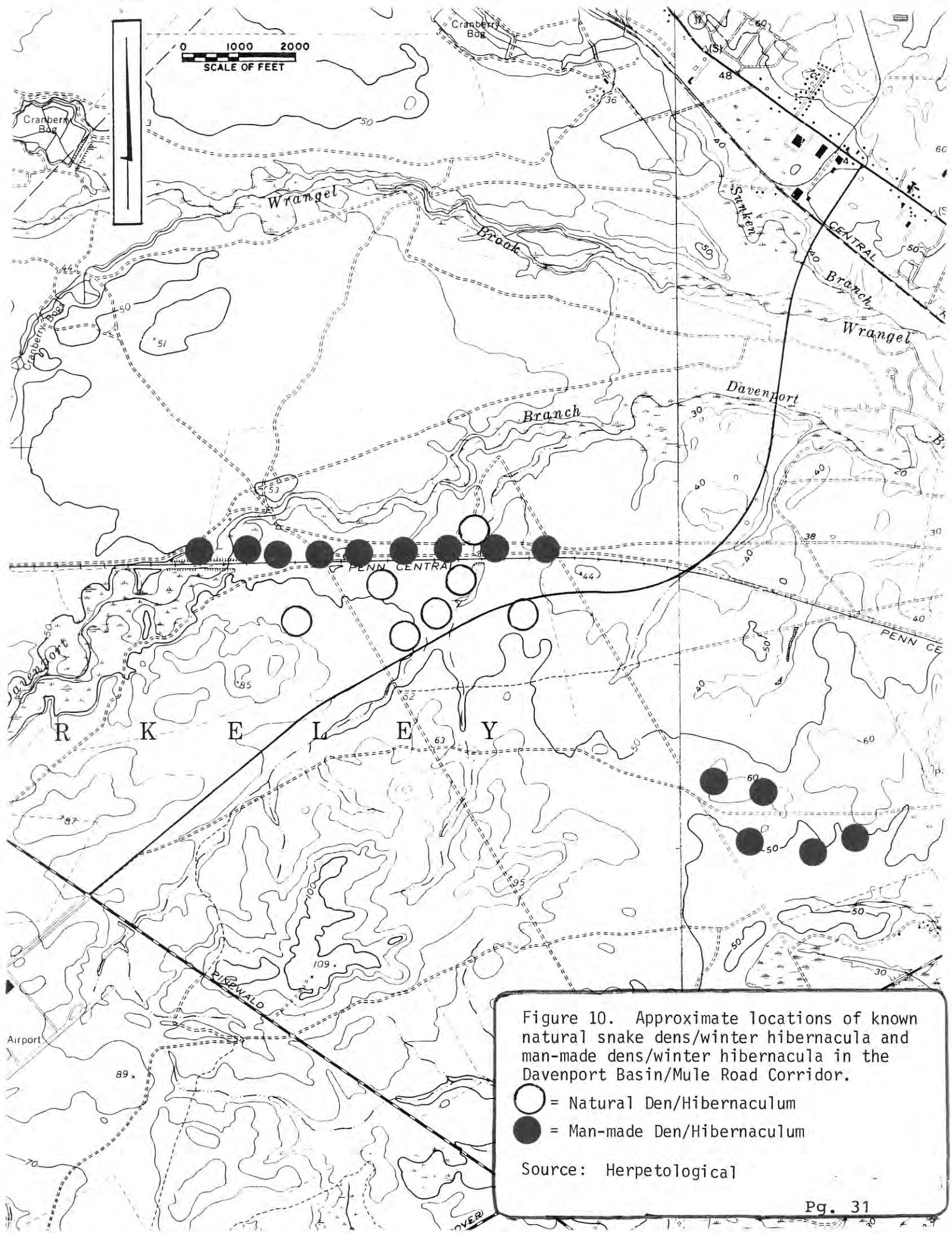


Figure 10. Approximate locations of known natural snake dens/winter hibernacula and man-made dens/winter hibernacula in the Davenport Basin/Mule Road Corridor.

○ = Natural Den/Hibernaculum

● = Man-made Den/Hibernaculum

Source: Herpetological

TABLE ONE - REPTILES AND AMPHIBINAS CONFIRMED IN THE "BERKELEY TRIANGLE" (DAVENPORT, JAKES AND WRANGLE BROOK BASINS) BETWEEN 1981 AND 1990 BY HA

COMMON NAME	SCIENTIFIC NAME	CURRENT NJDEP STATUS
TURTLES:		
Common Snapping Turtle	Chelydra s. serpentina	Stable
Spotted Turtle	Clemmys guttata	Undetermined
*Eastern Box Turtle	Terrapene c. carolina	Stable
Red-bellied Turtle	Chrysemys rubriventris	Undetermined
Musk Turtle	Sternotherus odoratus	Stable
Eastern Mud Turtle	Kinosternon s. subrubrum	Stable
*Eastern Painted Turtle	Chrysemys p. picta	Stable
Red-eared Turtle	Chrysemys scripta elegans	Introduced
LIZARDS:		
*Northern Fence Lizard	Sceloporus undulatus hyacinthinus	Stable
Ground Skink	Scincella lateralis	Undetermined
Five-lined Skink	Eumeces fasciatus	Undetermined

TABLE ONE - CONTINUED

COMMON NAME	SCIENTIFIC NAME	CURRENT NJDEP STATUS
SNAKES:		
*Corn Snake	Elaphe g. guttata	Endangered
*Northern Pine Snake	Pituophis m. melanoleucus	Threatened
*Eastern Kingsnake	Lampropeltis g. getulus	Undetermined
*"Coastal Plain" Milk Snake	Lampropeltis t. triangulum x. elapsoides	Undetermined
Northern Water Snake	Nerodia s. sipedon	Stable
*Northern Black Racer	Coluber c. constrictor	Stable
*Eastern Hognose Snake	Heterodon platyrhinos	Undetermined
*Eastern Ribbon Snake	Thamnophis s. sauritus	Stable
Northern Red-bellied Snake	Storeria o. occipitomaculata	Stable
*Southern Ringneck Snake	Diadophis p. punctatus	Stable
*Rough Green Snake	Opheodrys aestivus	Stable
Eastern Worm Snake	Carphophis a. amoenus	Stable
*Eastern Garter Snake	Thamnophis s. sirtalis	Stable

TABLE ONE - CONTINUED

COMMON NAME	SCIENTIFIC NAME	CURRENT NJDEP STATUS
SALAMANDERS:		
Red-spotted Newt	Notophthalmus viridescens	Stable
Northern Red Salamander	Pseudotriton r. ruber	Undetermined
*Red-backed Salamander	Plethodon c. cinereus	Stable
Four-toed Salamander	Hemidactylium scutatum	Stable
Two-lined Salamander	Eurycea bislineata	Stable
FROGS AND TOADS:		
*Northern Spring Peeper	Hyla c. crucifer	Stable
Northern Gray Treefrog	Hyla versicolor	Stable
*Pine Barrens Treefrog	Hyla andersonii	Endangered
Northern Cricket Frog	Acris c. crepitans	Undetermined
*Fowler's Toad	Bufo woodhousei fowleri	Stable
Eastern Spade Foot Toad	Scaphiopus holbrooki	Stable
Bullfrog	Rana catesbeiana	Stable

TABLE ONE - CONTINUED

COMMON NAME	SCIENTIFIC NAME	CURRENT NJDEP STATUS
Green Frog	Rana clamitans melanota	Stable
*Southern Leopard Frog	Rana sphenocephala	Stable
Pickerel Frog	Rana palustris	Stable
Carpenter Frog	Rana virgatipes	Stable

TOTAL = 41 SPECIES

* = Found in 1990 on Mule Road study corridor.

NOTE: Nomenclature agrees with Roger Conant (1975); and the status classifications used in this report are in accordance with those published by the New Jersey Department of Environmental Protection, Endangered and Nongame Species Program (1984).

Source: Herpetological Associates, Inc., 1990.

TABLE TWO

FREQUENCY OF ADULT PINE SNAKES CAPTURED ACTIVE, OR IN HIBERNATION, IN THE MULE ROAD STUDY CORRIDOR BETWEEN 1987 AND 1990

ACTIVITY OF SNAKES	ADULT MALES	ADULT FEMALES NON-GRAVID	ADULT FEMALES GRAVID		TOTALS
Active (Basking, Traveling, Resting, Nesting)	8	11	18	=	37
In Hibernation	29		22	=	51

Source: HA, Inc., 1990

TABLE THREE

SEX AND AGE OF PINE SNAKES FOUND INSIDE TWO NATURAL HIBERNACULA BETWEEN 1987-1990

NAME OF DEN	NO. OF ADULT MALES	NO. OF ADULT FEMALES	NO. OF NEONATES	NO. OF SUBADULTS
*DVNNA	6	12	20	10
CRSND	14	4	0	1
TOTALS:				
2 DENS	20	16	20	11

* = This natural den is within the Davenport Nesting Area whereas the other is about 1,500 north of it (Figure 10).

Source: Herpetological Associates, Inc., 1990.

RESULTS OF THE RADIO TRACKING STUDY:

Only two radio implanted corn snakes were monitored for more than sixty days. Poor signal reception and premature battery failure confounded HA's efforts to track the third specimen (non-gravid female, frequency number 626) for the above minimum period of time. As a result, data generated from her movements were not included in this study. The male (frequency number 377) and the other non-gravid female (frequency number 874) corn snake released at their original capture site on the western edge of the Davenport nesting area were successfully monitored from September 6 to November 28, 1990. Magnitude of movements, bearings and interval between relocations for the two radio-tracked individuals are given in Tables 4 and 5. Activity parameters are presented in Table 6. Total distance moved is the sum of all linear movements recorded. The distance traveled per day was obtained by dividing total distance moved by the number of days tracked. Maximum distance per day was the largest distance covered by a snake within a 24 hour period. Range length is the distance between two relocation sites that were furthest apart. The home range was calculated by using the convex polygon method described by Jennrich and Turner, 1969. The number of relocation sites used to calculate the home range area of each radio-tracked snake is given in parentheses.

The female corn snake was radio-tracked an average of every 48 hours (range 1 to 217) and a total of 42 relocations were generated (Table 4). After being released at their original capture point, the male and female dispersed in opposite directions and used separate areas with structurally different habitats. Unlike the male, the female continued to exploit the pitch pine lowland throughout most of the remaining active season. Prior to becoming opaque (the skin of a snake will loose its glossy appearance and become cloudy before it is ready to shed), she moved out of the pitch pine lowland habitat and traveled a considerable distance to several stumpholes and underground burrows which were used as overnight retreats for almost two weeks. These were located in open pine-oak forest of the Davenport nesting area. This movement also coincided with a temporary drop in ambient temperature. Other snakes were found associated with these burrows. An old corn snake shed and two pine snakes (an adult and a 1990 hatchling) were found within five feet of the entrances of two burrows. Following ecdysis (shedding of skin) and sporadic warm spells in the late fall, she returned to the pitch pine lowland and remained there until the weather deteriorated again. On November 15, she was relocated several feet south of Alignment B (the proposed Mule road right-of-way). During a

routine survey of the surrounding area, three adult, previously unmarked female corn snakes and one juvenile black racer were captured within 10 feet of the radio-tracked specimen. The large number of individuals observed and captured at this relocation site and the existence of a series of well compacted burrow entrances within several feet of two specimens, strongly suggested that the female had reached a hibernaculum. Consecutive relocations confirmed the female's use of this area as a hibernaculum. Her home range area was calculated to be 11.66 ha. (28.9 acres - see Figure 11).

A retrospective analysis of the visually dominant vegetation at each relocation site indicated that pitch pine lowland, open pine-oak and dense oak-pine upland were used by the female during the course of this study. Pitch pine lowlands are one of the driest wetlands that occur in the New Jersey Pine Barrens (Tiner, 1985). The habitat within the study site is composed of a sparse canopy of young pitch pines (Pinus rigida), a thick understory of sheep laurel (Kalmia angustifolia) and lowbush blueberry (Vaccinium vacillans) and turkey beard (Xerophyllum asphodeloides) as the dominant ground vegetation. Bracken fern (Pteridium aquilinum), greenbrier (Smilax sp.), blackjack oak (Quercus marilandica), and Sphagnum sp., although less abundant, also occurred in this lowland.

The open pine-oak upland consisted of a sparse overstory canopy of mostly medium sized pitch pines and shrub-like blackjack oak. Understory was largely dominated by lowbush blueberry and occasionally greenbriars as dense thickets. (Hudsonia ericoides and Pine Barrens sandwort (Arenaria caroliniana) vegetated the sunny, open areas.

The oak-pine upland was dominated by a dense understory canopy of blackjack oak. Sheep laurel and lowbush blueberry provided a well developed and thick understory. Like in most other habitats on the study site, bracken fern and greenbriar were also present. Fallen leaves from the abundant oak trees provided unlimited ground cover on the forest floor for snakes. Leaf litter in pitch pine dominated habitats was mostly made up of pine needles. Corn snakes were observed to effectively conceal themselves in both leaf litter types. Relocated specimens were very frequently found entirely hidden underneath thick mats of pine needles or with only portions of the body exposed or visible. In the absence of a thick layer of pine needles or perhaps to facilitate thermoregulation, both specimens were sometimes observed tightly coiled under a few oak leaves or the latter positioned around the snake so as to break up the outline of the coil, yet remain entirely exposed to the sunlight.

The male corn snake was radio-tracked an average of every 60 hours (range 8 to 545) and 33 relocation sites were generated (Table 5). As Figure 12 shows, home ranges did overlap somewhat. Pitch pine lowland was used for a short period of time while this individual was being followed, however, after a long-range movement, he was relocated deep inside dense pine-oak forest. It is interesting to note that during the last two years, he had been recaptured three times at the edge of the pitch pine lowland in the exact spot the female was captured. Monitoring the male during a full season would have revealed the extent of his utilization of the pitch pine lowland. His home range was estimated to be 8.42 ha. (20.8 acres, Figure 12).

Pine oak forest frequented by the male was characterized by a relatively closed canopy of pitch pine. Blackjack oak, lowbush blueberry, greenbriars, bracken fern, bearberry (Arctostaphy ura-ursi), sassafras (Sassafras albidum) and the evergreen shrub called inkberry (Illex glabra) were commonly found in this habitat. Activity remained centered in the pine-oak forest, but like the female, before turning opaque, he was radio-tracked to a burrow some distance away. The burrow which has turned out to be one of the many entrances to a well frequented hibernaculum, is located at the edge of a large open sandy area, approximately 1,000 feet south of the JCP&L Company right-of-way (see Figure 10). Three pine snakes and two black racers have already been found emerging from the same burrow used by the male corn snake or basking nearby. Future surveys around the burrow complex will most likely reveal more specimens.

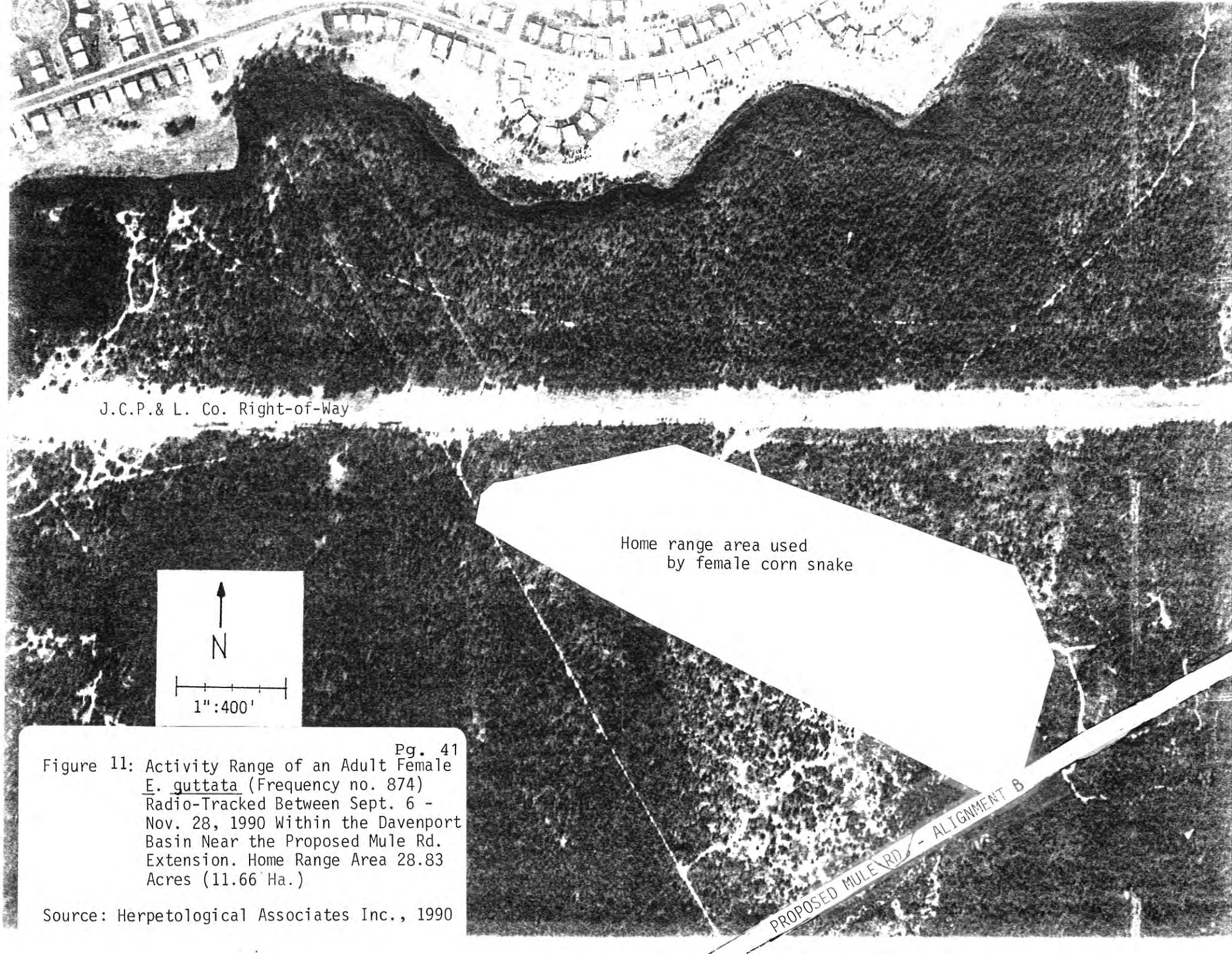


Figure 11: Activity Range of an Adult Female E. guttata (Frequency no. 874) Radio-Tracked Between Sept. 6 - Nov. 28, 1990 Within the Davenport Basin Near the Proposed Mule Rd. Extension. Home Range Area 28.83 Acres (11.66 Ha.)

