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Western pond turtle (Clemmys marmorata pallida)

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WESTERN POND TURTLE (*Clemmys marmorata pallida*)
WINTER HABITAT USE AND BEHAVIOR

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ABSTRACT

WESTERN POND TURTLE (*Clemmys marmorata pallida*)
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Thirty-one adult western pond turtles (*Clemmys marmorata pallida*) were radio-tracked for one or two years in 1995 through 1997 to determine timing and habitat use for overwintering at a central coastal California stream, lagoon and permanent pond. Turtles in the pond remained there for overwintering, but turtles using the stream in summer returned to the pond or upland sites for overwintering. Upland overwintering turtles used primarily riparian forest with dense native understory or seasonally ponded habitats; later, in winter and early spring, there was a shift to the ponded habitats. Overwintering turtles in upland habitats were usually buried in leaf litter or soil but were not dormant, except during the coldest months of December, January and February. Basking was common, especially in late winter. Protecting and enhancing the riparian forests, thickets and wetlands adjacent to streams should be an essential part of any plan to conserve this species.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

Introduction

The western pond turtle (*Clemmys marmorata*) is the only widespread freshwater turtle native to the Pacific Coast of North America (Bury 1972). Historically, it was abundant in streams, ponds and lakes west of the Cascade and Sierra Nevada mountain ranges from Washington south to the Baja Peninsula (Stebbins 1985). Today, the western pond turtle is in a general state of decline in an estimated 75-80% of its range (Holland 1991). The decline of the turtle began in the mid-late 1800's when humans started commercially harvesting it as a food source (Storer 1930). In recent years, the destruction and disturbance of critical habitat has further accelerated the decline of the species (Bury 1972). In 1991, the United States Fish and Wildlife Service evaluated the potential listing of the western pond turtle as a federally threatened or endangered species (Jennings et al. 1991), but the listing was denied pending additional information on species status.

The lack of information regarding species status is partially the result of a poor understanding of the life history and ecology of the western pond turtle. One of the least understood aspects of western pond turtle ecology is overwintering habitat use and behavior. A limited number of studies suggest that this species exhibits a significant amount of plasticity with regard to overwintering habits and that overwintering behaviors may even vary at an individual site on a year to year basis (Holland 1994). It is likely that turtles using stream habitats emerge from water in late fall and move extensive distances into upland areas for terrestrial overwintering, while turtles using ponds overwinter aquatically (Holland 1994, Rathbun et al. 1993). In addition, turtles overwintering in terrestrial habitats may move to several different locations, and some turtles may exhibit site fidelity from year to year (Holland 1994).

On stream systems in Northern California and Oregon, turtles have been reported to spend over ten months in terrestrial overwintering sites up to 500 meters from a watercourse (Holland 1994). In San Luis Obispo County, California, terrestrial overwintering sites were associated with relatively thick cover, such as willow (*Salix* spp.) and blackberry (*Rubus* spp.) thickets, where turtles buried themselves in leaf litter and occasionally, when exposed to direct sunlight, extended their heads and necks to bask (Rathbun et al. 1993). In the Chino Hills area of southern California, Goodman (1994) reported only brief movements (less than 2 months) to terrestrial habitats within 13 meters of the stream channel and no upland movements in some dry years.

Few data have been gathered on the turtle populations inhabiting the watersheds along the California coastline between Trinity and San Luis Obispo Counties. Studies of these populations are necessary for a complete understanding of the ecology of the species. Additionally, an understanding of upland habitat use is necessary to develop site-specific management plans related to development of riparian corridors. This study specifically addresses the overwintering habitat use and behavior of western pond turtles at Waddell Creek, Santa Cruz County and will aid the California Department of Parks and Recreation in their management of this turtle in Big Basin Redwoods State Park. The specific objectives of the Waddell Creek Watershed Study were to:

1. locate and quantitatively describe the types of upland habitats used by western pond turtles for overwintering;
2. determine how far from the stream western pond turtles go to overwinter;
3. compare upland overwintering versus pond overwintering;
4. determine the timing of upland movement for overwintering and any environmental factors which serve as cues for upland movement;
5. describe the amount and timing of activity associated with overwintering, including thermoregulatory behavior;
6. radio-track the same turtles over a two year period to establish degree of site fidelity.

STUDY AREA

The study area is a small coastal watershed located 80 km south of San Francisco (Fig. 1). Two permanent water sources exist at the site: Waddell Creek and Turtle Pond. Much of the watershed is within Big Basin Redwoods State Park, however, private land exists in the lower reaches, primarily on the east side of the stream and includes Turtle Pond.