Source: Herpetological Associates Inc., 1990

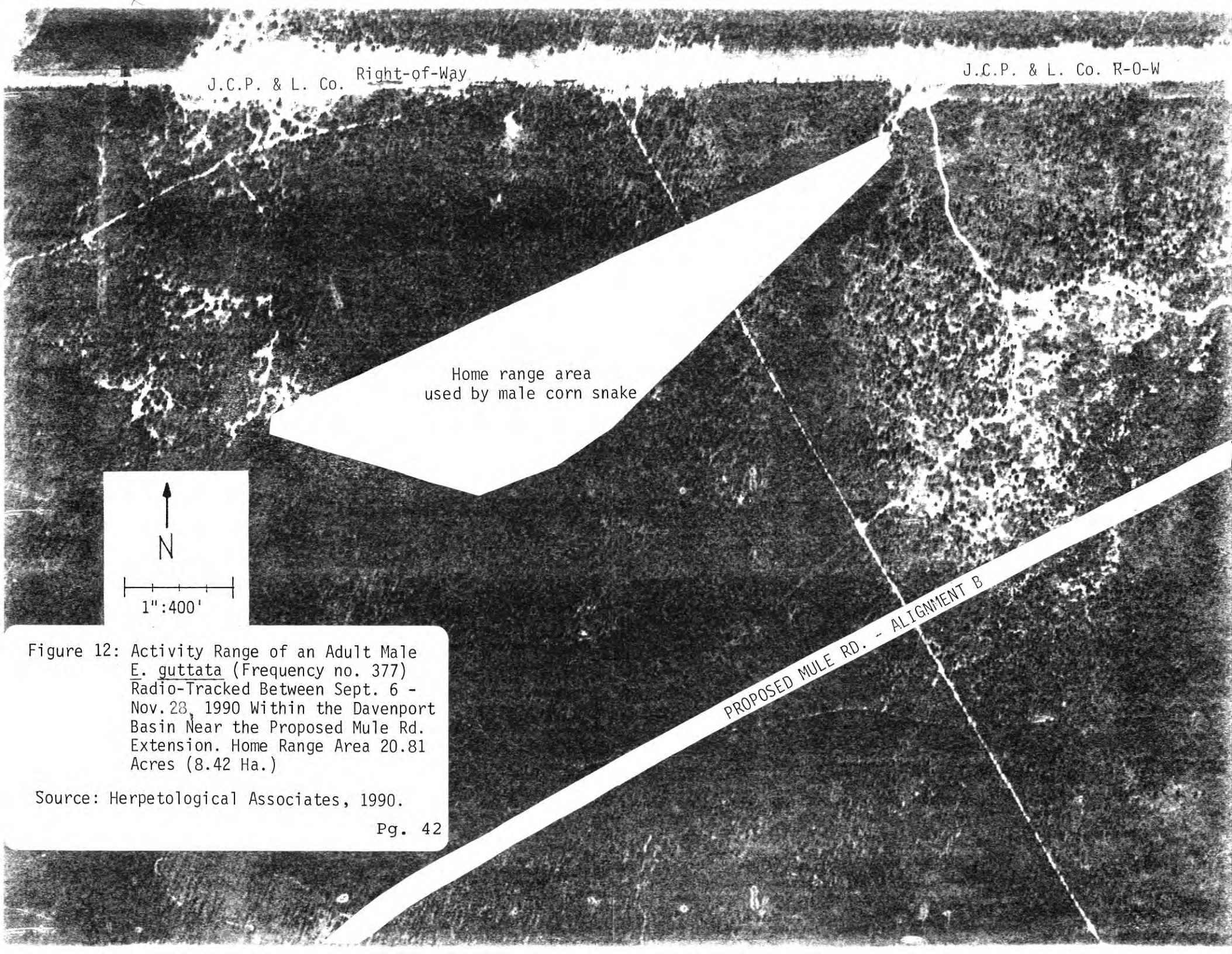


Figure 12: Activity Range of an Adult Male E. guttata (Frequency no. 377) Radio-Tracked Between Sept. 6 - Nov. 28, 1990 Within the Davenport Basin Near the Proposed Mule Rd. Extension. Home Range Area 20.81 Acres (8.42 Ha.)

Source: Herpetological Associates, 1990.

TABLE FOUR - DISTANCE AND DIRECTION OF MOVEMENTS OF RADIO-TRACKED FEMALE (NO. 874)

DATE OF RELOCATION	TIME OF RELOCATION	BEARING FROM PREVIOUS RELOCATION	DISTANCE FROM PREVIOUS RELOCATION (FT.)	INTERVAL BETWEEN RELOCATION (HRS.)
09-06-90	1800	320 degrees NW	61	24
09-07-90	930	Same location	-	15
09-08-90	1330	330 degrees NW	30	28
09-09-90	1810	220 degrees SW	5	29
09-10-90	1545	330 degrees NW	105	21
09-12-90	830	210 degrees SW	395	41
09-13-90	1830	230 degrees SW	207	34
09-14-90	800	Same location	-	13
09-15-90	1400	310 degrees NW	515	30
09-15-90	1900	310 degrees NW	8	5
09-15-90	2215	20 degrees NE	100	3
09-15-90	2330	Same location	-	1
09-16-90	900	Same location	-	9
09-18-90	1910	60 degrees NE	52	58
09-19-90	1533	115 degrees SE	965	20
09-20-90	1500	105 degrees SE	292	23
09-21-90	1700	110 degrees SE	656	26
09-23-90	1300	213 degrees SW	88	44
09-25-90	1430	33 degrees NE	88	49
09-26-90	1325	Same location	-	23
09-27-90	1520	Same location	-	26
09-28-90	1630	Same location	-	25
09-29-90	1810	Same location	-	26
10-02-90	1730	Same location	-	71
10-03-90	1440	Same location	-	22
10-06-90	1430	Same location	-	72
10-11-90	1900	291 degrees NW	1312	124
10-12-90	1048	159 degrees SE	29	16

TABLE FOUR - (CONTINUED)

DATE OF RELOCATION	TIME OF RELOCATION	BEARING FROM PREVIOUS RELOCATION	DISTANCE FROM PREVIOUS RELOCATION (FT.)	INTERVAL BETWEEN RELOCATION (HRS.)
10-13-90	1700	236 degrees SW	8	20
10-14-90	1620	304 degrees NW	34	23
10-16-90	1520	325 degrees NW	24	47
10-19-90	1730	116 degrees SE	430	75
10-20-90	1735	270 degrees W	7	24
10-21-90	1725	260 degrees SW	8	24
10-24-90	1542	106 degrees SE	910	70
10-30-90	1030	166 degrees SE	109	140
11-03-90	1500	223 degrees SW	53	100
11-05-90	1540	55 degrees NE	16	49
11-15-90	1510	205 degrees SW	450	215
11-18-90	1400	240 degrees SW	47	71
11-27-90	1500	21 degrees NE	62	217
11-28-90	820	137 degrees SE	16	17

Source: Herpetological Associates, Inc., 1990

TABLE FIVE - DISTANCE AND DIRECTION OF MOVEMENTS OF RADIO-TRACKED MALE (NO. 377)

DATE OF RELOCATION	TIME OF RELOCATION	BEARING FROM PREVIOUS RELOCATION	DISTANCE FROM PREVIOUS RELOCATION (FT.)	INTERVAL BETWEEN RELOCATION (HRS.)
09-06-90	1730	270 degrees W	59	24
09-07-90	900	20 degrees NE	5	16
09-08-90	1345	220 degrees SW	3	29
09-09-90	1730	150 degrees SE	75	28
09-10-90	1630	280 degrees NW	230	23
09-12-90	720	210 degrees SW	92	39
09-13-90	1900	260 degrees SW	200	24
09-14-90	830	240 degrees SW	144	13
09-15-90	1200	240 degrees SW	1050	15
09-15-90	2030	290 degrees NW	102	8
09-16-90	1045	270 degrees W	75	14
09-18-90	1614	280 degrees NW	200	53
09-19-90	1652	90 degrees E	3	24
09-21-90	1928	297 degrees NW	876	50
09-23-90	1220	Same location	-	42
09-25-90	1300	320 degrees NE	3	48
09-26-90	1400	300 degrees NW	3	24
09-27-90	1700	50 degrees NE	3	24
09-29-90	1738	207 degrees SW	60	24
10-01-90	1837	Same location	-	25
10-02-90	1819	27 degrees NE	60	24
10-03-90	1600	Same location	-	22
10-06-90	1400	Same location	-	70
10-11-90	1613	137 degrees SE	219	115

TABLE FIVE - (CONTINUED)

DATE OF RELOCATION	TIME OF RELOCATION	BEARING FROM PREVIOUS RELOCATION	DISTANCE FROM PREVIOUS RELOCATION (FT.)	INTERVAL BETWEEN RELOCATION (HRS.)
10-12-90	1205	130 degrees SE	575	20
10-13-90	1555	89 degrees NE	272	27
10-14-90	1740	322 degrees NW	54	26
10-16-90	1800	305 degrees NW	60	48
10-19-90	1600	300 degrees NW	900	70
10-20-90	1700	90 degrees E	13	25
11-05-90	1500	165 degrees SE	34	382
11-28-90	850	345 degrees NW	34	545

Source: Herpetological Associates, Inc., 1990

TABLE SIX - ACTIVITY PARAMETERS FOR TWO RADIO-TRACKED CORN SNAKES, (ELAPHE GUTTATA) IN THE DAVENPORT BASIN IN 1990

SNAKE FREQUENCY NUMBER	SEX	DAYS TRACKED	TOTAL DISTANCE (FT.)	DISTANCE/ DAY (FT.)	MAXIMUM DIST./DAY (FT.)	RANGE LENGTH (FT.)	HOME RANGE (ACRES)	HOME RANGE (HA.)
377	Male	83	5417	65.27	1152	2433	20.8	8.42 (33*)
874	Female (nongravid)	83	7324	88	965	2173	28.8	11.66 (42*)
Mean for Both	$(\bar{X})$ =	83	6370	76.6	1058	2303	24.8	10.04

*Figures in parentheses indicate number of relocations.

Source: Herpetological Associates, Inc., 1990.

TABLE SEVEN - CORN SNAKE RECORDS FOR THE STUDY AREA (1987-1990)

I.D.	SEX	DATE	LOCATION	CONDITION	BEHAVIOR	OTHER
87.25	F	08/11/87	MLERD	A	Active	Most southern record within study site
88.01	F	03/14/88	CRSND #1	N	Hibernating	
88.06	M	04/09/88	DVNND #1	N	Active	
88.07	M	04/09/88	CRSMM (4)	N	Active	
88.11	F	05/15/88	CRSMM (4)	S	Active	
88.46	F	10/15/88	CRSMM (3)	N	Active	
88.17	M	05/28/88	CRSMM (3)	A	Active	
88.24	F	06/05/88	CRSMM (3)	G	Active	
89.08	M	05/26/89	CRSMM (3)	?	Active	
89.15	M	06/15/89	DVNND #2	A	Active	
89.18	F	10/24/89	DVNND #2	A	Active	
89.18	F	10/17/89	DVNND #2	A	Active	
89.29	F	10/11/89	CRSMM (3)	A	Active	
88.46	F	10/11/89	CRSMM (3)	S	Active	
90.01	F	03/03/90	DVNND #1	N	Hibernating	
90.04	M	04/23/90	CRSMM (6)	A	Active	
90.06	F	05/17/90	DVNND #2	G	Active	Radio-tracked (Freq. #874)
89.15	M	05/17/90	DVNND #2	A	Active	Radio-tracked (Freq. #377)
89.15	M	07/13/90	DVNND #2	A	Active	
90.11	F	09/06/90	DVNND #2	H	Active	Lab hatchling released

TABLE SEVEN - (CONTINUED)

I.D.	SEX	DATE	LOCATION	CONDITION	BEHAVIOR	OTHER
90.12	F	09/06/90	DVNND #2	H	Active	Lab hatchling released
90.13	F	09/06/90	DVNND #2	H	Active	Lab hatchling released
90.14	M	09/06/90	DVNND #2	H	Active	Lab hatchling released
90.15	F	09/06/90	DVNND #2	H	Active	Lab hatchling released
90.16	F	09/06/90	DVNND #2	H	Active	Lab hatchling released
90.17	M	09/06/90	DVNND #2	H		Lab hatchling released
90.18	F	09/06/90	DVNND #2	H		Lab hatchling released
90.19	F	09/06/90	DVNND #2	H		Lab hatchling released
90.20	M	09/06/90	DVNND #2	H		Lab hatchling released
90.21	F	09/06/90	DVNND #2	H		Lab hatchling released
90.22	F	09/06/90	DVNND #2	H		Lab hatchling released
90.23	M	09/06/90	DVNND #2	H		Lab hatchling released

TABLE SEVEN - (CONTINUED)

I.D.	SEX	DATE	LOCATION	CONDITION	BEHAVIOR	OTHER
90.24	M	09/06/90	CRSMM (5)	H		Lab hatchling released
90.24	M	11/03/90	CRSMM (5)	H		
90.25	M	09/06/90	CRSMM (5)	H		Lab hatchling released
90.25	M	10/24/90	CRSMM (4)	H	Active	Lab hatchling moved
90.50*	F	09/08/90	CRSMM (3)	H	Active	
90.50*	F	10/12/90	CRSMM (3)	H	Active	Died a few days later
90.51	M	09/15/90	CRSMM (3)	A	Active	
90.53	M	11/03/90	CRSMM (3)	A	Active	
90.54	F	11/15/90	DVNND #4	A	Active	Located while radio-tracking female 874 or (90.06)
90.55	F	11/15/90	DVNND #4	A	Active	Located while radio-tracking female 874 or (90.06)
90.56	F	11/15/90	DVNND #4	A	Active	Located while radio-tacking female 874 or (90.06)

* Between 09/06/90 and 09/08/90, 10 shed skins of hatchling Elaphe guttata were found by den CRSMM (3).

TOTAL NUMBER OF INDIVIDUALS = 46
TOTAL NUMBER OF OBSERVATIONS = 53

Source: Herpetological Associates, Inc., 1990.

IV. Discussion

DISCUSSION:

The Davenport and Wrangle Brook Basins are known historically to support pine and corn snakes. Today, after 55 years since Kauffeld's explorations the species of concern continue to thrive successfully in these areas. HA's surveys have confirmed the presence of a vibrant pine and corn snake population, and numerous wetlands exploited by Pine Barrens treefrogs (two of which occur within the Mule Road study corridor).

Pine Barrens treefrogs ("endangered") are known to occur in wetlands 1 and 2. Breeding activity was not apparent at either site (e.g.; male and female found in amplexus, or tadpoles found in standing water) so the wetlands may provide only foraging habitat to resident frogs. On the other hand, the insular location of these very small wetlands may force the treefrogs to breed here. The wetlands should be protected by 300 foot buffers to ensure water quality, and preserve the vegetation.

Most male pine snakes were captured in the winter months inside dens because during the active season very few of them were seen. Males do not return to open areas in mid-summer, like gravid females (Burger and Zappalorti, 1986), but instead remain within their home range to forage and consequently are infrequently seen by the casual observer or collector. Radio-telemetry of five adult males showed that disturbed and undisturbed pine-oak forests, and sometimes pitch pine lowlands, were used as summer habitats (Burger and Zappalorti, 1989; Zappalorti and Johnson, 1982-B).

Snakes are very cryptic and are almost impossible to locate in dense vegetation or where cover is plentiful. Not a single snake was seen or captured along portions of the Mule Road alignment that was bordered by dense pine-oak forest with an understory of lowbush blueberry (Vaccinium vacillans). Yet observations of radio-tracked snakes (pine snakes, Burger and Zappalorti, 1989; corn snakes, Zappalorti and Johnson, 1982-A; timber rattlesnakes, Reinert and Zappalorti, 1988; and this study have confirmed that these areas are used to forage, nest and sleep).

Gravid females generated considerably more observations than either active males or active non-gravid females. Several factors played an important role in this outcome. Between late June and early July (approximate nesting period), gravid females moved to open sandy areas (such as the Davenport nesting area) to dig deep, long borrows into the soft sand to lay eggs (Zappalorti, pers. obs.). Females select nesting sites that offer maximum solar exposure, provide firm but penetrable sand, and contain shallow root systems, possibly to prevent the collapse of the roof burrow. Nesting areas studied were usually man-made (Burger and Zappalorti, 1989). The construction of the "nest", and the selection of the open, barren areas make them far more conspicuous than a similar sized pine snake in thickly vegetated habitat.

Nest site fidelity also aided the recapture of some individuals. By returning to specific areas where gravid females or nests had been found in previous years, our probability of recapturing marked gravid or nesting females was greatly enhanced. Much time and effort was dedicated during the short nesting period to locate gravid females. When a comparison of capture rates is attempted, time and effort are important variables to consider (Jones, 1986). Usually the more time and effort is invested, the greater the yield.

While sampling bias can largely explain the high capture rates of gravid females, the nesting behavior of pine snakes conveys important implications:

A. Openings in the forest such as the Davenport nesting area are "critical habitats" for this species.

B. Gravid females became particularly vulnerable and conspicuous to predators during the nesting season.

C. Temporal and spatial differences in activity patterns and habitat utilization exist between gravid females and other members of the population during and possibly prior to the nesting season. Burger and Zappalorti (1989), found no sexual differences in activity patterns, but gravid females were excluded from their study.

The proximity of the proposed roadway to a <u>confirmed nesting area</u> could have profound impacts on gravid females and/or their young. Because of their contribution, gravid females represent the most valuable individuals in a population. Much attention should therefore be given to prevent these impacts.

In the first years of life, pine snakes are believed to be very fossorial (Zappalorti, pers. observation). This behavior may explain the scarcity of young specimens seen by scientists during the summer months (activity season). Very few studies have attempted or achieved to document the movements of neonate or juvenile snakes (Gregory, et al, 1987). Movements and activity patterns of adults are interwoven with reproductive behavior. In the absence of this participation, juvenile snake movements (and life history) may be constrained by other selective pressures, e.g., diets, predators, etc. (Gibbons and Semlitsch, 1987).

It is recognized that the location of a hibernaculum is vital to the survival of neonates and may represent their first long range movement (Gregory et al, 1987; Graves, et al, 1986). The large number of neonate pine snakes captured inside and near the Davenport natural den number 1 suggests this den may be important to first year neonates. The recapture of two neonates at this den following their release at the Crestwood man-made den number 6 (1,650 feet distance) strengthens this hypothesis.

Neonate timber rattlesnakes are known to trail conspecific adults and neonates to winter dens (Brown and MacLean, 1983; Reinert and Zappalorti, 1987 and Graves, et al, 1986). Neonate pine snakes may also be capable of following scent trails of conspecifics to winter hibernacula. "Neonatal snakes of several species will aggregate in response to chemosensory cues ... trailing could be employed for den location if conspecific odors were deposited near or around dens", (Graves, et al, 1986). Many females captured nesting were found in the Davenport natural den number 1 together with the neonates and juveniles. The lopsided sex ratios of the adults and age groups at the Crestwood natural den number 1 and Davenport natural den number 1 deserves further long-term study.

During the past few years, with the intention of monitoring the man-made dens, most of our searching efforts were concentrated along the JCP&L right-of-way (Crossley, Crestwood and recently the Davenport nesting area; Figure 17; Tables 8 and 9). Because of this searching "bias", most of our sightings occurred not very far from this area and consequently, at this time, HA cannot provide much data on pine snake movements outside of the major nesting areas and/or dens. Recapture records may give an insight to the

magnitude of movements, e.g.; neonates traveling from Den 6 on the Crestwood right-of-way to the Davenport natural den, but would poorly outline a home range. It has been shown that adult pine snakes in the Pine Barrens have an activity range between 5.9 and 116 acres (x = 51, n = 7; Zappalorti and Johnson, 1982-B).

Records within the past years, limited the distribution of most corn snakes within the study area to the Crestwood JCP&L corridor. Radio-tracking data and observations made during this phase of the study confirm the Davenport nesting area as an "important and critical habitat" to both pine and corn snakes. While not conclusive, the information gathered suggests the following:

1. Home range requirements for this species in the New Jersey Pine Barrens may be greater than previously thought. The average home range area of both the male and female corn snakes was calculated to be 10.04 ha. (24.8 acres) with the average length being 2,303 feet. Zappalorti and Johnson, 1982-B, using the same methodology (convex polygon area) reported a home range of 4.57 ha. (11.3 acres) and a range length of 1,437 feet. for a single adult male corn snake relocated 13 times during a 72 day period. Future studies using larger sample sizes and superior statistical method (i.e.: harmonic mean analysis, Dixon and Chapman, 1980) are needed to accurately establish the home range requirements of Elaphe guttata in the Pine Barrens.

2. Four structurally different habitats were used by the two radio-tracked specimens, but pitch pine lowland may emerge as an important foraging habitat for corn snakes. Both radio-tracked animals were captured at the edge of this habitat underneath a rusted piece of sheet metal. The male had been captured at this identical location in June 1989. On May 17, 1990 he was recaptured a second time in the same spot with the female. He was weighed, measured and released. On July 13, 1990, he was recaptured a third time in the same location, but was held in the laboratory until a transmitter was surgically implanted. A 36 gram body weight gain on July 13, 1990 suggests that he was feeding well in this area. Pitch pine lowland was used more frequently by the female and considerable distance was covered to return to it after shedding. Also, at one of these relocations, she was picked up briefly to confirm the presence of a large mid-body bulge (a tell-tale sign of a recent meal).

Radio-telemetry was used in this study primarily to locate natural corn snake dens, thus specimens were only fitted with transmitters late in the season. To obtain accurate information on a species habitat use, individuals should be monitored for the whole active season (Reinert and Zappalorti, 1988). Future studies using a larger sample of radio-tracked corn snakes are needed to provide a far more complete picture of the habitat use of corn snakes and the importance of pitch pine lowlands to their ecology. A statistical analysis of habitat and climatic variables (Reinert and Zappalorti, 1988) collected at each relocation site was not germane to the purpose of this report and is thus not included.

3. Observations of snake behavior during relocation episodes confirm the species secretive and fossorial habits. The male was found concealed 42%, basking and inactive 36% and traveling 21% (n=33). The female was observed concealed 59%, basking and inactive 29% and traveling 12% (n=42). Concealed relocations were frequently recorded near stumpholes, burrows or where leaf litter was thick. On one occasion, the female was relocated in an open, sandy spot concealed underground. The strong radio signal was being received near a shallow mole tunnel. A gentle poke with a finger through the tunnel roof confirmed the presence of the female corn snake 2 inches below the ground.

Corn snakes were frequently relocated in thickly vegetated areas. Even with the aid of radio-telemetry equipment, the specimens were difficult or impossible to see. Individuals were often found entirely or partly hidden beneath leaf litter. The markings and color of the snakes blended extremely well with their surroundings. Unless one would go about raking leaf litter, it would be highly unlikely and time consuming to locate one in its natural habitat. Unfortunately, cryptic coloration and behavior reduces the success of collection and removal/relocation programs.

4. The construction of the Mule Road extension (Alignment B) will inevitably destroy at least one den frequented by corn snakes, black racers and possibly other snake species. If the road is approved, the den must be excavated and its residents removed prior to clearing and construction.

The results of our survey have clearly documented the presence of "endangered" and "threatened" snakes along some parts of the proposed alignment. The Davenport nesting area and the Crestwood/JCP&L Co. right-of-way man-made dens unquestionably surfaced as vital areas. The role that this habitat plays in the life cycle of the snakes should not be underestimated, but neither should the potential of other areas along this proposed Mule Road right-of-way where snakes were not found physically during our survey. The Davenport Basin supports a large community of snakes (pine and corn snakes are not the only abundant species here, see Table 1). Contiguous portions of the study area that lacked records of "endangered" or "threatened" species should still be viewed as ecologically important regions because of the difficulty of locating snakes in certain thickly vegetated habitats. The design of the proposed Mule Road should therefore prevent snake access along its entire length, or at least in all critical habitat areas identified during this study, to minimize potential long-term impacts to the population of "endangered" corn snakes and "threatened" pine snakes in the eastern Davenport Basin.

V. Assessment of the Project Impacts

ASSESSMENT OF THE MULE ROAD IMPACTS:

HA suggests that there are three possible alternatives for the proposed Mule Road and the subsequent positive and/or negative impacts it would cause to the "endangered" and "threatened" nongame wildlife in the eastern Davenport Basin. The three alternatives are:

1. Build a standard blacktop asphalt road as originally designed for the safety of Ocean County residents.

2. Provide mitigation by building a state-of-the-art elevated roadway that would be safe for both Ocean County residents and the "endangered" snake species by providing tunnels under it.

3. Do not build the road at all and save the "critical" corn and pine snake's habitat and the Ocean County tax dollars it would cost for construction.

We would like to explore both the positive and negative impacts of the three Mule Road alternatives with respect to corn and pine snakes in the study area. There are some short term adverse impacts that will result from the proposed Mule Road extension that are unavoidable. These short-term impacts will happen if either "Alternative One" or "Alternative Two" are chosen, however, the magnitude of these adverse effects can be minimized.

I. Temporary disturbance of sensitive areas will occur as construction workers and heavy machinery prepare the site. A 125 foot right-of-way has to be cut and cleared. Heavy vibrations near critical areas such as the Davenport nesting area and the four natural dens may disturb snake activity depending on the time of the year the clearing occurs. Soil compaction due to heavy equipment in areas used for nesting may prevent their future use (pine snakes require only moderately packed sand to excavate nesting burrows).

II. Vegetational and stump clearing of the existing habitat along the 125 foot wide right-of-way with bulldozers and other heavy equipment will result in the destruction of some foraging and critical nesting and denning habitat. The actual clearing process could destroy unidentified hibernacula and kill some snakes and other wildlife. One den, identified while radio-tracking is located on Alignment B, approximately 500 feet southeast of the Davenport natural den no. 1. Construction of the road will destroy this den.

Long term impacts associated with both alternatives will require bold mitigation measures to offset their effects:

I. The proposed Mule Road would further fragment the existing "Berkeley Triangle". In its current condition, the "Berkeley Triangle" provides snakes and other wildlife approximately 3,500 acres in which to forage, mate, lay eggs and hibernate (HA data; and Natural Lands Trust, 1987).

II. The presence of the proposed Mule Road may facilitate future approval to additional development of adjacent land. Development and further fragmentation would clearly reduce available habitat. It would also increase human encounters and exploitation, as well as introduce domestic predators, most likely and initiate a general decay of the resident "endangered" snake populations.

III. The paved road will facilitate the public's access to nearby sensitive areas. The current alignment has been placed 200 feet away from a major pine snake winter hibernaculum and right across the known pine snake nesting area habitat. The JCP&L Company right-of-way and the 25 man-made dens, especially built as mitigation for the "Crestwood Interceptor" by the Ocean County Municipal Utilities Authority to enhance the snake habitat, will be 1,000-2,000 feet away from the road (see Figure 17 and Tables 8 and 9). Intensified illegal dumping, vandalism and illegal collecting could in a matter of decades (directly or indirectly) drastically deplete a healthy "protected" corn and pine snake population. Dumping will in the long run facilitate illegal collecting. Snakes are frequently found under wooden boards, old carpets, shingle piles and generally any human refuse that provides either food (rodents) or suitable cover. The nearby man-made dens will very likely become targets for vandals and a bonanza for snake collectors.

ALTERNATIVE ONE:

Construction of the proposed Mule Road extension as originally designed and without any mitigation would most likely cause the following impacts:

A. Once the road is completed (as originally designed) snakes and other wildlife would be able to crawl upon the surface in an attempt to get across the road. During the summer of 1989, HA conducted two hourly traffic count experiments at the junction of Route 530 (at the entrance of the Ocean County Airpark) and the

existing sand Mule Road. We counted approximately 308 motor vehicles per hour between 09:00-10:00 hours; and 295 motor vehicles between 16:00-17:00 hours. If we use an average of 300 cars an hour at peak times of the day, it could be estimated that about 5 cars a minute will use the proposed Mule Road. It is doubtful that very few snakes (or other wildlife) will safely get across the 120 foot roadway.

Snakes attempting to cross or thermoregulate on the road will most likely get run over accidently or intentionally. The heavy traffic (approximately 300 cars per hour) will no doubt inflict massive casualties. The proximity of several snake dens and nesting areas to the alignment, and the relative abundance of snakes (pines in particular) throughout the eastern Davenport Basin will augment the above impacts significantly. The numerous gravid pine snakes that nest at the Davenport nesting area will be prime targets (Figures 23 through 30). Signs warning motorists of snakes would be mostly ignored and would worsen the situation by informing eager illegal collectors of the abundance of snakes.

B. Removal of vegetation will create an open edge approximately 1.5 miles long by 125 feet wide through mostly pine-oak forest. The effects of a forest edge have long been viewed as desirable by some wildlife managers (Leopold, 1933; and Burger, 1973). The implementation of edge habitats in the management of a variety of game and nongame animals is a common practice used by the NJDEP. Some snakes (hognose, rattlesnakes, black racer, and pine snakes) benefit from open areas and man-made clearings (Zappalorti and Burger, 1985; Reinert and Zappalorti, 1988; and Burger and Zappalorti, 1986). Unfortunately use (thermoregulation, nesting, crossing, etc.) of the open Mule Road corridor by snakes (or any other small animal) will be short lived unless measures are taken to prevent their access upon the hardtop surface of the road.

C. Habitat evaluations and the presence and/or absence of snakes has shown that the area closest to Route 530 are the <u>least important habitat</u> along the Mule Road study corridor. The habitat next to Route 530 is generally similar to the pine-oak forest throughout the eastern Davenport Basin, but the high volume of traffic on the road significantly reduces the value of the habitat for snakes (and other wildlife). The use of areas near roads will increase the animal's probability of getting killed on a road. Similar adverse impacts would take place from a standard paved road as originally designed by the OCED (see Figures 23 through 30).

ALTERNATIVE TWO:

Construction of a state-of-the-art elevated roadway that prevents snakes from crawling onto the tarmac would still cause the short-term and long-term impacts discussed earlier, but would enable "endangered" and "threatened" species (as well as other small wildlife) to move across the roadway without getting killed. Alternative Two eliminates the most direct and detrimental impact associated with a busy roadway.

Figures 13 through 16 illustrate one possible method of building the road. In order to minimize short and long term impacts, the following suggestions are made:

A. Accidental death/injury of snakes can be almost eliminated if clearing operations and construction are carried out between the months of mid-April to mid-October when snakes are active on the surface and can escape the disturbance. A qualified herpetologist should be on site (particularly prior to and during the initial clearing of the vegetation) to identify/excavate potentially new dens and/or remove snakes along the right-of-way, and ensure that heavy equipment is maintained away from nesting or other vital snake habitat.

B. Replanting native vegetation along the road (pitch pines) to replace some of the cleared trees. This option would limit access to adjacent land and prevent (or control) illegal collecting, dumping, etc. Since the road would be partially elevated by a wall, trees would only be required in some places.

C. Critical corn and pine snake habitat identified during this study in the Davenport Basin (along the proposed Mule Road right-of-way) could be deed restricted to remain forever wild. Perhaps, areas close to Route 530 could be traded for critical habitat further north that is crucial to the snakes.

D. To avoid the imminent slaughter of snakes on the road, a barrier along the whole length of the Mule Road alignment preventing snakes from getting squashed, should be incorporated into the planning and construction of the road. Culverts under the road enabling corn and pine snakes (and other small animals) to cross underneath the barrier and reach the other side unharmed, would ensure unrestricted movements. Small 40 foot bridges across the wetlands (see map for approximate locations) would allow bigger animals such as deer, raccoon, fox, skunk, opossum, etc. to cross the barrier at two locations (Figure 15).

E. On July 24, 1990, a meeting was held with the Ocean County engineering staff and the authors to discuss the design and construction of such a barrier. As a result of that meeting, a plan was drafted and is shown in Figures 13 and 16. Unfortunately, the design may not be very cost effective, but it achieves the following:

1. The height of the wall and the projecting 12 inch lip will practically guarantee that no native snake will climb over and clear the structure

2. The proposed 18 by 24 inch precast concrete culverts fitted with removable 1.5 inch wire screens will allow snakes to cross the barrier, but exclude their predators such as fox, skunks, cats, and raccoons. The distance between the culverts could be about 500 feet apart (Figure 15).

3. The elevated highway will keep undesirable motorists (dumpers, collectors, etc.) on the road and away from sensitive areas bordering the road (nesting areas, winter dens).

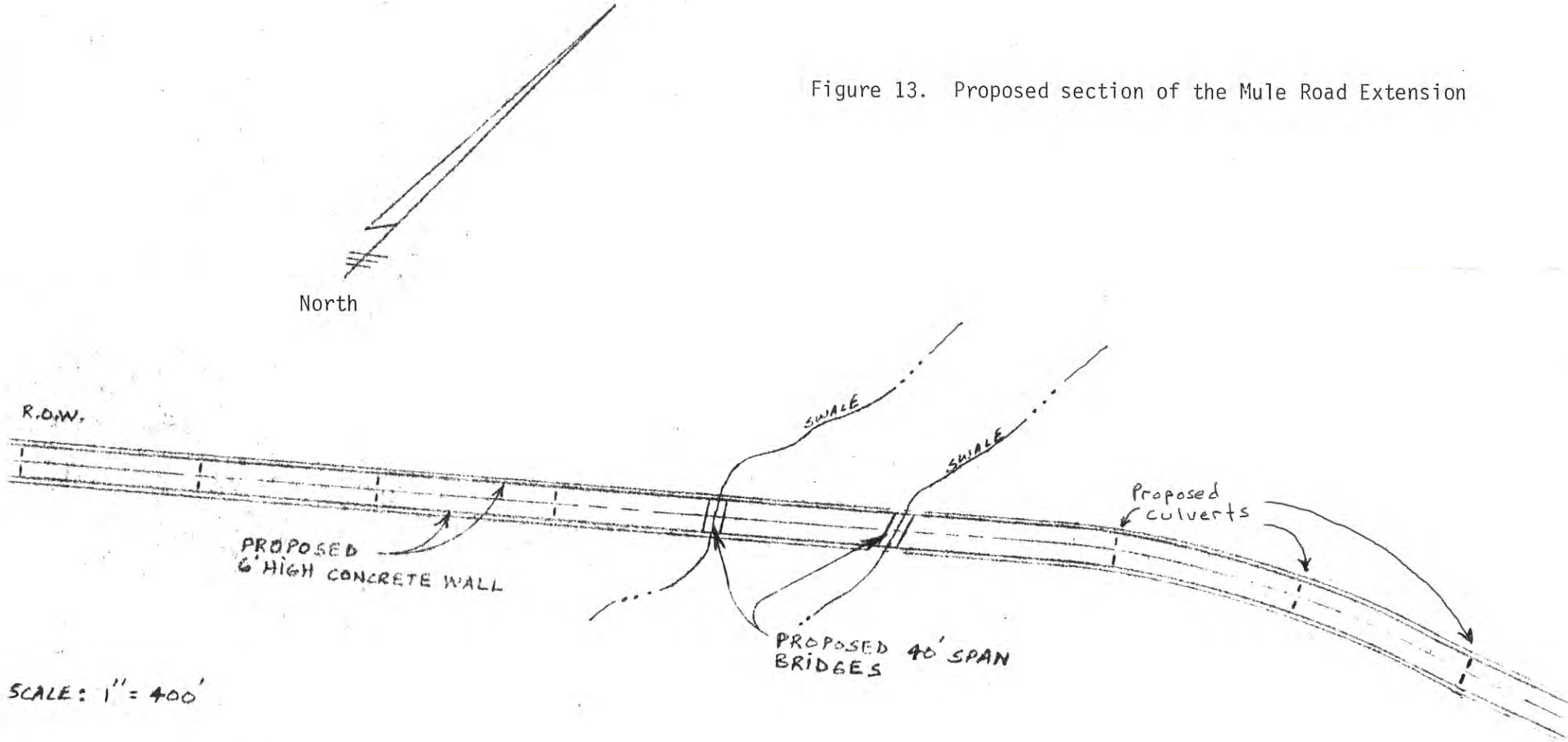
4. "Endangered" snakes and other animals will be able to enjoy the edge habitat along the road without getting flattened by cars. Brush and log piles every 50-75 feet apart on both sides of the road will provide shelter against predators. Motorists will not have to worry about hitting deer or other wildlife.

5. The concrete structure, unlike wood or metal, would be durable and almost impervious to the attacks of vandals. The structure would guarantee a safe thruway to motorists and fauna for many years to come (Figures 13 through 16).

ALTERNATIVE THREE:

The last alternative consists of not building the road at all. This would probably benefit the snakes the best, but would leave the County without the much needed roadway from Holiday City South to the Ocean County Airpark. However, it would save the taxpayers $1.5 to $3.5 million. The construction of the Mule Road extension represents a challenge to both the OCEP and HA. The foreseeable impacts on an "endangered" and "threatened" snake population could be disastrous without any aggressive mitigation; yet, a cost effective and reliable solution seems unreachable. The project will test Ocean County's commitment to the preservation of "endangered" and "threatened" species.

Figure 13. Proposed section of the Mule Road Extension



Section of the Proposed Mule Road Extension from Holiday City South to Robert Miller Airpark, Berkeley Township, Ocean County, New Jersey

DRAFT

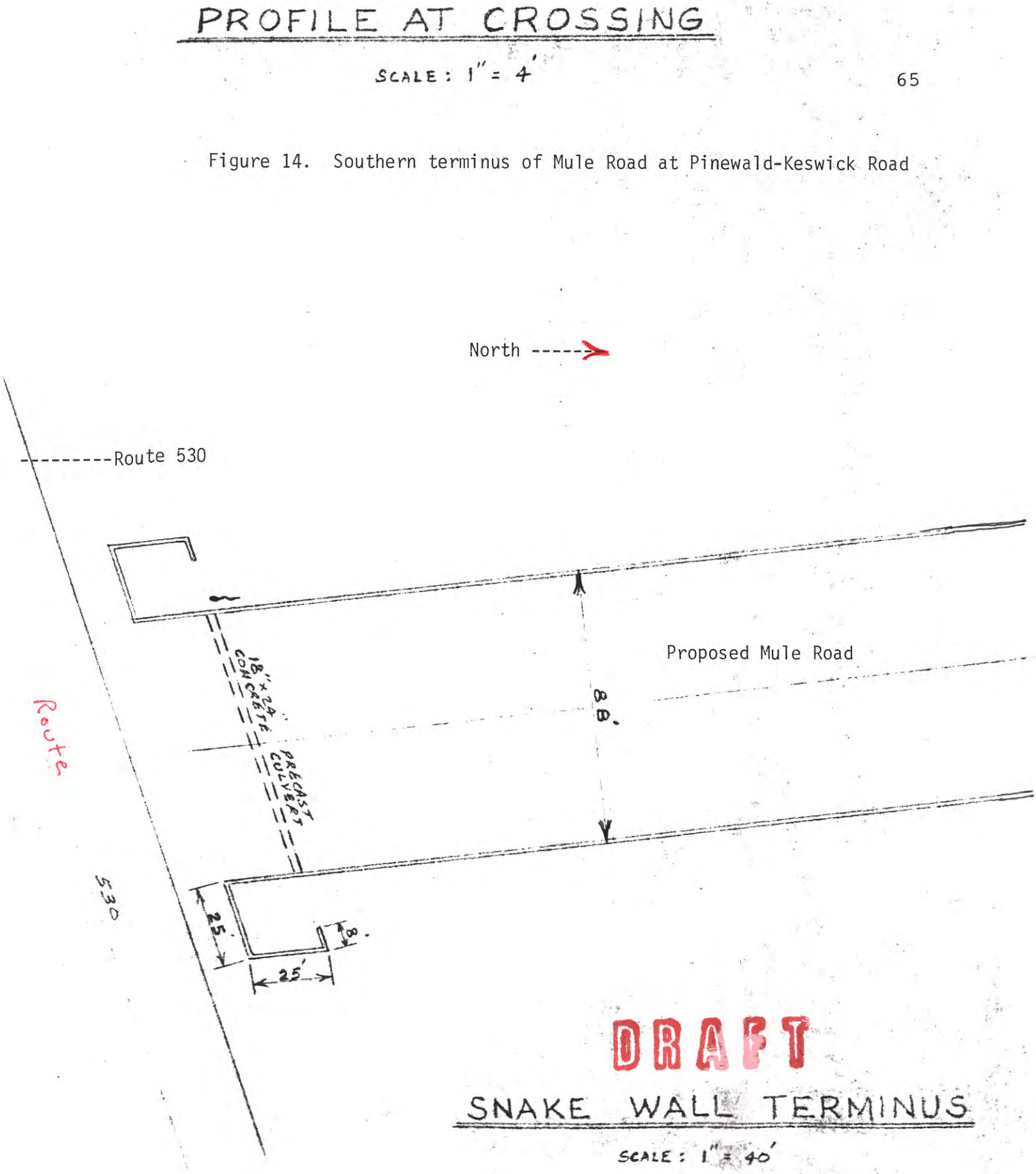
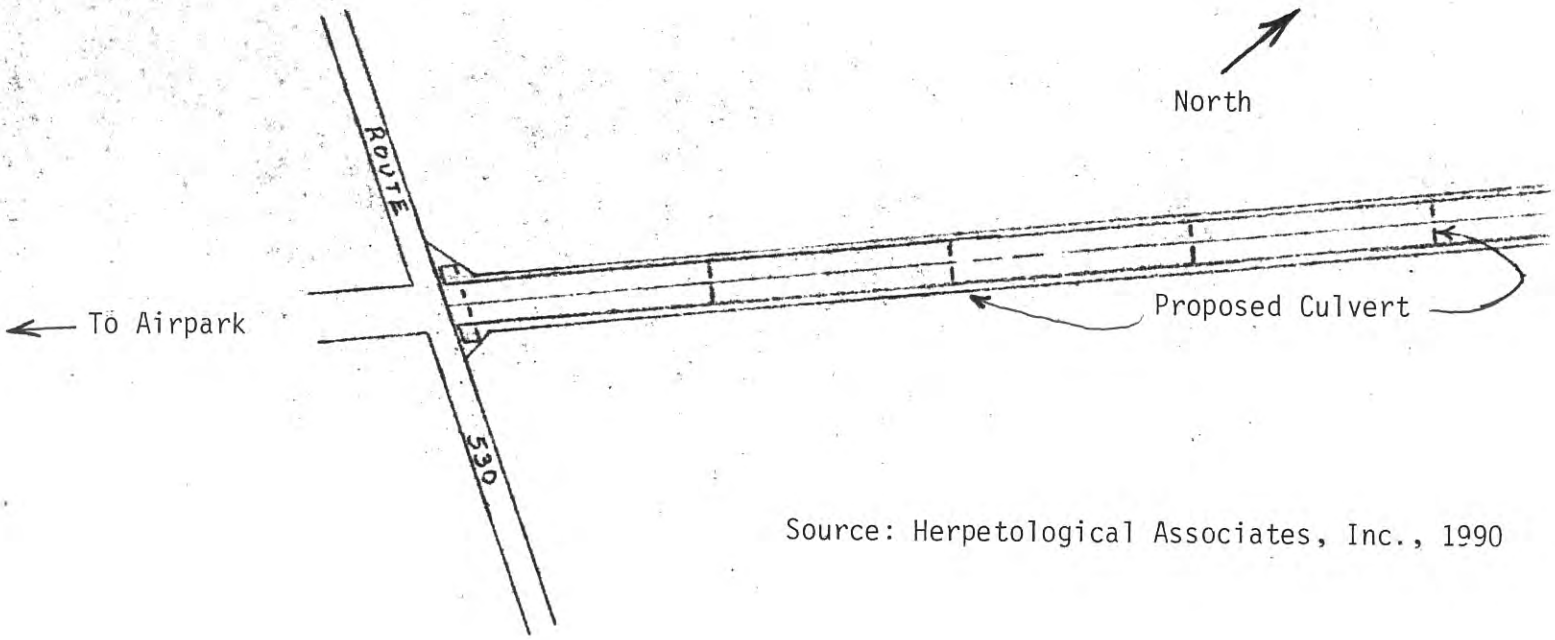