Waddell Creek is a fourth order stream that runs north to south for approximately 16 km and flows directly into the Pacific Ocean. The stream has two forks which branch approximately 5400 channel meters above the U.S. Highway 1 bridge. Downstream of the forks, a dense riparian border of willows (*Salix* spp.) and alders (*Alnus rhombifolia*) exists on both sides of most of the channel (Hickman 1993). California boxelder (*Acer negundo californicum*) and redberry elder (*Sambucus racemosa*) are also common, and the understory is dominated by poison oak (*Toxicondendron diversiloba*), California blackberry (*Rubus vitifolius*), non-native German ivy (*Senecio mikanoides*) and stinging nettle (*Urtica dioica*). The riparian tree border is absent for 200 m upstream of the Highway 1 bridge, which crosses the stream approximately 150 m from the mouth. Throughout the stream, deep pools with woody debris are common.

Beach development by summer wave action builds a sandbar at the mouth of the stream. When fully closed, this sandbar can back up water 1 km upstream forming a productive brackish or freshwater lagoon. During this time, the lagoon often overflows its banks or percolates laterally, saturating adjacent wetlands. Most of these wetlands have permeable soils, with complex sand/silt/clay bedding patterns (Smith et al. 1997). Winter rain puddles briefly on most of the surface before being lost to evaporation or percolation. Some portions of the wetland have thicker surface or subsurface clay/silt layers which retain rain and runoff. Several temporary ponds and channels are present on both sides of the lagoon in winter. The largest of these is a temporary pond to 1 m deep which develops on the west side of the lagoon. This pond, although located on the west bank, is referred to as "North Pond" and supports a dense growth of cattails *(Typha latifolia)* and can maintain surface water through late May or June. The wetlands contain a mosaic of plant species including: tules (*Scirpus* spp.), cattails, sedges (*Carex* spp.), rushes (*Juncus* spp.), cinquefoil (*Potentilla anserina pacifica*), saltgrass (*Distichlis spicata*) and pearly everlasting (*Anaphalis margaritacea*).

In drier, higher elevations surrounding the wetlands, coastal scrub species such as coyote brush (*Baccharis pilularis*), coastal sagebrush (*Artemisia californica*), poison oak, and California blackberry dominate. In addition, open fields dominated by non-native grasses are present outside the riparian boarder on both sides of the lagoon. A portion of one field on the west side is fenced and used as a horse corral. On the east side, just upstream of the lagoon, is a large agricultural field used for growing pumpkins. A few additional grasslands and agricultural fields are present further upstream.

Moister upland forest areas throughout the watershed are dominated by Coast Redwood (*Sequoia sempervirens*), Douglas Fir (*Pseudotsuga menziesii*), California bay (*Umbellularia californica*) and tanbark oak (*Lithocarpus densiflorus*). Bracken and sword ferns (*Pteridium aquilinum, Polystichum munitum*), periwinkle (*Vinca major*) and poison oak are the most common understory species. Monterey pines (*Pinus radiata*) form stands on steeper and drier slopes near the coast, including upland from Turtle Pond.

Turtle Pond lies approximately 100 m southeast of the mouth of Waddell Creek. It is a man-made pond about 135 m long and 75 m wide that was created by an access road acting as a dam (Smith et al., 1997). A 0.3 m culvert that passes through the road controls the water level of the pond. During the summer months, the water level in the pond falls about 0.3 m to a depth of about 1.2 m. Dense tules are rooted to the bottom in the shallower portions of the pond and form a continuous floating mat approximately 0.3 m thick over most of the deeper areas. Although much of the pond consists of tules, open water areas occur naturally along willow-shaded portions of the perimeter and in two small areas (4 and 6 m diameter) in the center. These two open water areas are easily observable in old aerial photographs and appear to have retained their size since 1982. Seasonal mats of duckweed (*Lemna* spp.) flourish in the open water areas of Turtle Pond, and algae mats also dominate the smaller open water area.

In addition to western pond turtles, several sensitive vertebrate species utilize the habitats at the mouth of Waddell Creek. The San Francisco garter snake (*Thamnophis sirtalis* *tetrataenia*) and tidewater goby (*Eucyclogobius newberryi*) are federally listed as endangered. The California red-legged frog (*Rana aurora draytonii*), coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Oncorhynchus mykiss*) are federally listed as threatened.

Methods

Environment

In September 1995, the wetlands to the east and west of the lagoon were surveyed for ground level elevation. Vegetation types were recorded along each transect line and a portion of the transect points was staked for later use as location reference markers. The data obtained were combined with the information available on recent (1993) aerial photographs to generate accurate study area maps of the site (Figs. 2-4).