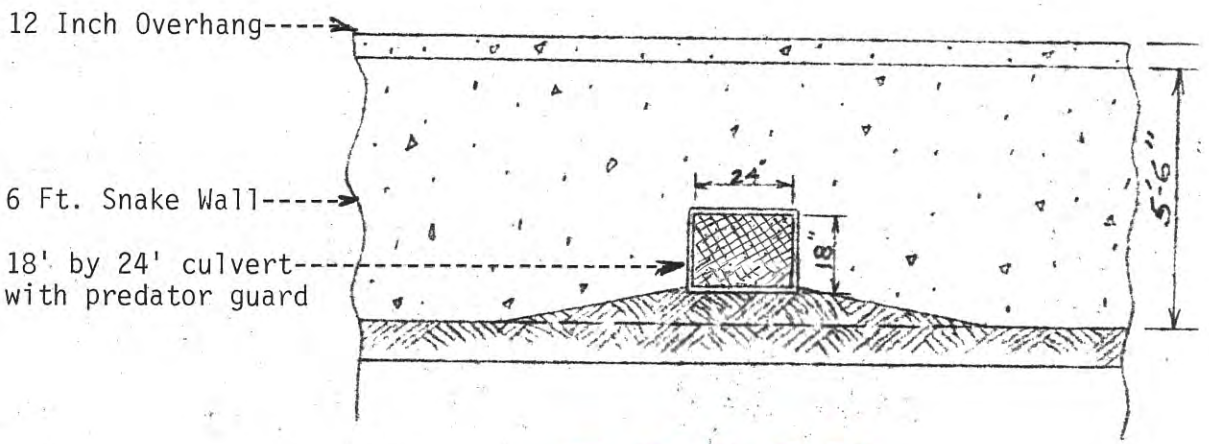
Figure 14. Southern terminus of Mule Road at Pinewald-Keswick Road

Herpetological Associates, Inc., 1990

Figure 15. Proposed Mule Road Extension with Snake Tunnel under pavement.



Source: Herpetological Associates, Inc., 1990



DRAFT

PROFILE AT CROSSING

SCALE: 1" = 4'

Figure 16. Construction Detail of Proposed Mule Road Extention

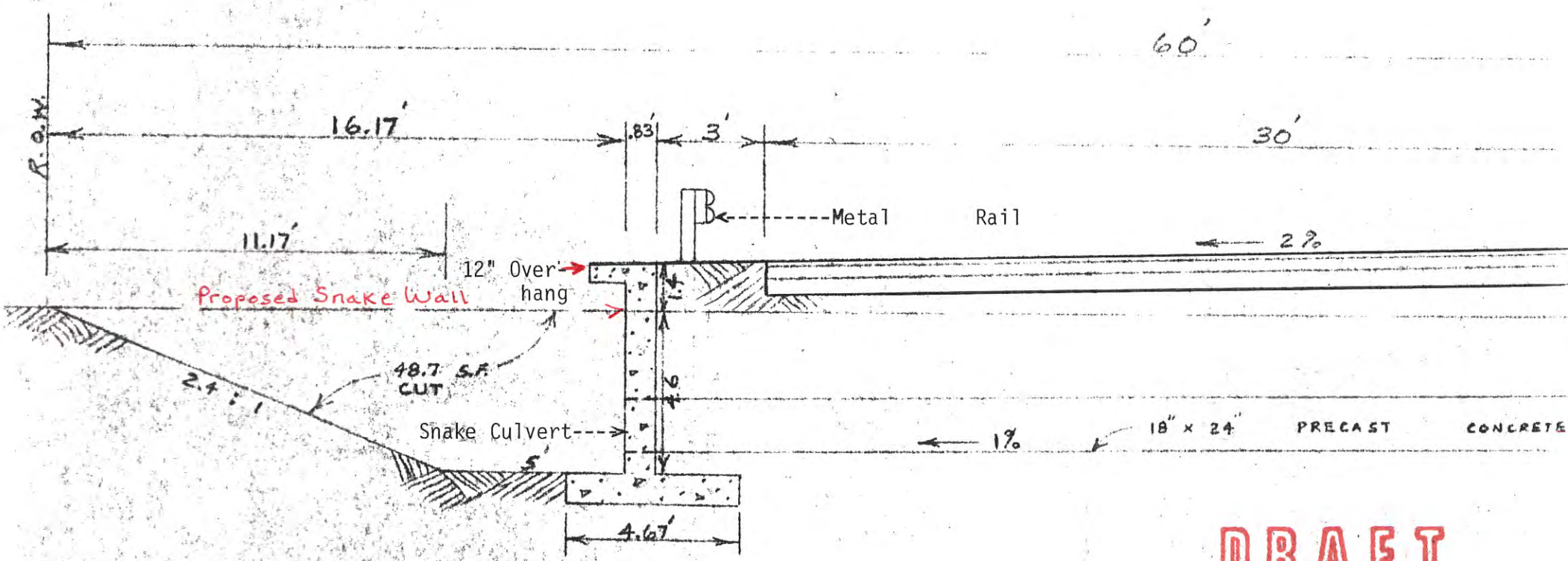


Figure 17

FREQUENCY OF OBSERVATION OF SNAKES AT MAN-MADE HIBERNACULA FROM 1987 TO 1989

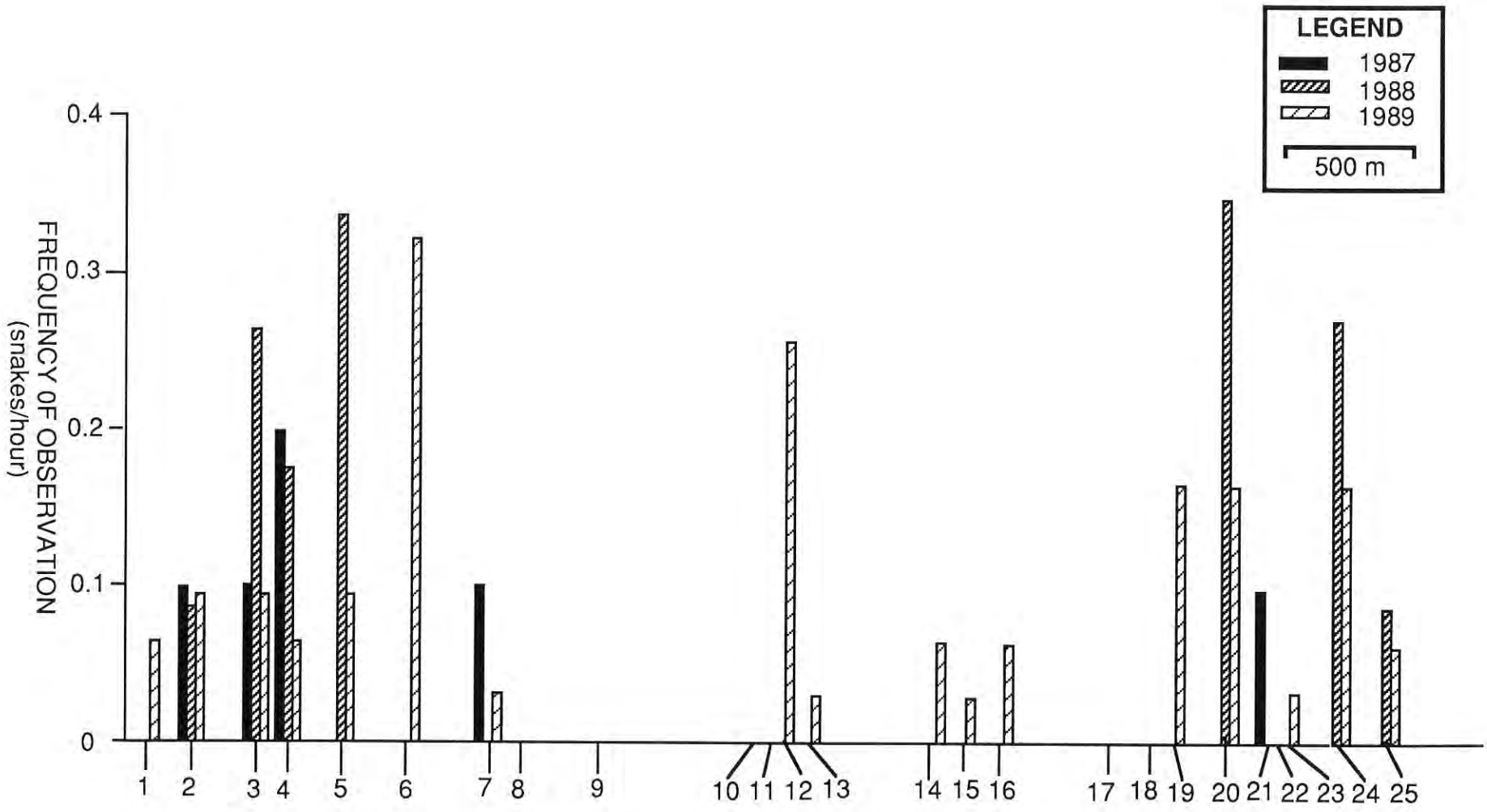


Figure 17. HIBERNACULUM NUMBER AND RELATIVE SPACING ALONG RIGHT OF WAY

Source: Herpetological Associates, Inc., Zappalorti & Reinert, 1990

Table 8

SNAKES OBSERVED PER HOUR AT MAN-MADE HIBERNACULA

YEAR	MONTH* APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV
1987	0.190	0.046	0.081	0.000	0.095	0.171	0.286	0.000
1988	0.086	0.152	0.090	0.025	0.000	0.048	0.118	0.143
1989	0.119	0.063	0.101	0.000	0.000	0.032	0.291	0.037
Mean	0.132	0.087	0.091	0.008	0.032	0.084	0.232	0.060
S.D.	0.053	0.057	0.010	0.014	0.055	0.076	0.098	0.074

*the frequency of snakes observed per hour differed significantly in different months, $F_{s(7,14)} = 3.47$, $P < 0.05$

Source: Herpetological Associates, Inc., Zappalorti & Reinert, 1990

Table 9

SNAKES OBSERVED PER HOUR AT MAN-MADE AND NATURAL HIBERNACULA

YEAR	MAN-MADE	NATURAL
1987	0.073	0.120
1988	0.069	0.069
1989	0.073	0.160
Mean	0.072	0.116
S.D.	0.0023	0.0456

*the frequency of snakes observed per hour did not differ significantly between man-made and natural hibernacula over the three years, $F_{s(1,4)} = 2.87$, $P > 0.05$

Source: Herpetological Associates, Inc., Zappalorti & Reinert, 1990

ASSESSMENT OF SECONDARY IMPACTS:

The possible approval of the proposed Mule Road extension by the Pinelands Commission and Division of Fish, Game and Wildlife (NJDEP) will be based upon an evaluation of the potential negative impacts to the corn and pine snake populations known to occur in the "Berkeley Triangle". In order to make a thorough and sound evaluation of the project, long-term secondary adverse impacts should also be addressed.

The existing section of Mule Road south of Route 530 (adjacent to the Ocean County Airpark) is already paved. The asphalt paving extends south to the Lacey Township line, but continues as a sand road, southward all the way to Lacey Road; it then crosses Lacey Road and continues southward through Greenwood Forest Wildlife Management Area (NJDEP - owner) all the way to Route 539, just north of Webb's Mill. Because of the presence of the only known timber rattlesnake (Crotalus horridus) population in Ocean County, this section of Greenwood Forest Wildlife Management Area should be considered "Critical and Endangered Species Habitat". Future plans may include paving Mule Road further south through the Lacey Township section - all the way to Lacey Road. HA is strongly opposed to this action because of the long-term adverse impacts it would cause. The pine-oak forest in this area is currently undeveloped land and is habitat for the northern pine snake and corn snake. However, no corn snakes have been captured or observed south of Lacey Road (in Greenwood Forest) prior to 1965 (Zappalorti and Johnson, 1982-A). Yet suitable habitat is present and the species may still occur in Greenwood Forest Wildlife Management Area.

The paving of Mule Road southward into Lacey Township would increase its use by automobiles by 90%. The same adverse impacts suggested for the current Mule Road extension in Berkeley Township would also affect wildlife in Lacey Township. We strongly recommend that Mule Road should not be paved south of the Berkeley/Lacey Township lines. The adverse effects of traffic on Mule and Good Luck roads on rattlesnakes and other local ophidians inhabiting the Greenwood Forest Wildlife Management Area was previously evaluated (Zappalorti and Reinert, 1984). The following is an excerpt from this report:

"RECOMMENDATIONS FOR PROTECTION OF
THE OCEAN COUNTY POPULATIONS OF SNAKES:

The corn snake, pine snake and timber rattlesnake are on the decline in Ocean County, New Jersey. This is due to one or more of following reasons:

1. The encroachment of mankind on critical breeding and foraging habitat (e.g.: Ocean County is the fastest growing county in New Jersey).

2. The general prejudice that some people have is: "The only good snake - is a dead snake".

3. Increased automobile, ATV's, and motorcycle traffic on local paved and sand roads throughout Manchester, Berkeley and Lacey Townships (Figures 18 and 19).

4. Illegal collecting by animal dealers, amateur hobbyists and snake breeders.

HA strongly suggests that NJDEP close certain sand roads in Greenwood Forest Wildlife Management Area. This will prevent wildlife in general, and C. horridus in particular from being killed on the sand roads. HA has documented the fact that as many as 94 C. horridus were killed while attempting to cross the paved and sand roads in Berkeley and Lacey Townships (Table 10). A number of other species were also found dead on the roads between 1982 and 1990 such as: 8 northern pine snakes, 4 corn snakes, 10 black racers, 2 king snakes, 3 coastal plain milk snakes, 8 eastern hognose snakes, 5 garter snakes, and 3 northern water snakes. If certain sand roads were closed off in Greenwood Forest Wildlife Management Area, and the proposed Mule Road extension in Berkeley Township is elevated, the number of snakes and other wildlife killed by traffic would be reduced. The following sand roads should be closed:

1. Mule Road between Lacey Road and Webb's Mill Road.

2. Good Luck Road between Dover Road and the Lacey and Manchester Township lines.

3. All unnamed sand roads within the known rattlesnake area in Greenwood Forest.

The closing of these roads will not cause any major hardship to people seeking to reach Route 539 and/or Lacey Road, since there are existing roads nearby that will accommodate local traffic and are in better condition (paved or hardpacked gravel) than Mule Road or Good Luck Road. The suggested alternative routes are as follows:

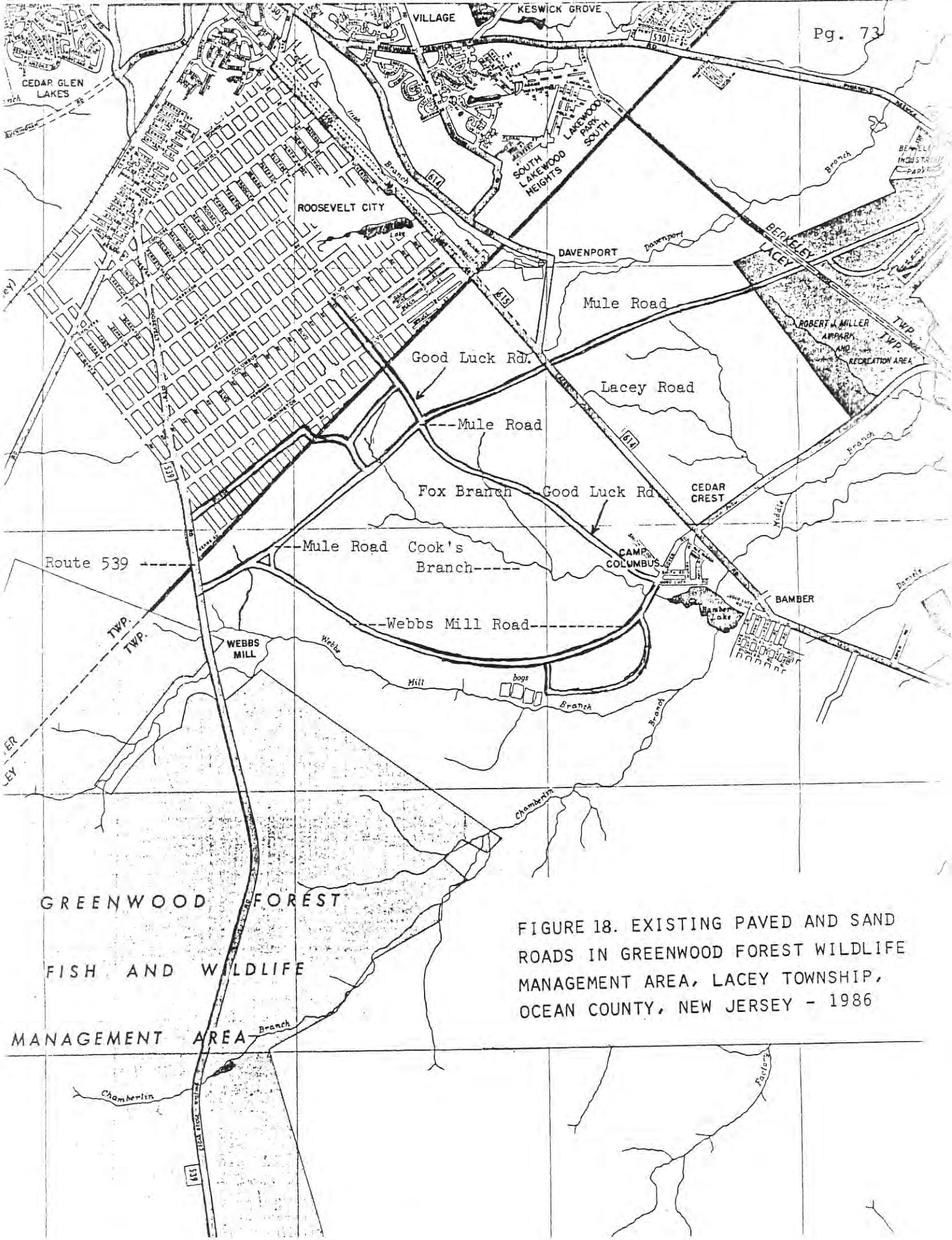


FIGURE 18. EXISTING PAVED AND SAND ROADS IN GREENWOOD FOREST WILDLIFE MANAGEMENT AREA, LACEY TOWNSHIP, OCEAN COUNTY, NEW JERSEY - 1986

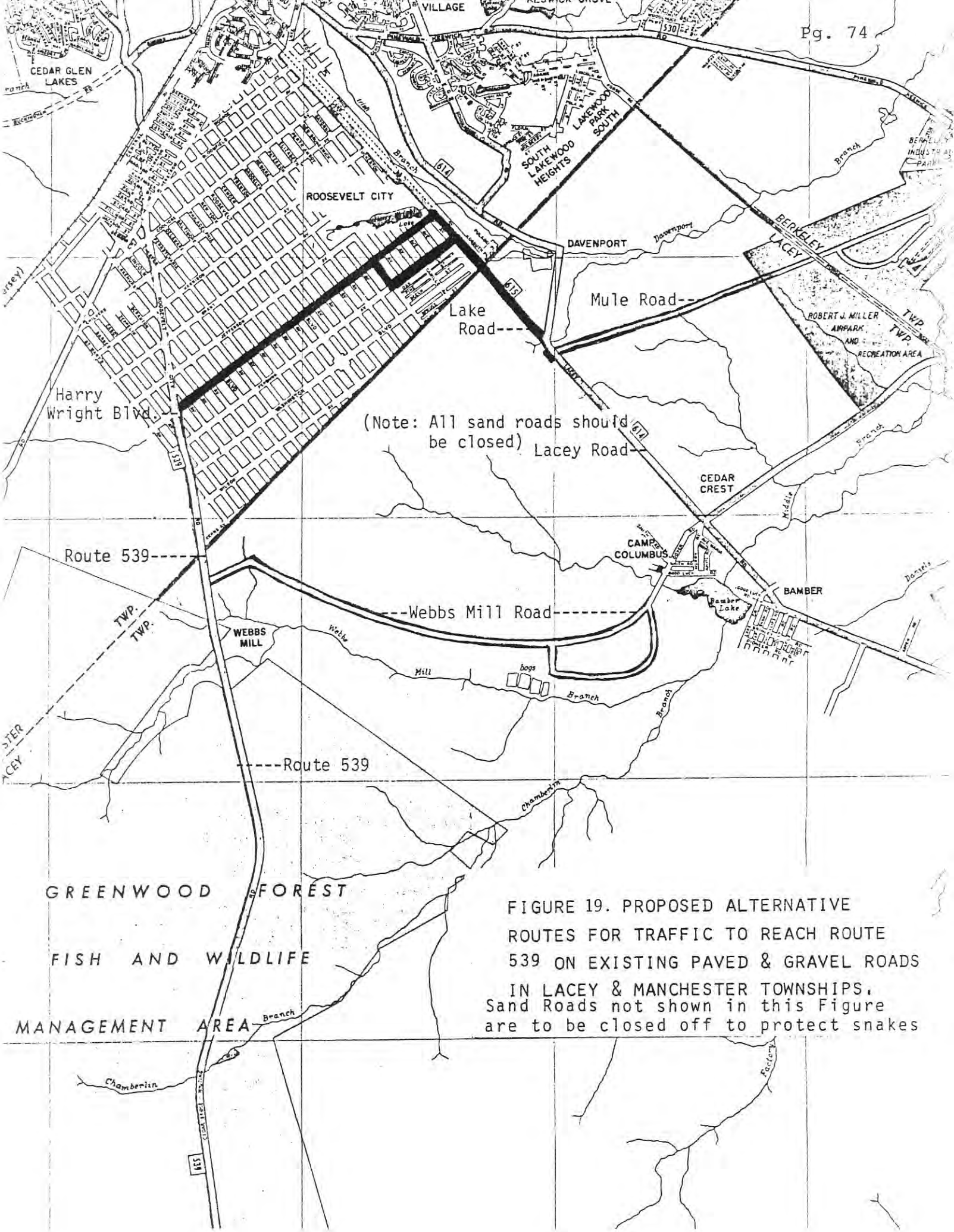


FIGURE 19. PROPOSED ALTERNATIVE ROUTES FOR TRAFFIC TO REACH ROUTE 539 ON EXISTING PAVED & GRAVEL ROADS IN LACEY & MANCHESTER TOWNSHIPS. Sand Roads not shown in this Figure are to be closed off to protect snakes

Traveling east to Lacey Road from Route 539 - take Harry Write Boulevard to Elizabeth Avenue (turn right), go one block to Pershing Avenue (turn left) and proceed to Lake Road which will connect with Lacey Road (at the junction of Mule Road). This route can be reversed to reach Route 539 from Lacey Road.

Traveling west on Dover Road to reach Route 539 - continue on Dover Road to Webb's Mill Road. This will junction with Mule Road and connect with Route 539. In order to reach Lacey Road and/or Dover Road from Route 539, the above route is easily reversed.

"TABLE 10 - RATTLESNAKES KILLED ON VARIOUS ROADS BY VEHICULAR TRAFFIC BETWEEN 1981-1989

LEGEND - M = Male, F = Female; Fg = Gravid Female; ? = Sex Unknown

YEAR	ROUTE 539	LACEY ROAD	MULE ROAD	LUCK ROAD	TOTALS
1981	0	0	2 (M:F)	1 (Fg)	3
1982	1 (?)	0	0	1 (?)	2
1983	0	1 (F)	0	1 (F)	2
1984	0	0	1 (F)	1 (Fg)	2
1985	0	0	2 (M:F)	1 (F)	3
1986	1 (F)	0	1 (M)	1 (Fg)	3
1987	0	0	1 (Fg)	2 (M:Fg)	3
1988	0	1 (?)	1 (Fg)	1 (F)	3
1989	1 (F)	0	1 (F)	1 (Fg)	3
TOTALS:					
9 YEARS =	3	2	9	10	24

Source: Herpetological Associates, Inc., 1990

The number of C. horridus cited above are the ones we have seen ourselves, or were reported by reliable sources. There may have been others about which we did not learn. Many of our radio-tracked snakes also crossed these roads during this investigation, but were not hit by motor vehicles. Of the 18 rattlesnakes killed, 5 were gravid females. Based on information gathered during HA's 10 year study, female timber rattlesnakes give birth biannually and have an average brood of 10 young (range 4-21). If each of the females was carrying an average of 10 young, the death rate from road-killed rattlesnakes over the nine year period could be estimated at 94 (24 adults and 70 young). This is strong justification for closing the sand roads within the activity range boundaries of the Greenwood Forest population. An alternative to closing roads would be to clear-cut two fields between the stream where the hibernacula are and the sand roads where the females bask. The gravid females may use the proposed fields for basking and not the edges of the roads. (See Figures 23 through 30).

Since the land in which Mule Road and Good Luck Road passes through is owned by NJDEP, the closing of these sand roads may be possible. The long term adverse impacts caused by increased vehicular traffic may eventually cause the loss of C. horridus in Ocean County. Our research has shown the gravid females congregate along the edges of Mule Road and Good Luck Road to maximize sun exposure. Many of the radio tracked males and non-gravid females also crossed the sand roads several times during each season and expose themselves to the danger of accidental contact with motor vehicles. The benefits that the timber rattlesnake population in Ocean County will receive by closing off a few sand roads, far outweighs any slight inconveniences that people may have. Timber rattlesnakes, along with the corn snake, are truly "endangered" serpents in the State of New Jersey. Protection of these snakes, along with their critical habitat will ensure their survival for years to come. Aside from this, preserving New Jersey's natural wildlife needs no special reason or excuse."

ASSESSMENT OF SECONDARY IMPACTS OF THE PROPOSED ELEVATED ROADWAY:

In the past staff biologists of the Division of Fish, Game and Wildlife (NJDEP) have raised some valid questions about culverts (tunnels) under roads to safely channel snakes from one side - to the other. HA has considered all potential negative impacts of the proposed elevated roadway and presents the following additional information:

1. THE USE OF TUNNELS BY SNAKES:

Some concern was raised about the possibility that snakes will not use the tunnels. HA would not recommend something to mitigate the serious negative impacts of the proposed Mule Road extension, if we were not absolutely sure it will work. Our judgment is based upon long-term observations of snake movements in the Davenport Basin and their use of man-made dens/ hibernacula. When the snake dens were originally designed, skeptics in the NJDEP staff were doubtful that snakes would use these structures.

It was suggested that they would not crawl into the entrance pipes since they were not "natural material" and were dark inside. If one considers the fact that snakes generally crawl into dark places in order to remain hidden from predators, it stands to reason they will crawl into a pipe or a tunnel. Tables 8 and 9 and Figure 17 substantiate the use of man-made dens by pine and corn snakes.

Our preliminary design for the elevated Mule Road calls for precast concrete pipes that measure 18 by 24 inches. The large size was suggested in order to provide access for monitoring and maintenance purposes. The bottom of the culvert will be covered with 5 to 10 inches of Pine Barrens sand, pine needles, and other natural litter, to provide a natural substrate. The culvert will have some daylight shining in the tunnel (from the other side of the road). We hypothesize that if a snake is crawling east foraging or searching for food, it will come in contact with the snake wall (elevated roadway). It will then have to crawl north or south along the base of the wall and eventually find one of the tunnels which are ca. 500 feet apart. At that point, it has a choice to continue crawling eastward, or along the wall. Snakes have a strong fidelity to their home range (Zappalorti and Johnson, 1982-B; and Reinert and Zappalorti, 1988) and/or their nesting areas (Burger and Zappalorti, 1986; and in press, 1990) and will endeavor to find and use available familiar habitat within their activity range. HA is convinced the snakes will use the tunnels to get to known foraging or nesting habitat.

2. POTENTIAL INCREASE IN PREDATION:

A concern was raised about the possibility of predators such as foxes, skunks, raccoons, and feral cats which may be able to attack snakes as they crawl along the wall. This can be remedied by providing log and brush piles along the edge of the wall (but not closer than two feet so the snakes cannot use it to climb over the wall). The brush piles should be spaced 100 feet apart for the entire length of the road/wall. They will provide a safe retreat for the snakes and other small wildlife as they migrate or forage within the eastern Davenport Basin. Monitoring of the tunnel walls, and brush piles during its first year of operation by a qualified herpetologist, will help to make judgments if additional brush piles are needed. An additional safety measure to protect the snakes would be to place heavy-duty wire screens (with 1.5 inch square holes) over each tunnel entrance. The covers would allow plenty of light and fresh air into the tunnel, yet prevent mammalian predators from using the tunnels and/or attacking the snakes while inside the tunnels.

3. LONG-TERM MAINTENANCE:

HA suggests that our design for the elevated roadway (Figures 13 through 16) will be structurally sound, long-lasting, permanent and almost maintenance free. The durability and strength of a concrete structure will not require constant repair. The wall would also be fire and termite proof. Given the high probability of forest fires in the Davenport Basin, wood or aluminum would be a poor choice.

VI. Mitigation and Recommendations

MITIGATION AND RECOMMENDATIONS

As cited above, there are sections along the right-of-way that are "critical wildlife habitat". There are winter dens and nesting areas for breeding and egg laying (Figures 8, 9 and 10) located on the right-of-way. Construction of the proposed Mule Road will cause direct short-term adverse impacts. Adult female pine snakes and corn snakes migrating from the pine-oak forest to the nesting and breeding area will be killed by cars unless the road is elevated. In order to prevent adverse impacts to the "endangered" snakes, HA suggests the following mitigation procedures:

1. If possible, construction should take place between April 1st and October 29th, the time when the snakes are active and able to move away from the temporary disturbance.

2. Two nylon silt fences should be erected along both sides of the right-of-way near the nesting and breeding areas. The silt fence should be at least 175 feet long and will act as a visual barrier to keep construction equipment/ trucks away from this sensitive upland habitat. The silt fences should be at least three feet high and be buried in a shallow trench 8-10 inches deep to keep snakes and other small wildlife from getting under it and out of "harms way" during road construction.

3. Absolutely no oil/diesel fuel should be pumped in the vicinity of the pine snake nesting area or the intermittent stream corridor near the Pine Barrens treefrog breeding ponds. If any diesel fuel or oil is spilt during maintenance of construction equipment, it must be immediately cleaned up. The contractor must take extra precautions when working near sensitive upland or wetland areas.

4. Prior to construction, a qualified herpetologist should field mark the confirmed natural snake dens and nesting habitat with surveyor's flagging tape. The contractor will then know the area where a nylon silt fence should be constructed in order to separate the sensitive snake habitat from the construction areas. A qualified herpetologist should be present to monitor and supervise construction activity in all the "endangered species habitat" along the right-of-way.

5. Prior to right-of-way preparation and clearing, a team of qualified herpetologists (2-4 persons) should conduct an intensive collection and removal program of all small wildlife in the area illustrated in Figures 8 and 9. All reptiles, amphibians and small mammals will be captured by hand, net or trapped and removed off the right-of-way to suitable nearby habitats. The collection program should begin about 8-15 days prior to actual tree and brush clearing or construction and should be carried out for a minimum of six eight-hour days in order to remove as many animals as possible, especially pine and corn snakes.

6. A qualified herpetologist should be present on a daily basis during actual construction to monitor wildlife encounters along the right-of-way. If box turtles, corn snakes, pine snakes or small mammals are found on the right-of-way, they can be captured and removed to a safe location away from the construction area. This person should be present during construction in all "endangered species habitats" identified during this study.

7. If the elevated roadway is approved, log or brush piles should be built along the trench, near the base of the six foot concrete wall, in order to provide a safe retreat for snakes as they crawl along the edge of the roadway wall in search of a culvert or tunnel. These brush piles will help to prevent mammalian predators such as fox, skunk and raccoons from attacking and eating small snakes. They should be placed about every 100 feet apart, since the proposed culverts will be about 500 feet from one another (Figure 13).

8. If an elevated roadway is approved by the Pinelands Commission, bi-monthly site inspections (four hour blocks of time) should be made of the two bridge culverts and snake tunnels by a qualified herpetologist. On-going monitoring should also be carried out in order to check the brush piles, the screen covers over the snake tunnels, and snakes' activity along the Mule Road right-of-way for the next several years. Monitoring is important in case problems arise with vandalism, dumping or predators so it can be corrected.

9. A natural corn snake winter hibernaculum has been identified on Alignment B (Figure 10). This den will be lost as a result of the construction of the Mule Road extension. As mitigation for this loss of the natural den, HA suggests building a man-made den (following our design Figure 20) away from the construction area, but in the same general vicinity of it. It should be noted that Alignment A was rejected by HA because it came too close to the "Davenport natural den" - No. 1 which is a major hibernaculum for pine snakes, corn snakes and black racers. It also crossed the critical nesting habitat so we recommended the switch to Alignment B. If we weigh the differences in adverse impacts on the overall snake population - Alignment B is the route that would cause the minimum impacts even though the newly discovered corn snake den will be lost.

Figure 20. Man-made Concrete Block Snake Den/Hibernaculum

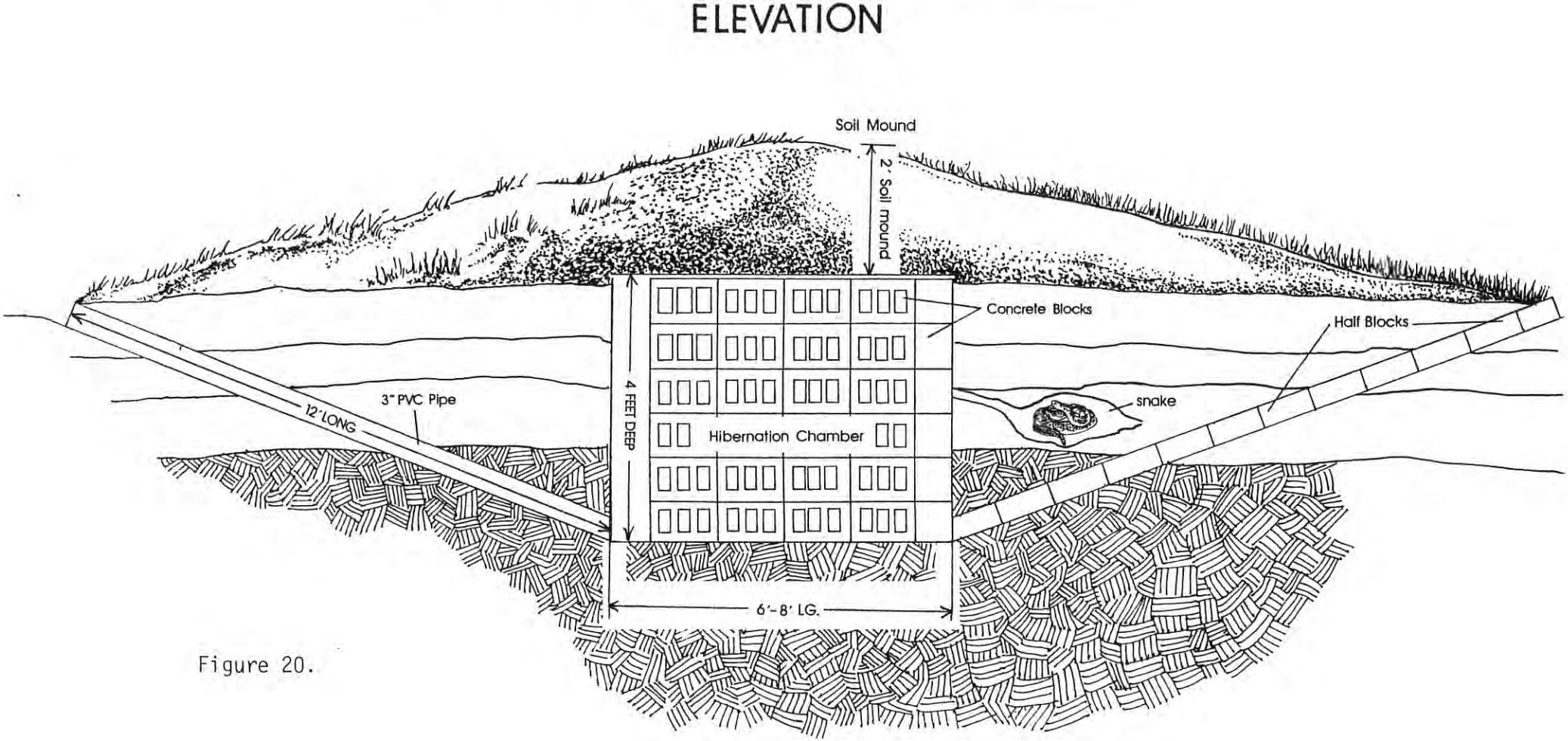


Figure 20.