In order to monitor in-stream turtle movements, the stream channel was divided into 25 m segments starting at the Highway 1 bridge. Each segment was clearly marked in the field with wooden stakes and surveyor's flagging. Turtle locations were recorded as distance from the Highway 1 bridge and distance from the nearest bank. The perimeter of the pond was similarly divided into 20 m segments. Locations were recorded as distance from the nearest location reference marker and distance from bank. Upland movements were either recorded as distance upstream from the Highway 1 bridge and distance from the stream or referenced to the nearest location reference marker or permanent landmark with a compass bearing.

Sand bar status and lagoon depth, salinity and temperature were monitored periodically throughout the study period. Staff gauges, surveyed in to read directly to mean sea level elevation, were placed in the pond and lagoon and in five locations in the adjacent wetlands to determine water depth. In addition, automatic temperature recorders (Stowaways manufactured by Onset Computer Corporation, Pocasset, MA), were placed in several locations throughout the study site. The Stowaways recorded either water or air temperature (°C) at half hour intervals. In addition, a rain gauge, placed near the Highway 1 bridge, was used to determine seasonal rain fall.

General habitat data were gathered on all upland locations used for overwintering. Specific microhabitat data were additionally gathered at locations where turtles remained fixed for the longest period of time during each overwintering season. Some of the more invasive microhabitat measurements were taken only after a turtle had left a site in order to avoid influencing natural overwintering behavior. A quadrant pole and disc were placed at the center of each overwintering site. Within each quadrant, the nearest tree and shrub were identified and measured. A metric ruler was used to determine litter depth in each quadrant. At these same locations, a soil moisture meter and a soil compaction meter were used to determine soil moisture and compaction at various depths. Percent canopy closure was determined using a densiometer placed on top of the quadrant pole (1 m in height). Lastly, an inclinometer and a compass were used to determine slope and aspect along the ground where the quadrant pole was located. Habitat available for overwintering use was estimated by constructing a polygon around sites used by turtles and estimating relative abundance of habitat types from an aerial photograph.

Turtle Studies

In order to capture turtles for radio-transmitter attachment, twenty baited hoop traps were placed throughout Waddell Creek and Turtle Pond. The traps were approximately 1.5 m in length with a double funnel arrangement inside a 0.4 m diameter tube of 2.5 cm nylon mesh. A float was placed at one end to provide adequate breathing space for the turtles. The traps were checked at regular intervals and rebaited with canned sardines every 3-4 days. Trapping was conducted from July through November in 1995 and from April through August in 1996 in order to capture turtles for radio-tracking, establish the minimum number of turtles present, and to allow for the continued collection of movement and other data. Turtles were also captured in 1996 at a weir/migration trap located immediately upstream of the lagoon.

All captured turtles were individually marked with small (2-4 mm) triangular notches in their marginal scutes that corresponded to a numbering system modified from Holland (1991). In addition to notching, a passive integrated transponder (PIT) tag was subcutaneously implanted just anterior to the right rear leg insertion of each turtle. These two systems for individual identification were deemed necessary, as notches sometimes become obscured by wear and/or shell damage and PIT tag readers may not always be available in the field. Turtles were measured (carapace length, width and depth and vent-tail length (mm)) with a specially designed measuring board and were weighed to the nearest 5 g with Pesola scales. When observable, plastron growth rings were counted and traced onto a piece of clear tape which was then transferred to a data sheet. In addition, turtles were sexed, if possible, and the reproductive status of female turtles was checked by palpating the inguinal pocket for eggs.

Turtles generally larger than 135 mm were fitted with radio-transmitters according to the attachment techniques used by Rathbun et al. (1993). Only large turtles were tracked to avoid hindering growth and movement of smaller individuals. Three turtles smaller than 135 mm (>120 mm) were radio-tagged because of unique capture locations. Transmitters (manufactured by Advanced Telemetry Systems, Isanti, MN) measured 45 X 20 X 15 mm with an internal antenna and weighed 20 g attached. The internal antenna reduced transmission range to about 1 km but may interfere less with turtle movement in dense vegetation. Transmitters were attached with 5 minute epoxy to the carapace and the package smoothed with dental acrylic stained with xerographic toner. When several turtles showed shell rot associated with the use of the epoxy, later transmitters were attached using only dental acrylic. For males, the transmitter was placed along the axis of the spine and centered in the middle of the carapace. For females, it was placed forward on the carapace and perpendicular to the spine so as not to interfere with mating.