Source: Herpetological Associates, Inc., 1990

Figure 21. Top View of Hibernaculum Roof Made of Wolminized Plywood

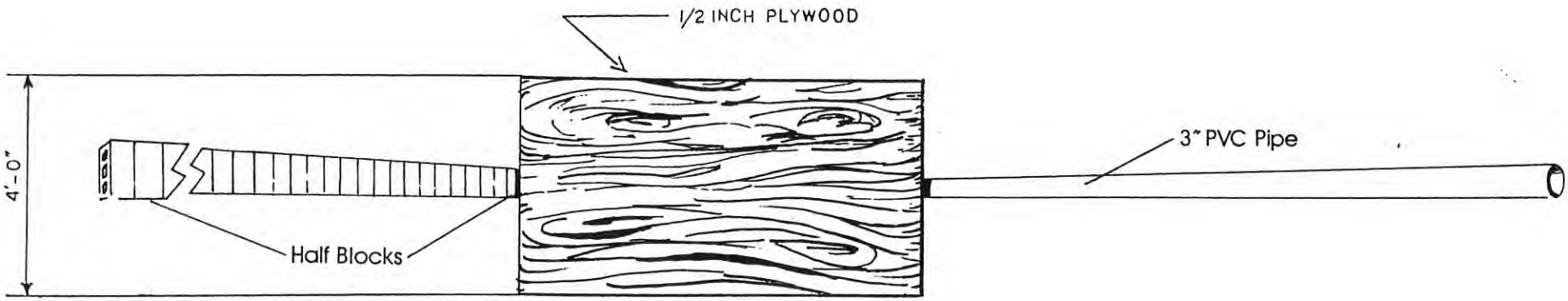
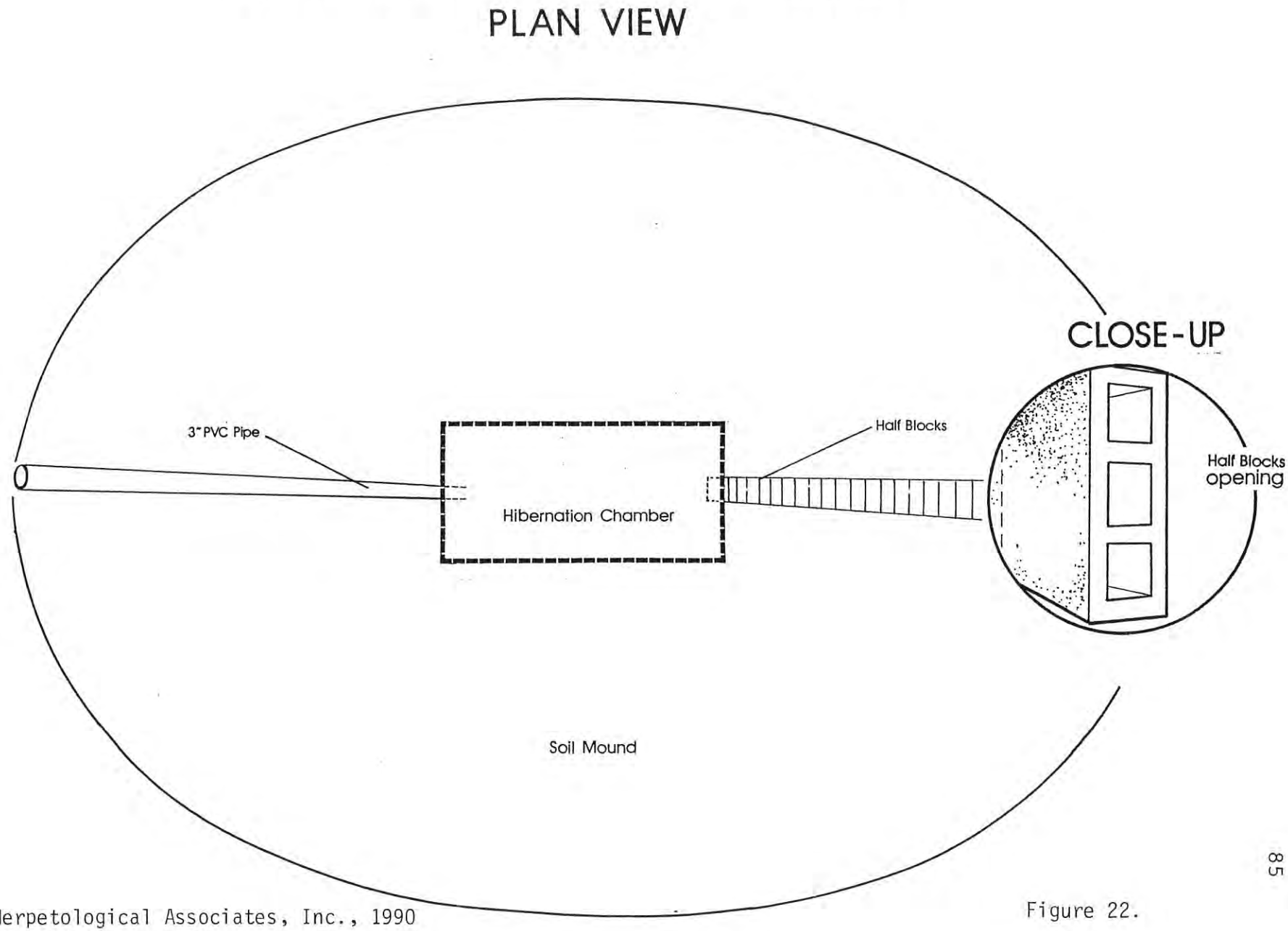


Figure 21.

PLAN BELOW SOIL MOUND

Source: Herpetological Associates, Inc., 1990

Figure 22. Top View of Hibernaculum Chamber and Entrances



Source: Herpetological Associates, Inc., 1990

Figure 22.

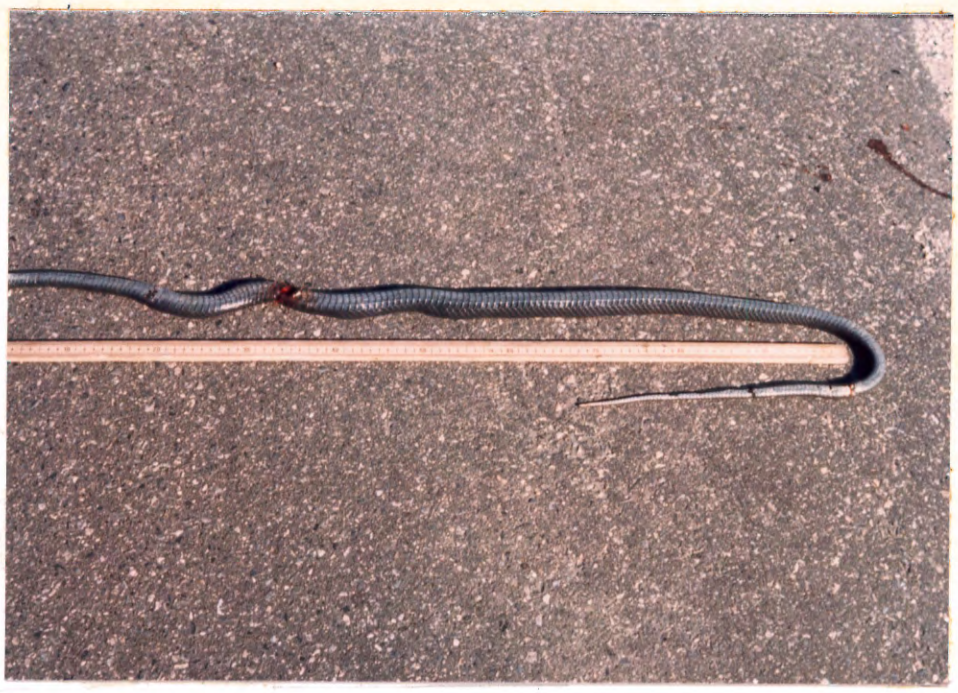


Figure 23. An adult male northern black racer found D.O.R. at the junction of Crossley Road and Route 530 in August of 1986.

Figure 24. This adult male northern water snake was killed at the junction of Davenport Branch and Route 530. Photo taken in May of 1985.

Photos by: R.T. Zappalorti, Nature's Images

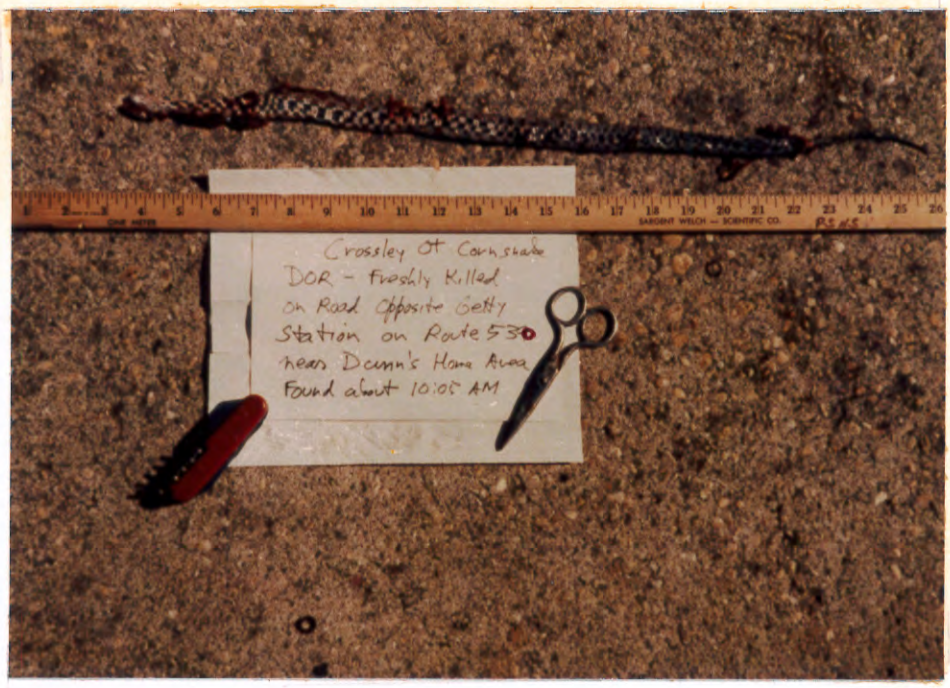


Figure 25. A road killed corn snake found near the Getty Gas Station on Route 530 (Pinewald-Keswick Rd.). The snake was found by Otto Heck (HA Staff) in June of 1985.

Figure 26. This is a young male corn snake found dead on Crossley Road (D.O.R.) in August of 1985. Increased traffic on the road by motorist is having serious adverse impacts to the wildlife.

Photos by: R.T. Zappalorti, Nature's Images

Figure 27. A hatchling northern pine snake found D.O.R. on Crossley Road, near the NJDEP Wildlife Sanctuary. Photo was taken on May 21, 1985.

Figure 28. A young female pine snake killed by a car at the junction of Route 530 and Township Line Road (Berkeley and Manchester Townships). Photo taken in July 1986.

Photos by: R.T. Zappalorti, Nature's Images

Figure 29. An adult male timber rattlesnake found D.O.R. on Mule Road in Greenwood Forest Wildlife Management Area in Lacey Township. The snake was found in June of 1986 and was purposely run over as it attemted to crawl across the sand road. Two or 3 rattlesnakes are killed on Mule and Good Luck Roads every year. During 1987, HA has found 3 dead rattlesnakes as of August 13, including one pregnant female that was carring 15 young snakes.

Photos by: R.T. Zappalorti, Nature's Images

Figure 30. A large pregnant female pine snake found D.O.R. at the junction of Township Line Road and the J.C.P.& L. Co. right-of-way in July of 1987. Two known nesting areas are nearby.

EXECUTIVE SUMMARY:

It is our opinion that the installation of the proposed elevated Mule Road extension (as suggested and design by HA and the OCED) will only cause minor, short-term, adverse impacts to some of the wildlife identified in this report and their habitat, if the above-mentioned mitigation procedures are followed. The impacts can be further reduced by the presence of a qualified herpetologist on the study corridor during all phases of construction. These adverse impacts can be minimized if the work is carried out during the snakes' active season so they can crawl out of "harms way". Some important snake habitat may be encroached upon, but these impacts can also be minimized by fencing and seasonal limitations for actual construction as cited above. It is probable that no critical breeding habitat or nesting areas for the corn snake and pine snake will be lost as a result of the construction of the proposed Mule Road extension. However, one corn snake hibernaculum will be lost since it is directly on Alignment B. This den could be replaced off the right-of-way by a man-made structure.

These suggestions for mitigation (e.g.: by collecting wildlife prior to actual construction); placing nylon silt fences along the edge of the right-of-way (to prevent animals from entering the construction area); and daily monitoring during the actual construction are subject to review and approval by the NJDEP and the Pinelands Commission. However, we would like to point out that HA conducted a similar project for the Ocean County Municipal Utilities Authority during the construction of the Crestwood Interceptor in 1986-1989. We also assisted JCP&L Company with the mitigation plan and environmental monitoring on a daily basis during the construction of the 230 kV transmission line between Whiting and Manitou Park between 1989-1990. Finally, we worked on another project in the Great Swamp National Wildlife Refuge in 1987-1988 for the Algonquin Gas Transmission Company. All these projects were reviewed and approved by the NJDEP, the Pinelands Commission and the U.S. Fish and Wildlife Service who issued "Special Use Permits" for these actions. HA has high confidence that we can assist in OCED and the Freeholders to minimize adverse impacts on wildlife in general and the "endangered" corn snakes and pine snakes in particular during the construction of the proposed Mule Road extension in Ocean County, New Jersey.

VII. References

BIBLIOGRAPHY AND GENERAL WORK REFERENCES

This list consists of publications which deal in a general manner with the amphibians and reptiles of Ocean County and the State of New Jersey and is provided for those who wish to learn more about these plants and animals of the Pine Barrens.

Ambrose, H.W. III and K.T. Ambrose — 1981. A Handbook of Biological Investigation. Hunter Publishing Company, Winston Salem, North Carolina.

Anderson, J.D — 1965. Ambystoma annulatum. Cat. American Amph. Rept., 19.1-19.2.

Anderson, J.D. — 1967. Vertical Migration and Stratification of Larval Ambystoma Copeia, No. 2, p. 371-374.

Anderson, J.D. and R.V. Giancosie — 1967. Ambystoma laterale in New Jersey. Herpetologica, Vol. 23, #2, pp. 108-111.

Anderson, J.D. — 1967-A. Ambystoma maculatum. Cat. American Amph. Rept., 51.1-51.4.

Anderson, J.D. — 1967-B. Ambystoma opacum. Cat. American Amphi. Rept., 46.1-46.2.

Anderson, J.D. — 1967-C. Ambystoma texanum. Cat. American Amph. Rept. 37.1-37.2.

Anderson, J.D. — 1976. The status of the tiger salamander, Ambystoma tigrinum, blue-spotted salamander, Ambystoma laterale, Tremblay's salamander, Ambystoma tremblayi, gray treefrogs, Hyla andersonii, and bog turtle, Clemmys muhlenbergii, in New Jersey. Special report to the Nongame and Endangered Species Project, mimeographed, pp. 67.

Anderson, J.D., J. Galandak and K. Howthorne — 1978. A report on the status of the endangered reptiles and amphibians of New Jersey. Bulletin, New Jersey Academy of Science, Vol. 23, No. 1, 26-33 pp.

Arndt, R.G. — 1977. Notes on the Natural History of the Bog Turtle, Clemmys muhlenbergii in Delaware Chesapeake Science, 18 (1) pp. 67-76.

Britton, N.L. — 1988. Catalogue of Plants Found in New Jersey. Geol. Surv., New Jersey Final Rep. State Geol. 2:27-642.

Burger, G.V. — 1973. Practical Wildlife Management. Winchester Press, New York (11).

Burger, J. and R.T. Zappalorti — 1988. Habitat Use in Free-ranging Pine Snakes (Pitouphis melanoleucus) in the New Jersey Pine Barrens. Herpetologica, 44(1) pp. 48-55.

Burger, J. R.T. Zappalorti, M. Gochfeld, I. Boarman M. Caffrey, V. Doig, S.D. Garber, B. Lauro, M. Mikovsky, C. Safina and J. Saliva — 1988. Hibernacula and Summer Den Sites of Pine Snakes (Pituophis melanoleucus) in the New Jersey Pine Barrens. Journal of Herpetology, Vol. 22, No. 4, pp. 425-433.

Brown, W.S. and F.M. MacLean — 1983. Conspecific Scent Trailing by Newborn Timber Rattlesnakes, Crotalus horridus. Herpetologica 39:430-436.

Campbell, H.W. and S.P. Christman — 1982. Field Techniques for Herpetofaunal Community Analysis. In Herpetological Communities, edited by Norman J. Scott, Jr., U.S. Dept of the Interior, Fish and Wildlife Service, Wildlife Research Report No. 13, pp. 193-200.

Clark, D.R., Jr. 1975. Branding as a Marking Technique for Amphibians and Reptiles. Copeia, No. 1, pp. 148-151.

Conant, R. 1975. A Field Guide to Reptiles and Amphibians of Eastern and Central North America. Houghton Mifflin Company, Boston, Mass.. pp. 1-149.

Dixon, K.R. 1980. Harmonic Mean Measure of Animal Activity Areas. Ecology 61:1040-1044.

Dodd, C.K., Jr. 1987. Snakes: Ecology and Evolutionary Biology, Chapter 15; edited by R. Seigel, J. Collins and S. Novak. MacMillan Pub. Co., New York, NY pp. 478-521.

Fairbrothers, D.E. and M.Y. Hough 1973. Rare or Endangered Vascular Plants of New Jersey. State Museum Science Notes No. 14.

Fairbrothers, D.E. and N. Caiazza 1980. Threatened and Endangered Vascular Plant Species of the New Jersey Pinelands and their Habitats. Report prepared for the New Jersey Pinelands Commission.

Fernald, M.L. 1950. Gray's Manual of Botany. Eighth edition, American Book Co., New York.

Forman, R.T., et al. 1979. Editor, Pine Barrens: ecosystems and Landscape. Academic Press, New York, Chapters 25, 27 and 31, pp. 443-553.

Fowler, H.W. 1907. Amphibians and Reptiles of New Jersey. Anno. Rep. NJ State Mus. 1906, pp. 23-250.

Freda, J. and Morin, P.J. 1984. Adult Home Range fo the Pine Barrens Treefrog, Hyla Andersonii, and the Physical, Chemical and Ecological Characteristics of its Preferred Breeding Ponds. Final Report prepared for the New Jersey Endangered and Nongame Species project by the Division of Pinelands Research, Center for Coastal and Environmental Studies at the State University of New Jersey, with support from the N.J. Dept. of Environmental Protection, Endangered and Nongame Species Program, and the Division of Pinelands Research.

Freda, J. and R.J. Gonzalez 1986. Daily Movements of the Treefrog, Hyla andersonii. Journal of Herpetology, Vol. 20(3) 469-471. Copyright 1986 Society for the Study of Amphibians and Reptiles.

Frier, J. and R.T. Zappalorti 1983. Reptile and Amphibian Management Techniques. Transactions of the Wildlife Society. 40:142-148.

Gibbons, J.W. and R.D. Semlitsch 1987. Activity Patterns In: Snakes: Ecology and Evolutionary Biology. Siegel, R.A., J.T. Collins, and S.S. Novak, MacMillan Publishing Co., NY, NY. p. 415.

Goin, C.J. and O.B. Goin 1971. Introduction to Herpetology, Second Edition W.H. Freeman and Co., San Francisco, California, p. 1-337.

Gregory, P.T. 1983. Identification of Sex and Small Snakes in the Field. Herp. Review 14:(2)42-43.

Gregory, P.T., McCartney, J.M. and K.W. Larsen 1987. Spatial Patterns and Movements. In: Snakes: Ecology and Evolutionary Biology. Siegel, R.A., J.T. Collins and S.S. Novak. MacMillan Publishing Co., NY, NY. pp. 380.

Graves, B.M., D. Duvall, M. B. King, S.L. Lindstedt, and W.A. Gern

1986. Initial Den Location by Neonatal Prairie Rattlesnakes; Functions Causes and Natural History in Chemical Ecology, pp. 285-304, Chemical Signal Invertibrates, No. 4; Ecology, Evolution and Comparative Biology, D. Duvall, D. Muller-Schwarze and R.M. Silverstein (Editors). Plenum Press, NY, NY.

Hastings, R.W, E.W. Stiles, and T. Uzzell

1982. A Critique of Reports by Herpetological Associates and the Ocean County Planning Board on Two Threatened Snake Species in Berkeley Township, Ocean County. Unpublished Report submitted to the N.J. Pinelands Commission by the Division of Pinelands Research Center for Coastal and Environmental Studies, Rutgers, the State University of New Jersey, Doolittle Hall - Busch Campus, New Brunswick, NJ 08903.

Hough, M.Y.

1963. New Jersey Wild Plants. Harmony Press, Harmony.

Hulmes, D., P. Hulmes, and R.T. Zappalorti

1981. Notes on the Ecology of the Pine Barrens Treefrog in New Jersey. Bulletin of the New York Herpetological Soc., 17:1-19.

Jennrich, R.I. and F.B. Turner

1969. Measurement of Non-circular Home Range. Journal of Theoretical Biology 22:227-237.

Jones, K.B.

1986. Amphibians and Reptiles In: Inventory and Monitoring of Wildlife Habitat. Cooperrider, A.Y., R.J. Boyd, and H.R. Stuart, eds. U.S. Dept. Interior, Bur. Land Management Service Ctr., Denver, CO p. 274-277.

Karns, D.R. 1986. Field Herpetology Methods for the Study of Amphibians and Reptiles in Minnesota. Published in Cooperation with the Nongame Wildlife Program of the Minnesota Dept. of Nat'l Resources. James Ford Bell Mus. of Nat'l. History, University of Minn., Occasional paper No. 18, 17 Sept.

Kartesz, J.T. and R. Kartesz 1980. A Synonymized Checklist of the Vascular Flora of the United States, Canada, and Greenland. The University of North Carolina Press, Chapel Hill, p. 498.

Kauffeld, C.F. 1957. Snakes and Snake Hunting. Hanover House, Garden City, NY, p. 36-55.

Kauffeld, C.F. 1969. Snakes: The Keeper and the Kept. Doubleday & Co., Garden City, NY, p. 168.

Langton, T. 1984. Toads on Roads. Published by Fauna and Flora Preservation Soc., Inc., P.O. Box 1108, Boston, MA 02130.

McCormick, J. 1970. The Pine Barrens: A Preliminary Ecological Inventory, NJ State Mus., Res. Rep., No. 2, Trenton, New Jersey.

McCormick, J. and L. Jones 1973. The Pine Barrens Vegetation Geography, New Jersey State Mus., Research Rept. No. 3, p. 53.

Means, D.B.and C.J. Longden 1976. Aspects of the Biology and Zoogeography of the Pine Barrens Treefrog, Hyla andersonii, in Northern Florida. Herp. 32:117-130.

Means, D.B. and P.A. Moler — 1979. The Pine Barrens Treefrog: Fire, Seepage Bogs, and Management Implications. In (R.R. Odum, ed.) Proc. of the Rare and Endangered Wildlife Symposium, GA Dept. Nat. Res. Game and Fish Div. Tech. Bull. WL-4

New Jersey Dept. of Environmental Protection, Div. of Fish, Game and Wildlife and U.S.D.A. Soil Conservation Service — 1980. Endangered and Threatened Species of New Jersey. Special Publication of the Endangered Species Program. pp. 44.

New Jersey Dept. of Environmental Protection, Div. of Coastal Resources — 1986. Rules on Coastal Resources and Development (NJAC 7:7E-1.1 et. seq.) Trenton.

New Jersey Pinelands Commission — 1980. Comprehensive Management Plan. New Lisbon.

Noble, G.K. and R.C. Noble — 1923. The Anderson Treefrog, Hyla andersonii, Baird, Observations on Its Habitat and Life History. Zoologica II (18):416-455.

Quinn, H. and J.P. Jones — 1974. Squeeze Box Technique for Measuring Snakes. Herp. Rev. 5:32.

Parker, W.S. and M.V. Plummer — 1987. Snakes: Ecology and Evolutionary Biology. Chap. 9; Edited by R. Seigel, J. Collins and S. Novak, MacMillan Pub. Co., NY, NY, pp. 253-301.

Reinert, H.K. and D. Cundall — 1982. An Improved Surgical Implantation Method for Radio-Tracking Snakes. Copeia 1982:702-705.

Reinert, H.K. and R.T. Zappalorti — 1988-A. Rimber Rattlesnakes Crotalus horridus of the Pine Barrens: Their Movement Patterns and Habitat Preference. Copeia 1988:964-978.

Reinert, H.K. and R.T. Zappalorti — 1988-B. Field Observation of the Association of Adult and Neonatal Timber Rattlesnakes, Crotalus horridus, with Possible Evidence for Conspecific Trailing. Copeia 1988:1057-1059.

Reynolds, R.P. and N.J. Scott, Jr. — 1982. Use of a Mammalian Resource for a Chihuahuan Snake Community. In: Herpetological Communities, edited by N.J. Scott, Jr., U.S. Dept. of the Interior, Fish and Wildlife Service, Wildlife Research Rept., No. 13, pp. 99-118.

Rodda, G.H. — 1990. Highway Madness Revisited: Road-killed Iguana iguana in the Llanos of Vennezuela. Journal of Herpetology, 24(2):209-211.

Schaefer, W.H. — 1934. Diagnosis of Sex in Snakes. Copeia 1934:181.

Snyder, D.B. and V.E. Vivian — 1981. Rare and Endangered Vascular Plants in New Jersey. Conservation and Environmental Studies Center.

Stone, W. — 1911. The Plants of Southern New Jersey, with Especial Reference to the Flora of the Pine Barrens. Ann. Rep. New Jersey State Mus., 1910, Part II:21-828.

Tiedemann, J.A. — 1983. The Occurrence of the Pine Barrens Treefrog, Hyla andersonii, in Berkeley Township, Ocean County, NJ. Bulletin, NJ Acad. Sci., Vol. 28, No. 2, pp. 67-70, Fall.

Tiner, R.W., Jr. — 1985. Wetlands of New Jersey. U.S. Fish and Wildlife Ser., Natural Wetlands Inventory, Newton Corner, MA p. 76.

Uzzell, T.M., Jr. — 1964. Relations of the Diploid and Triploid Species of the Ambystoma jeffersonianum Complex (Amphibia, Caudata) Copeia #2, pp. 257-300.

Zappalorti, R.T. 1979. A Commentary on JCP&L Co.'s Application for Permit to Construct, Install or Alter Apparatus or Equipment and Request for Variance to NJAC 7:27-6.5, Unpublished Report Submitted to the Ocean County Planning Board. HA File No. 79.01:1-39.

Zappalorti, R.T. and E.W. Johnson 1982-A. Additional Updated Locality and Distribution Records of Endangered and Threatened Amphibians and Reptiles in New Jersey (Fifth Supplement). Unpublished report submitted to the NJDEP, HA File No. 82.08. pp. 1-138.

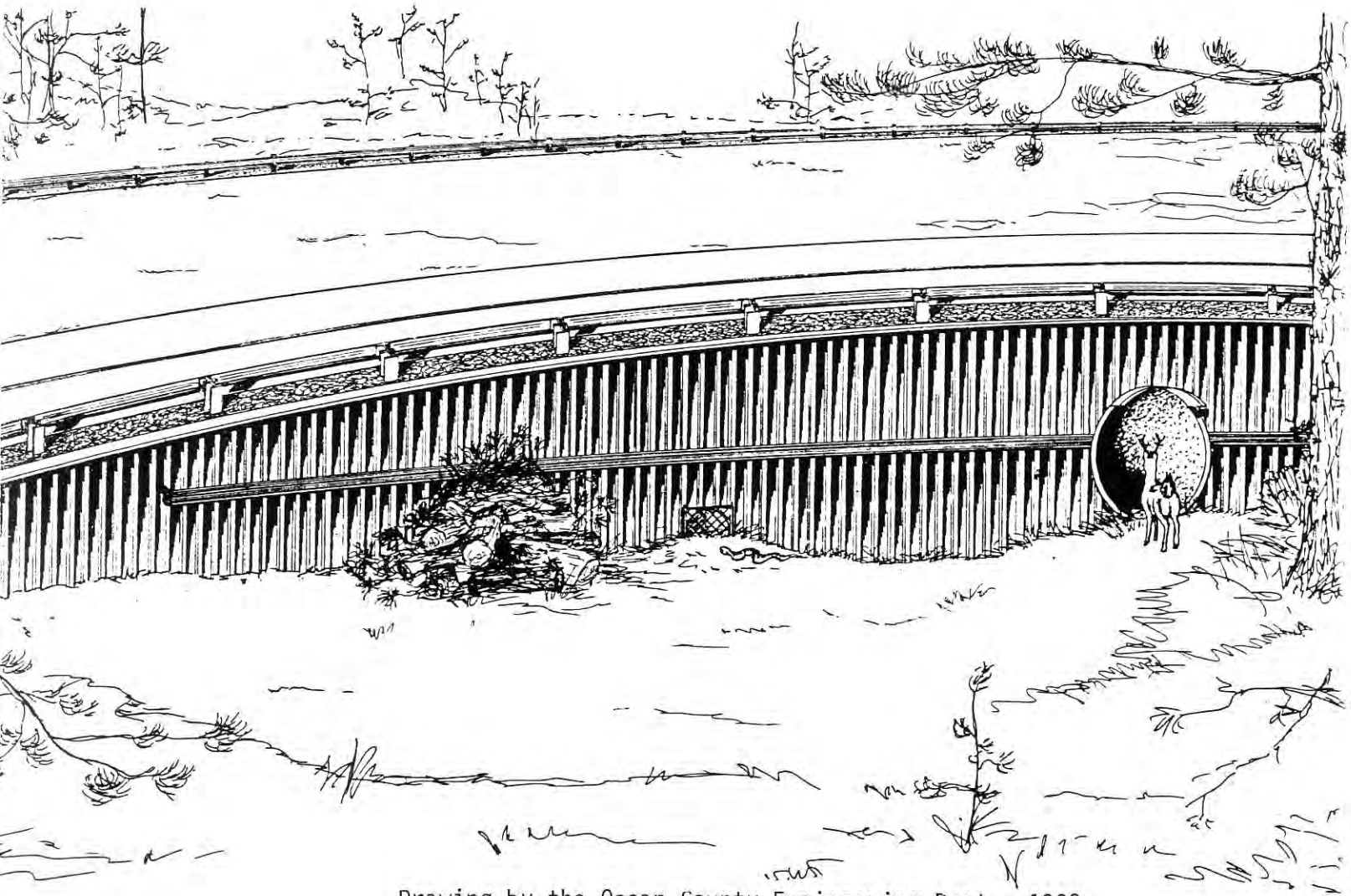
Zappalorti, R.T. and E.W. Johnson 1982-B. Critical Habitat Requirements of Two Threatened Species in the Davenport Basin, Ocean County, New Jersey. Unpublished Report Submitted to the Ocean County Planning Board, 82.04:1-22.

Zappalorti, R.T. and J. Burger 1985. On the Importance of Disturbed Sites to Habitat Selection by Pine Snakes in the Pine Barrens of New Jersey, Environmental Conservation, 12(4):358-361.

Zappalorti, R.T. and J. Burger 1986. Final Report on Habitat Utilization by the Timber Rattlesnake, Crotalus horridus (Linnaeus) in Southern New Jersey with Notes on Hibernation. Unpublished Report Submitted August 31, HA File No. 85.20.

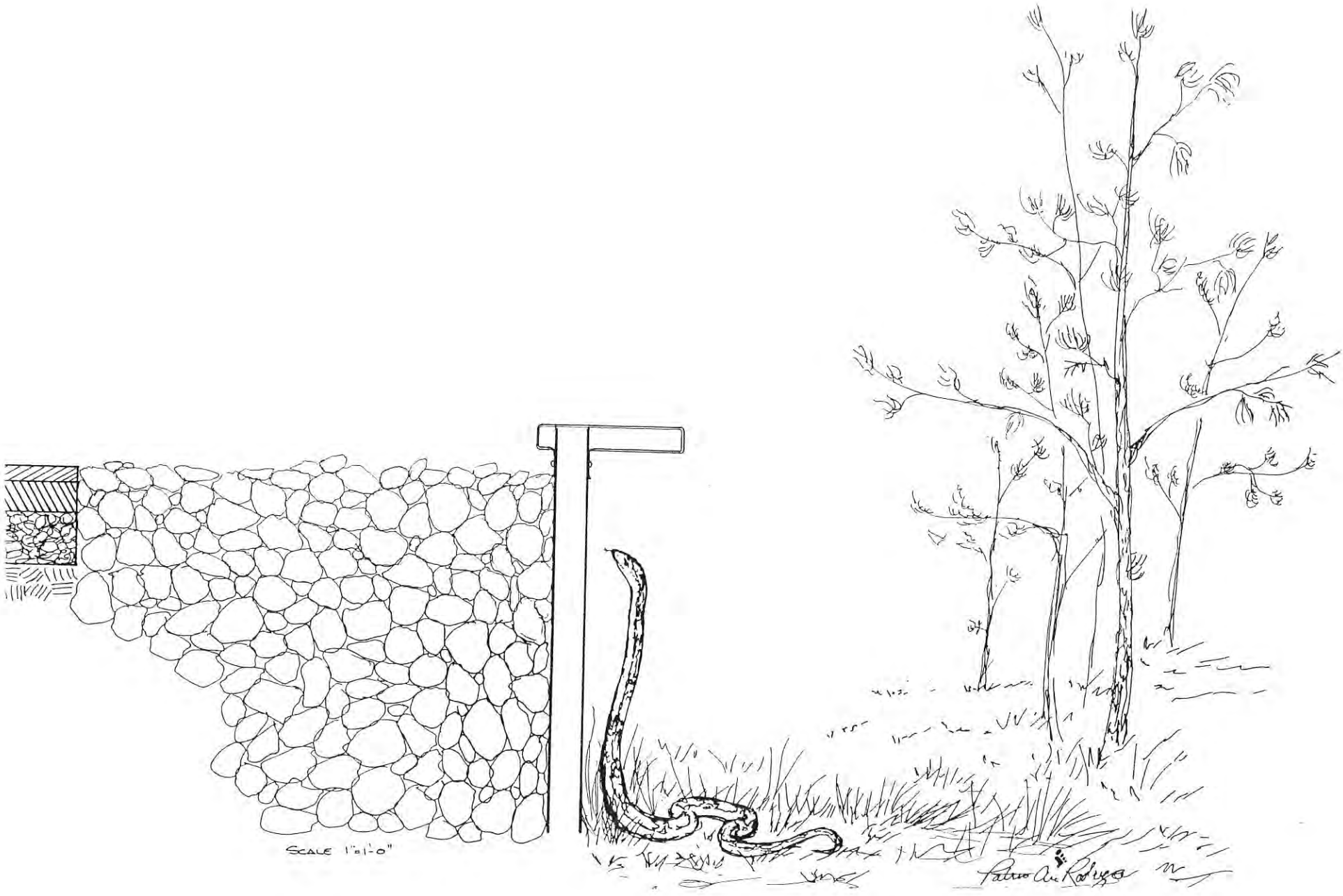
Appendices

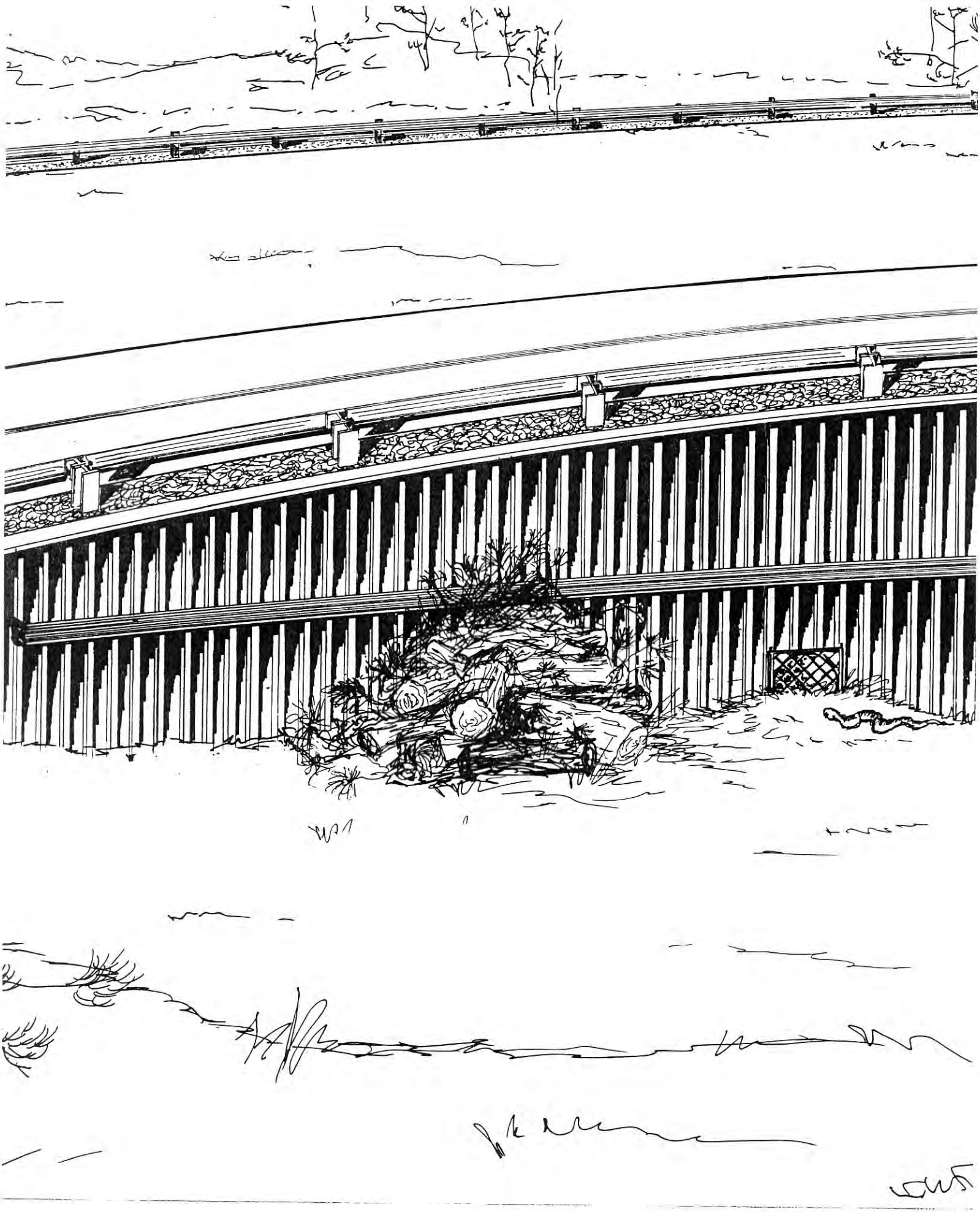
Proposed Mule Road Extention - Elevated Roadway With Wildlife Tunnels

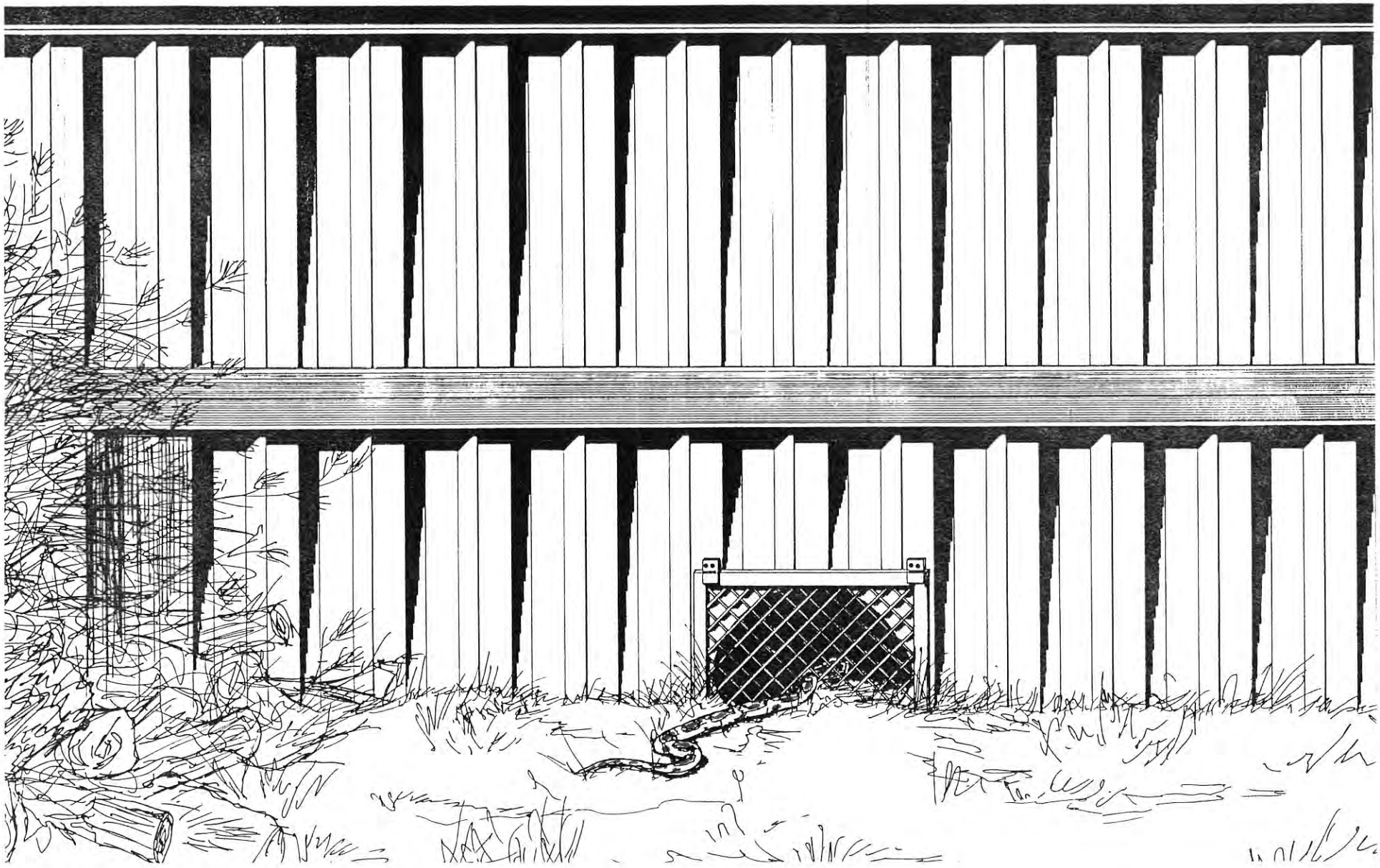


Drawing by the Ocean County Engineering Dept., 1992

HERPETOLOGICAL ASSOCIATES, INC.
Plant and Wildlife Cosultants
2525 Dover Road
Forked River, New Jersey