Transmitters had a temperature-variable pulse rate, which allowed determination of transmitter temperature. This was used to determine activity (basking) and microhabitat use during once or twice weekly radio-tracking. In 1996, a portion of the transmitters had "motion" sensors, with very slow pulse rates triggered by 24 hours of inactivity; this feature was useful in determining winter activity. Transmitters were programmable and were on for approximately 9 or 12 hours per day to extend battery life to 11 to 14 months.

In late summer and fall of 1995, 16 adult western pond turtles (8 males & 8 females) were fitted with individual frequency radio-transmitters. In the summer of 1996, transmitters were replaced on 15 of the original 16 turtles (one radio-tagged female died of a suspected loon attack). Thirteen additional turtles were radio-tagged in 1996 and two in early 1997, resulting in a total of 30 turtles (15 males & 15 females) tracked during all or part of the 1996/97 overwintering season. Nine of the new turtles radio-tagged in 1996 were captured at upstream sites or at the weir/migration trap upstream of the lagoon. These upstream movements in 1996 occurred earlier (June and July) than lagoon trapping began in 1995, so this segment of the turtle population was not represented in 1995 results. A breakdown of the individual characteristics of each turtle radio-tagged during the study period can be found in Table 1.

During the 1996/97 overwintering season, two of the radio-tagged male turtles were additionally fitted with small temperature recorders (Tidbits manufactured by Onset Computer Corporation, Pocasset, MA) in order to determine daily basking activity patterns. These recorders were placed behind the transmitter and molded to the shell with dental acrylic. Each unit was programmed to take temperature (°C) readings every half hour.

During winter, radio-tagged turtles were tracked once or twice weekly. When motion sensors, worn by 14 turtles during the 1996/97 season, indicated no movement for 24 hours and the location had been very recently checked, the turtle was not relocated. Otherwise turtles were tracked to actual location, and activity level was classified as either dormant (hunkered down, inactive), resting (alert but not moving), basking, moving (in transit to a new location) or undetermined. Initial checks of the extent of burial in 1995/96 appeared to disturb turtles and cause them to move locations, so checks were limited to the first months of 1995/96 or to recapture of turtles for transmitter replacement.

Results

Environment

The seasonal distribution of rainfall at Waddell Creek Lagoon during the study period was typical for the region, with most of the rain falling during the months of November through April (Fig. 5). The total estimated rainfall during the 1995/96 overwintering season was 779 mm. This is 106 mm more than the 1960-1977 yearly average at Davenport, California (approximately 8 km south of Waddell Creek), of 673 mm (National Climatic Data Center 1995). The total rainfall during the 1996/97 overwintering season was 672 mm, about average, but the rainfall was concentrated earlier in the season than in 1995/96. The earlier decline in rainfall in 1996/97 resulted in much earlier drying of ponded areas, including North Pond (Fig. 6).

Mean monthly air temperatures decreased gradually from September to January during both overwintering seasons (Fig. 7). In 1996/97, January and February air temperatures were similar then increased from February to April. In 1995/96, February air temperatures were substantially warmer (11.7 versus 10.4 °C) than in January and were even warmer than for March. Furthermore, February 1996 was on average 1.4 °C warmer than February 1997; this was the largest monthly difference between the two overwintering seasons.

Population Characteristics

Between August 1995 and April 1997, 196 turtles were captured by trap or hand. Of the 196 turtles captured, 109 were recaptured at least once. Population estimates could not be made based upon recapture ratios because most trapped turtles tended to avoid recapture. A loose estimate of population size, based on the total number of captures, ratios of radio-tagged to non-radio-tagged turtles in visual sightings, counts of basking turtles in Turtle Pond and proportions of radio-tagged turtles using different habitats, indicates that perhaps 200-350 turtles utilize the Waddell Creek watershed. The overwhelming majority of turtles are concentrated in the lagoon and Turtle Pond area (Site A). Few turtles apparently make much use of the remaining watershed.

Captured adult males outnumbered adult females by approximately 2 to 1 (Table 2) although among turtles captured only in the lagoon the sex ratio was much closer. Immature turtles, which could not be sexed, made up about 1/3 of the population. Roughly equal numbers of turtles apparently utilized either Waddell Creek or Turtle Pond, but a portion (13.3%) of the turtles, based upon recaptures and radio-tracking, moved between these two habitats. Most (19 of 26) of the turtles confirmed as moving between the two habitats were mature males. Radio-tracked turtles were more equally divided between male and female (Table 3). However, relatively few Turtle Pond turtles were radio-tagged, because they displayed few movements and were difficult to recapture for transmitter replacement or removal.