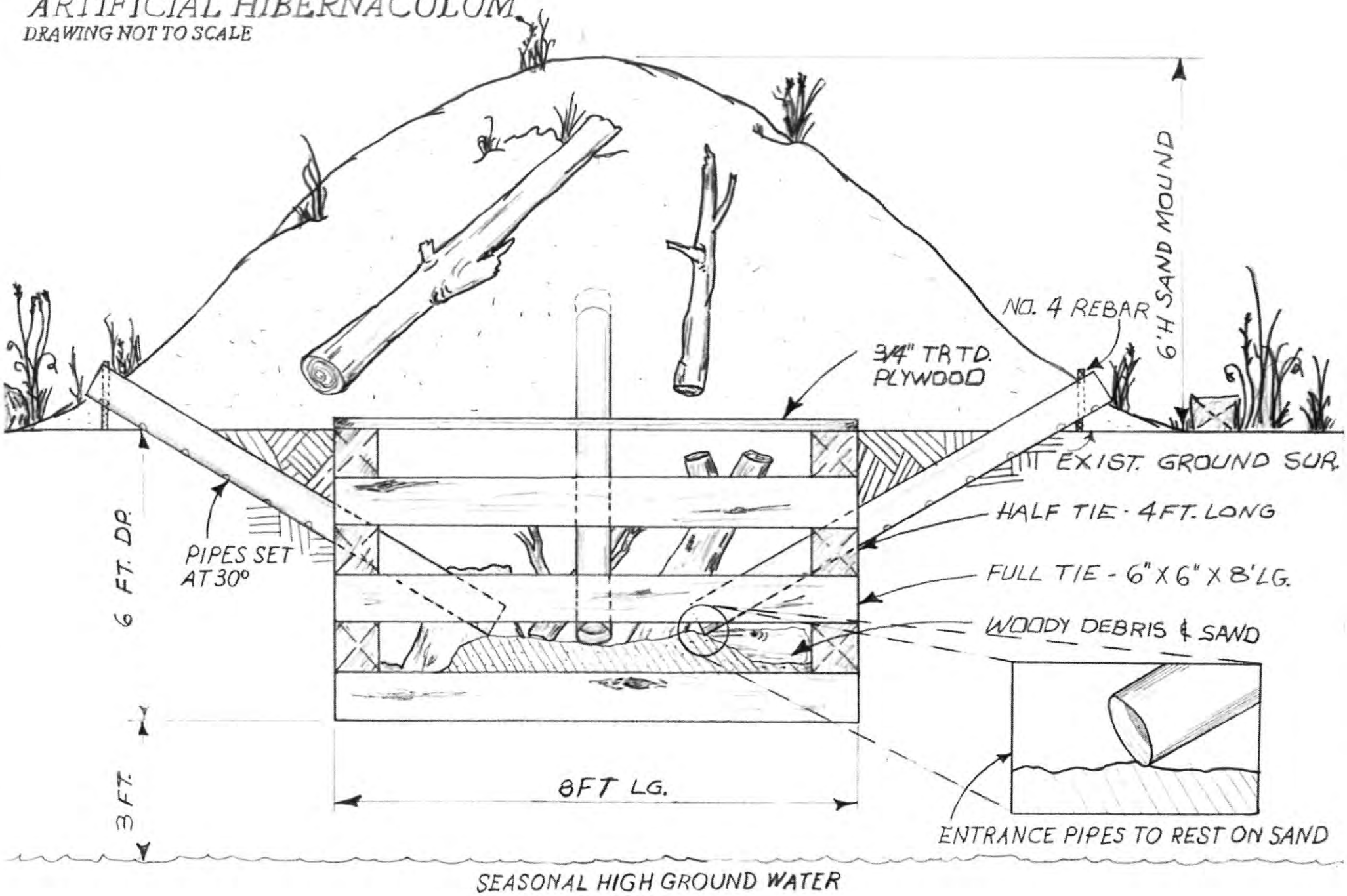

SCALE 1"=1'-0"



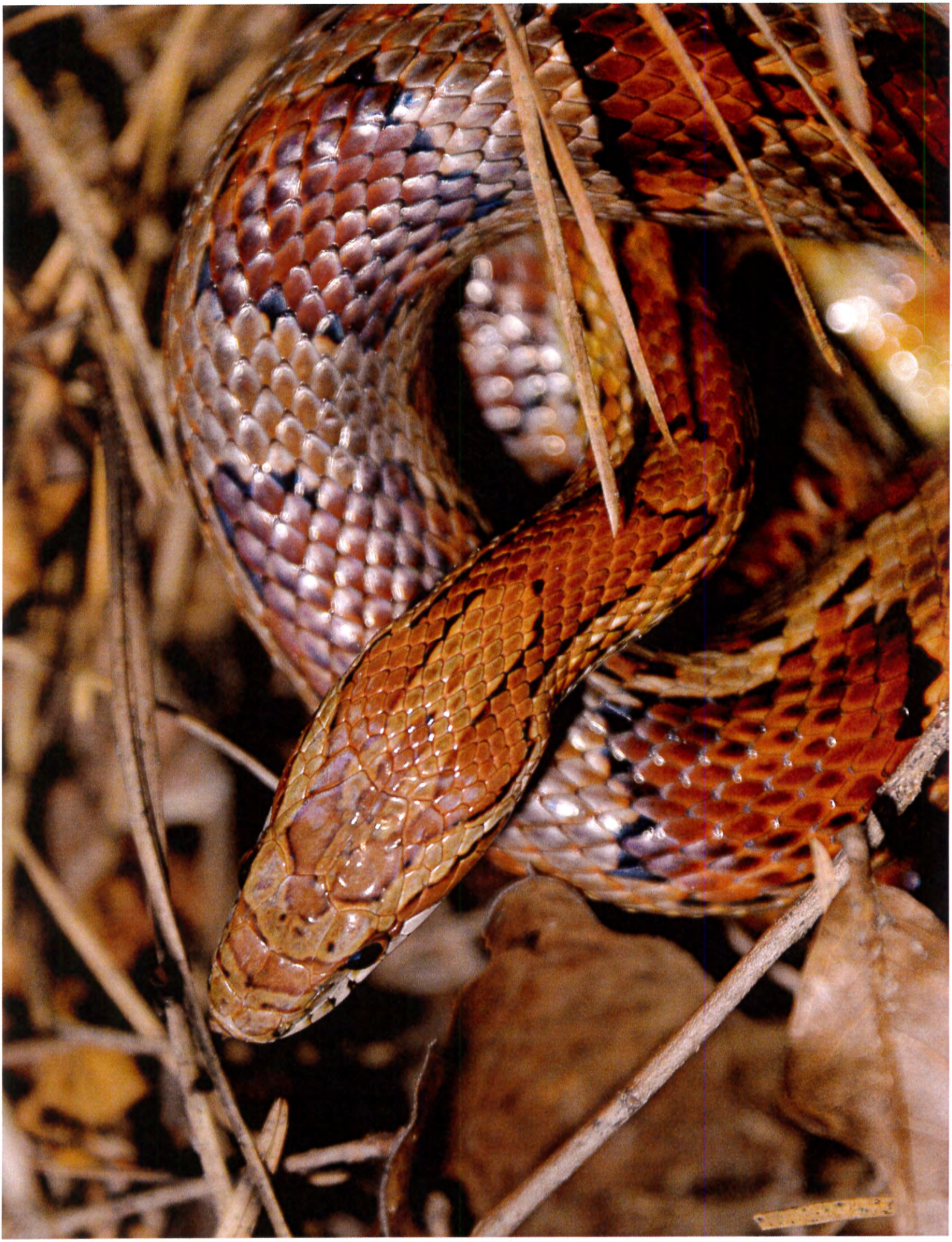


ARTIFICIAL HIBERNACULUM

DRAWING NOT TO SCALE



HERPETOLOGICAL ASSOCIATES, INC. 2010



Appendix One

Table 11 - Pine Snake Records for the Study Area Between (1986-1990)

Source: HA Files

Record#	ID	SEX	DATE	LOCATION	CONDITION	BEHAVIOUR	OTHER
1	8698	F	09/01/86	DVNND	N	ACTIVE	
2	8649	M	04/13/87	CRSND	A	HIBERNAT	
3	8701	F	04/13/87	CRSND	A	HIBERNAT	
4	8703	M	04/13/87	CRSND	A	HIBERNAT	
6	8704	F	04/13/87	CRSND	A	HIBERNAT	
9	8708	F	04/13/87	CRSND	A	HIBERNAT	
10	8708	F	09/26/87	CRSMM	A	ACTIVE	
11	8742	F	06/28/87	DVNNA	G	NESTING	
17	8743	F	06/28/87	DVNNA	G	NESTING	
21	8744	F	06/28/87	DVNNA	G	NESTING	
22	8744	F	11/04/87	DVNND	A	ACTIVE	
28	8745	F	07/01/87	DVNNA	G	NESTING	
31	8765	F	09/26/87	CRSMM	A	ACTIVE	
35	8766	F	11/07/87	DVNND	S	ACTIVE	
38	8709	M	04/13/87	CRSND	A	HIBERNAT	
42	8707	M	04/13/87	CRSND	A	HIBERNAT	
44	8706	M	04/13/87	CRSND	A	HIBERNAT	
46	8705	M	04/13/87	CRSND	A	HIBERNAT	

Record#	ID	SEX	DATE	LOCATION	CONDITION	BEHAVIOUR	OTHER
12	8742	F	07/13/88	DVNNA	G	NESTING	
18	8743	F	07/13/88	DVNNA	G	NESTING	
23	8744	F	07/06/88	DVNNA	G	NESTING	
29	8745	F	04/09/88	CRSMM	A	ACTIVE	
30	8745	F	07/07/88	DVNNA	G	NESTING	
32	8765	F	04/09/88	CRSMM	A	ACTIVE	
33	8765	F	07/07/88	DVNNA	G	NESTING	M-CRSMM
39	8709	M	03/14/88	CRSND	A	HIBERNAT	
43	8707	M	03/14/88	CRSND	A	HIBERNAT	
45	8706	M	03/14/88	CRSND	A	HIBERNAT	
47	8705	M	03/14/88	CRSND	A	HIBERNAT	
48	8703	M	03/14/88	CRSND	A	HIBERNAT	
49	8822	M	03/14/88	CRSND	A	HIBERNAT	
51	8823	F	03/14/88	CRSMM	A	HIBERNAT	
53	8824	M	03/14/88	CRSND	A	HIBERNAT	
56	8825	M	03/14/88	CRSND	A	HIBERNAT	
57	8826	M	03/14/88	CRSND	A	HIBERNAT	
59	8827	F	03/14/88	CRSND	S	HIBERNAT	
60	8828	F	03/14/88	CRSND	A	HIBERNAT	
61	8829	M	03/14/88	CRSND	A	HIBERNAT	
62	8830	M	03/14/88	CRSND	A	HIBERNAT	
64	8831	M	03/14/88	CRSND	A	HIBERNAT	
66	88292	M	05/30/88	CRSMM	A	ACTIVE	
68	8836	M	06/04/88	CRSMM	A	ACTIVE	
70	8837	M	06/30/88	CRSMM	A	ACTIVE	
71	8838	F	07/06/88	DVNNA	G	NESTING	
73	8845	F	09/30/88	DVNND	S	ACTIVE	

Record#	ID	SEX	DATE	LOCATION	CONDITION	BEHAVIOUR	OTHER
5	8703	M	03/12/89	CRSND	A	HIBERNAT	
7	8704	F	03/17/89	DVNND	A	HIBERNAT	M-CRSND
13	8742	F	03/17/89	DVNND	A	HIBERNAT	
36	8766	F	04/17/89	DVNND	A	HIBERNAT	
40	8709	M	03/17/89	DVNND	A	HIBERNAT	M-CRSND
50	8822	M	03/17/89	CRSND	A	HIBERNAT	
54	8824	M	03/17/89	CRSND	A	HIBERNAT	
58	8826	M	03/17/89	DVNND	A	HIBERNAT	M-CRSND
63	8830	M	03/17/89	CRSND	A	HIBERNAT	
72	8838	F	03/17/89	DVNND	A	HIBERNAT	
74	8845	F	04/05/89	DVNND	A	ACTIVE	
75	8926	F	03/17/89	DVNND	N	HIBERNAT	
76	8927	F	03/17/89	DVNND	N	HIBERNAT	
78	8928	M	03/17/89	DVNND	N	HIBERNAT	
80	8929	F	03/17/89	DVNND	A	HIBERNAT	
81	8930	M	03/17/89	DVNND	S	HIBERNAT	
83	8931	M	03/17/89	DVNND	A	HIBERNAT	
84	8932	F	03/17/89	DVNND	S	HIBERNAT	
86	8933	F	03/17/89	DVNND	A	HIBERNAT	
88	8934	F	03/17/89	DVNND	N	HIBERNAT	
89	8935	M	03/17/89	DVNND	N	HIBERNAT	
90	8936	M	03/17/89	DVNND	S	HIBERNAT	
91	8938	F	03/17/89	DVNND	A	HIBERNAT	
93	8939	F	03/17/89	DVNND	A	HIBERNAT	
96	8940	F	03/17/89	DVNND	S	HIBERNAT	
97	8960	M	04/12/89	CRSMM	N	ACTIVE	

Record#	ID	SEX	DATE	LOCATION	CONDITION	BEHAVIOUR	OTHER
14	8742	F	06/26/89	DVNNA	G	NESTING	
19	8743	F	06/25/89	CRSMM	G	ACTIVE	
24	8744	F	06/26/89	DVNNA	G	ACTIVE	
25	8744	F	10/07/89	DVNND	A	ACTIVE	
34	8765	F	06/01/89	CRSMM	A	ACTIVE	M-DVNNA
37	8766	F	10/07/89	DVNND	A	ACTIVE	
52	8823	F	04/20/89	CRSMM	A	HIBERNAT	
69	8836	M	05/30/89	CRSMM	A	ACTIVE	M-CRSMM
98	8967	F	04/20/89	CRSMM	S	ACTIVE	
99	8968	U	04/20/89	CRSMM	N	ACTIVE	DEAD
100	8970	F	04/20/89	CRSMM	N	ACTIVE	
101	8976	M	05/04/89	CRSMM	A	ACTIVE	
102	89125	M	10/24/89	DVNND	N	ACTIVE	
105	89127	M	10/24/89	DVNND	N	ACTIVE	
106	89128	M	10/25/89	DVNND	S	ACTIVE	
130	89115	M	09/05/89	CRSMM	N	ACTIVE	LAB H
131	89116	M	09/05/89	CRSMM	N	ACTIVE	LAB H
132	89117	F	09/05/89	CRSMM	N	ACTIVE	LAB H
133	89118	F	09/05/89	CRSMM	N	ACTIVE	LAB H
134	89118	F	10/23/89	DVNND	N	ACTIVE	LAB H
137	89119	F	09/05/89	CRSMM	N	ACTIVE	LAB H
138	89119	F	10/24/89	CRSMM	N	ACTIVE	LAB H
139	89120	M	09/05/89	CRSMM	N	ACTIVE	LAB H
142	89121	F	09/05/89	CRSMM	N	ACTIVE	LAB H
143	89122	M	09/05/89	CRSMM	N	ACTIVE	LAB H
147	89123	M	09/05/89	CRSMM	N	ACTIVE	LAB H

Record#	ID	SEX	DATE	LOCATION	CONDITION	BEHAVIOUR	OTHER
15	8742	F	11/20/89	DVNND	A	ACTIVE	
94	8939	F	10/26/89	DVNND	A	ACTIVE	
103	89125	M	11/01/89	DVNND	N	ACTIVE	
104	89124	M	11/13/89	DVNND	N	ACTIVE	
107	89131	F	10/30/89	DVNND	N	ACTIVE	
108	89131	F	11/27/89	DVNND	N	ACTIVE	
109	89134	M	11/13/89	DVNND	N	ACTIVE	
110	89135	F	11/13/89	DVNND	N	ACTIVE	
112	89136	F	11/17/89	DVNND	N	ACTIVE	
135	89118	F	10/26/89	DVNND	N	ACTIVE	LAB H
140	89120	M	11/06/89	CRSMM	N	ACTIVE	LAB H
141	89120	M	11/13/89	CRSMM	N	ACTIVE	LAB H
144	89122	M	10/26/89	DVNND	N	ACTIVE	LAB H/ M-CRSMM
145	89122	M	11/17/89	DVNND	N	ACTIVE	LAB H
146	89122	M	11/20/89	DVNND	N	ACTIVE	LAB H
148	89123	M	11/06/89	CRSMM	N	ACTIVE	LAB H
149	89123	M	11/27/89	CRSMM	N	ACTIVE	LAB H

Record#	ID	SEX	DATE	LOCATION	CONDITION	BEHAVIOUR	OTHER
8	8704	F	03/03/90	DVNND	A	HIBERNAT	
16	8742	F	03/03/90	DVNND	A	HIBERNAT	
26	8744	F	03/03/90	DVNND	A	HIBERNAT	
41	8709	M	03/03/90	DVNND	A	HIBERNAT	
55	8824	M	03/03/90	DVNND	A	HIBERNAT	M-CRSND
65	8831	M	03/21/90	CRSMM	A	ACTIVE	DEAD
77	8927	F	03/03/90	DVNND	S	HIBERNAT	
79	8928	M	03/03/90	DVNND	S	HIBERNAT	
82	8930	M	03/03/90	DVNND	A	HIBERNAT	
85	8932	F	03/03/90	DVNND	A	HIBERNAT	
87	8933	F	03/03/90	DVNND	A	HIBERNAT	
92	8938	F	03/03/90	DVNND	A	HIBERNAT	
95	8939	F	03/03/90	DVNND	A	HIBERNAT	
111	89135	F	03/03/90	DVNND	N	HIBERNAT	
113	9001	F	03/03/90	DVNND	A	HIBERNAT	
114	9002	F	03/03/90	DVNND	S	HIBERNAT	
115	9003	F	03/03/90	DVNND	S	HIBERNAT	
116	9004	M	03/03/90	DVNND	S	HIBERNAT	
117	9005	M	03/03/90	DVNND	S	HIBERNAT	
118	9006	F	03/03/90	DVNND	S	HIBERNAT	
119	9007	F	03/03/90	DVNND	S	HIBERNAT	
120	9008	M	03/03/90	DVNND	A	HIBERNAT	
121	9043	F	03/03/90	DVNND	N	HIBERNAT	
122	9044	M	03/03/90	DVNND	S	HIBERNAT	
123	9045	U	03/03/90	DVNND	N	HIBERNAT	
124	9046	F	03/03/90	DVNND	N	HIBERNAT	
125	9047	M	03/03/90	DVNND	N	HIBERNAT	
126	9048	F	03/03/90	DVNND	N	HIBERNAT	
136	89118	F	03/03/90	DVNND	N	HIBERNAT	LAB H

Record#	ID	SEX	DATE	LOCATION	CONDITION	BEHAVIOUR	OTHER
20	8743	F	07/03/90	CRSMM	G	NESTING	
27	8744	F	06/28/90	DVNNA	G	ACTIVE	
67	88292	M	05/17/90	CRSMM	A	ACTIVE	
127	9056	M	05/16/90	MLRD	A	ACTIVE	
128	9057	F	06/25/90	DVNNA	G	ACTIVE	
129	9064	F	07/03/90	CRSMM	G	ACTIVE	POST NEST
150	8823	F	07/06/90	CRSMM	G	ACTIVE