Overwintering Locations

All four turtles originally radio-tagged in Turtle Pond remained there throughout both overwintering seasons. Turtle Pond was also used for overwintering in both seasons by 3 of 13 turtles originally radio-tagged in Waddell Creek in 1995. Over the entire study, 4 of 31 (12.9%) radio-tagged turtles moved between the lagoon and Turtle Pond. Most of the turtles radio-tagged in Waddell Creek, however, moved upland from the stream to overwinter terrestrially. Turtles that moved upland were concentrated in three different areas along the stream channel (Figs. 2-4). All upland turtles tracked during the 1995/96 season were radio-tagged in the lagoon and overwintered at Site A (lagoon area). In 1996/97, nine of thirteen new radio-tagged turtles were captured at upstream sites or trapped at the migration trap immediately upstream of the lagoon. Two of four turtles trapped at the migration trap moved upstream for the summer. Many of these turtles (6 of 9) and 26.1% of the total upland overwintering turtles that were radio-tagged overwintered at Sites B and C in 1996/97 (Table 4).

Overwintering Distance Traveled

Figs. 8 - 16 show the major overwintering movements made by each turtle monitored during the study. Once upland, the distance a turtle traveled from the watercourse varied from 3 to 300 meters. Although their locations were not fixed, most turtles remained within roughly 25 to 150 meters of the stream channel. The typical pattern was for turtles to be located closer to the stream in the first months upland with movements further away from the watercourse as the seasons progressed. Occasionally, a turtle would return to the watercourse briefly and/or switch banks in mid season. Table 5 shows a breakdown of the distances of movements detected by twice weekly or weekly tracking of turtles at Site A during both overwintering seasons. Although all turtles were upland by December each year, they were most likely to be fixed in one spot in January of 1996 and February of 1997. Upland movements greater than 50 m within a week were rare (<16.7%) in all months, but the extent of movements increased significantly after February in both years. Turtles began returning to the stream in April.

Overwintering Site Fidelity

All 15 turtles radio-tracked regularly throughout both overwintering seasons returned to Site A to overwinter and most (73.3%) returned to the same general location (same bank or Turtle Pond). Twenty percent of the turtles switched banks at one time or another during one or both seasons, and a small percent (6.7%) switched banks between years. In 1996/97, 13 (86.7%) turtles utilized sites that were within 5 m of those used in 1995/96. Furthermore, 9 of 15 (60.0%) turtles spent extended dormant periods at sites in 1996/97 that were within 20 m of sites used for extended periods during the previous year.

While these tracking data demonstrate fairly good overwintering site fidelity, the incidental data, which include partial seasonal tracks and hand or trap captures, suggest that some turtles did move between Sites A and C in different years. For example, two male turtles captured at Site A during the 1995/96 overwintering season were found overwintering upstream at Site C in 1996/97. Another male turtle overwintered at Site C during the 1996/97 season, but was found at Site A in 1997/98.

Overwintering Macrohabitats

At Site A, upland movements through November were mainly concentrated in densely forested areas such as low lying willow thickets and alder forests with native understories (Tables 6 & 7). No turtles at Site A used forest with German ivy understory at any time although it made up three percent of available habitat and was often adjacent to habitats heavily utilized. With rains in December, water ponded beneath some of the forested areas and in the marsh. A higher percent (17-52%) of the turtles were found in upland ponded areas under a closed canopy through March. Once those areas dried up, turtles either moved back to the stream or moved to open ponded water areas such as North Pond. Open habitats such as grasslands and agricultural fields were rarely used, and marshlands were used by only two turtles in 1996/97.

Turtles overwintering at Sites B and C used closed canopy forest often with a predominantly non-native understory of periwinkle or German ivy. Upland habitats with native understory were unavailable. Turtles at Site C were more likely than those at Sites A and B to periodically return to the stream between winter storms.

Overwintering Microhabitats

Figs. 2-4 show the locations where overwintering site microhabitat measurements were taken. These locations were chosen because individual turtles spent extended dormant periods, so the sites did not represent temporary locations of moving turtles. Turtles overwintering at Site A had a tendency to stay fixed in areas with approximately 90% total canopy closure, dominated by deciduous trees, especially willow. Vegetation closer to the ground than 1 meter was made up primarily of blackberry and low lying willow branches. Litter depth averaged 5.7 cm with moist to wet, soft soil beneath. If a site was located on a slope, it was usually less than 5 degrees and south facing.

At Sites B and C, turtles remained fixed in areas with approximately 77.0% canopy closure dominated by alder (Site B) and bay (Site C). Sword fern and non-native periwinkle made up the bulk of the understory. Litter depth averaged 12.0 cm with dry to moist, soft soil beneath. These sites tended to be located on south and east facing slopes with an average slope of 11.5 degrees.

All dormant turtles checked were hidden by burial in litter and/or in soil. Those buried in soil had dug down sufficiently so that soil reached the edge, or in some cases, covered the carapace with only the transmitter sticking above the soil surface. In the second and third winters, turtles appeared to bury themselves deeper in the soil, so that even the transmitter was obscured.

Timing of Overwintering Movements

During both overwintering seasons, most movements to terrestrial overwintering sites coincided with the onset of the first big storms of the season in late November and early December. In 1995, however, five turtles moved upland as early as September. Three of these "early movers" did not overwinter terrestrially, but instead, they moved over land to overwinter in Turtle Pond.

Movement To and From Turtle Pond. The same three turtles that moved from Waddell Creek to Turtle Pond to overwinter in 1995/96 returned in 1996/97. The three turtles initiated movement to Turtle Pond at the same time in 1995 and again in 1996, but the movements occurred at different times between years. In 1995, all three turtles left Waddell Creek within 30 days of each other during the month of September. In 1996, all three turtles left Waddell Creek within 23 days of each other, but the movement occurred during November rather than September (Figs. 17 & 18).

Although the initiation of movement from Waddell Creek to Turtle Pond coincided for the three turtles, the time spent moving between these two habitats varied from a day to several weeks. The most commonly used corridor was from the stream edge approximately 200-265 channel meters upstream of the Highway 1 bridge through the South Swale and into Turtle Pond along its north edge. The other corridor, used by only one turtle during the 1995/96 overwintering season, ran along the toe of the Highway 1 bridge embankment with entrance to Turtle Pond along its west edge (Fig. 19).

The duration of time spent in Turtle Pond also varied considerably among the three turtles. During the 1995/96 season, the first turtle to return to the stream did so in April after spending approximately six months in Turtle Pond (Fig. 17). This turtle was later found upland briefly in the South Swale area on 17-19 May 1996. The other two turtles generally remained in Turtle Pond until July, although one turtle made a brief excursion to the stream for a week in May. During the 1996/97 season, two of the turtles returned to the stream by March and April, but one did not leave Turtle Pond until late June (Fig. 18).

Movement To and From Terrestrial Overwintering Sites. Most of the turtles radio-tagged in Waddell Creek that overwintered terrestrially moved upland with the onset of the first heavy rains of each season and were upland in December (Fig. 20). Two females, however, moved upland during the 1995/96 season as early as September. The first remained upland, while the second quickly returned to the stream and remained there until December. An additional female moved upland around 27 October 1995. She returned to the stream in late November and was upland again in December.

During the first season of study, all ten radio-tagged turtles that overwintered terrestrially at Site A remained upland through March 1996. Nine of these turtles were still upland as of April. By May, however, only two remained upland. These turtles eventually made their final move back to the stream in June when the remaining bodies of upland ponded water were beginning to dry up (Fig. 6).

During the 1996/97 season, all terrestrially overwintering turtles at Site A were located upland in December 1996 and January 1997 (Fig. 20). Although all but one of these turtles were also found upland in February and March 1997, conditions dried earlier in 1997 (Fig. 6) and the return to the stream started earlier than in 1996. Less than half of the turtles remained upland in April. Only three turtles were still upland as of May 1997 and they were back in the stream on 13 May 1997. In 1998, conditions were very wet, and North Pond was nearly full in mid-June. Two of six radio-tagged turtles were present in the pond in May. One of these turtles, along with several other non-radio-tagged turtles, remained in the pond through at least late June.

All five turtles tracked at Sites B and C in 1996/97 were located upland in December and January. Four of these turtles were still upland in March. By April, however, only one male turtle, who spent most of the winter dormant at Site B and then moved to Site C, was found upland.

Overwintering Behavior

Even when upland during fall-spring the degree of activity of turtles varied seasonally (Table 8). Actual dormancy (hunkered down, inactive) was observed in a majority of turtles only in November - February in 1995/96 and November - March in 1996/97. Over 80% of observations were of dormant turtles in December and January of both years. In September 1995, most upland turtle observations were of basking turtles, and in March - May 1996 most turtles were resting (alert but not moving) or basking. In 1996/97, basking was most commonly observed in upland turtles in April and May.

Similar patterns of dormancy behavior are reflected in the data gathered from motion sensors worn by 14 turtles during the 1996/97 overwintering season (Fig. 21). Overall, these data show the most observations of inactivity (no movement for at least 24 hours) among upland turtles occurring during February (66%) with lesser inactivity in December, January and March (38-50%). Very limited inactivity (<15%) was observed among upland turtles in October, November or April. In contrast, observations of 24-hour inactivity among turtles in Turtle Pond were very infrequent in any month.

The mean transmitter temperatures (based upon transmitter pulse rates) of turtles checked between 10:00 and 16:00 showed a marked decline from December to February in 1995/96 and from late November to January in 1996/97 (Figs. 22 & 23). These drops in transmitter temperature agree with direct observations, which showed basking behavior to be rare during December and January. A rise in mean and maximum transmitter temperature during the second half of each overwintering season, however, indicates that basking did occur later in the season. Basking also varied with breaks in winter weather. During the 1995/96 season, almost all of the transmitter temperatures recorded on 7

February 1996 indicated a sudden increase in basking behavior compared to the previous week. This coincides with a break in the generally rainy weather (Fig. 5).

The data from the temperature recorders attached to turtles varied considerably between the two turtles which wore them during the 1996/97 overwintering season (Fig. 24). Turtle #14, who remained dormant in the North Swale Channel at Site A throughout most of the season, showed no evidence of basking until it moved to the stream in mid-March. Once in the stream, basking and high temperature recorder temperatures occurred almost daily. Turtle #202 was located upland at Site C but moved back to the stream almost immediately after the temperature recorder was attached in late January. Temperatures, regularly reaching 38 °C, indicate that this turtle basked daily during most of the winter.

Fig. 25 shows the mean temperature recorder temperatures for both turtles during the months of February and April and compares them to the air temperatures recorded at Site B (halfway between the two turtles). During the month of February, the mean temperatures recorded by the temperature sensor attached to Turtle #14, which was in the North Swale, remained low and fairly constant. Turtle #202, however, showed a marked increase in mean Tidbit temperature above mean air temperature between 10:00 and 15:00. In April, both turtles showed a rise in mean temperature sensor temperature lasting from 8:30 to 13:00.

DISCUSSION

Although commonly thought to be a mainly aquatic animal, western pond turtles can make extensive use of upland habitats for overwintering. In this study turtles in a permanent pond remained there during winter, but stream turtles moved either to the pond or to upland habitats for overwintering. In fact, some stream turtles in the Waddell Creek watershed spent more time in upland habitats than they did in the stream. Consequently, the riparian forests, thickets and wetlands adjacent to stream channels appear to be critical in maintaining viable populations of stream turtles.

Upland turtles at Site A (lagoon area) overwintered buried in litter or soil within forested areas with dense understories of blackberry, poison oak and stinging nettle. Additionally, they made extensive use of seasonally ponded habitats, especially in spring when these habitats may also provide foraging opportunities. Both the riparian habitats and the ponded areas may provide protection from weather and predators equivalent to that provided by the permanent pond.

Upstream habitats for overwintering appeared to be less suitable, possibly because of a narrow flood plain and riparian forest. Although a portion of the turtles overwintered at Sites B and C (upstream), the lagoon area appears to play a central role in terms of dispersal to most terrestrial overwintering sites. Several turtles that migrated upstream to nest or forage during the summer months were eventually found back in the lagoon area by September. Later, these turtles were found upland in the habitats surrounding the lagoon. Turtles moving to Turtle Pond to overwinter also returned to the lagoon before moving overland to Turtle Pond. The importance of maintaining the lagoon area and its surrounding habitats, therefore, appears to be critical to the survival of the turtles at this site.

While most turtles were found to move upland with the onset of the first winter storms in November and December, some turtles moved upland as early as September. Some of these turtles moved to terrestrial overwintering sites, while others moved to Turtle Pond. These findings suggest that some turtles may be triggered to move upland by factors other than increased winter stream flows such as decreased food availability.

Even when upland, overwintering turtles were relatively active at this mild central coast site. They were most likely to be hunkered down in the colder months of December, January and February but were relatively alert and often basked in other months. The extent of basking was a surprise, as this should increase metabolic rate and use of stored fat at a time when no foraging was apparently going on and predation risk may be increased by basking. Winter basking may be necessary for eliminating accumulated waste or some other important metabolic activity.

Predation, especially by raccoons (*Procyon lotor*), appears to be an important factor in turtle populations at some locations (Holland 1994). However, at Waddell Creek there was little evidence of predation. Only one radio-tagged turtle was lost (to a loon) and few (3 of 196 turtles) showed signs of shell or limb damage. The high quality of the potential overwintering sites may be partially responsible for the low predation rate of upland turtles.

Limited data indicates that juveniles may use the same habitat as adults for overwintering (several juveniles were found using North Pond in the spring). This study, however, focused only on overwintering by adult turtles because of the difficulties of placing long-lived transmitters on small turtles. Short-lived, small transmitters could be used to determine overwintering habitat use and timing for juvenile turtles. These individuals may be especially vulnerable to predation in upland sites.

MANAGEMENT IMPLICATIONS

Both the development of riparian corridors and flood control measures have direct impacts on overwintering turtles. Riparian clearing results in a loss of vegetation and seasonally ponded water areas used by turtles for terrestrial overwintering. Development and flood control measures often leave no flood plain or upland habitats for overwintering (or nesting). In areas where channelization has occurred, often the only habitat above the flood line is a sparsely vegetated levee.

Construction activity that involves disturbance to riparian habitats after the first storms of the season or from November to April is likely to kill or displace overwintering turtles. Because the turtles are buried in litter or soil, searching for and removing them during that period is not a practical mitigation method. Waiting until May or later to disturb riparian areas is unlikely to impact overwintering turtles, however, adult females are likely to be moving through riparian corridors to gain access to open areas for nesting. Other species such as nesting birds may also be impacted at this time. Construction activity in early fall (September or October) is least likely to impact turtles or breeding birds.

Although a portion of the available habitat at Site A consisted of closed canopy forest with a non-native German ivy understory, no turtles were found using this habitat to any great extent for overwintering. Non-native vegetation was used when no other was available (Sites B and C), but turtles definitely indicated a lower preference for German ivy. Efforts to prevent its spread may be important to maintaining good overwintering turtle habitat. Hand removal of German ivy is least likely to disturb turtles in early fall (after nesting and prior to overwintering).

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TABLES

Table 1: Transmitter attachment dates, identification number, sex, length, weight and location at time of initial capture and checklist of radio-tracked turtles that wore transmitters with activity sensors during the 1996/97 over-wintering season.

Transmitter Attachment Dates	ID #	Sex	Total Carapace Length (mm)	Weight (grams)	Initial Capture Location	Activity Sensor 1996/97
21 Aug 95 - Jun 98+	14	M	171	585	Lagoon	X
21 Aug 95 - Dec 97 (Failed)	15	F	164	605	Lagoon	
21 Aug 95 - 27 Aug 97	18	F	148	455	Lagoon	X
21 Aug 95 - 14 Jul 97	82	M	155	435	Lagoon	X
28 Aug 95 - 26 Aug 97	16	F	168	715	Lagoon	X
28 Aug 95 - 4 Jul 96 (Died)	87	F	155	525	Lagoon	
30 Aug 95 - 18 Jun 97	8	M	163	590	Lagoon	X
30 Aug 95 - 13 Apr 97	22	M	153	385	Lagoon	X
30 Aug 95 - 14 Jul 97	23	M	151	500	Lagoon	X
30 Aug 95 - Jun 98+	93	F	142	345	Lagoon	X
2 Sep 95 - 21 Aug 97	17	F	168	720	Lagoon	X
2 Sep 95 - 26 Aug 97	71	F	158	565	Lagoon	X
2 Sep 95 - 4 Mar 97	97	M	144	360	Turtle Pond	
18 Sep 95 - 10 Mar 97	110	M	139	320	Turtle Pond	
25 Sep 95 - 17 Aug 97	61	F	138	375	Turtle Pond	X
20 Dec 95 - 25 Apr 97	13	M	152	470	Lagoon	
9 Apr 96 - Jun 98+	21	F	159	690	North Pond	
9 Apr 96 - Jun 98+	118	F	160	655	North Pond	
9 May 96 - 17 Aug 97	169	F	138	405	Turtle Pond	
20 Jun 96 - 12 Jul 97	88	M	148	435	Weir	X
21 Jun 96 - 16 Aug 97	173	F	130	285	Upstream	X
2 Jul 96 - Jun 98+	177	F	164	645	Weir	X
23 Jul 96 - 3 Jul 97	119	M	133	325	Weir	
23 Aug 96 - 20 Jun 97	139	M	160	575	Upstream	
17 Sep 96 - 18 Aug 97	183	F	121	235	Upstream	
24 Sep 96 - 13 Aug 97	11	M	150	495	Weir	
11 Oct 96 - 24 Aug 97	9	M	153	480	Lagoon	
18 Oct 96 - 9 Sep 97	200	F	143	460	Lagoon	
26 Nov 96 - Jun 98+	202	M	163	590	Upstream	
28 Jan 97 - 12 Dec 97	19	M	146	475	Upstream	
24 Mar 97 - 27 Aug 97	122	F	162	560	North Pond	

Table 2: Habitats and sexes of turtles captured in the Waddell Creek Study Area from July 1995 to April 1997.

HABITAT	MALES	FEMALES	UNDETERMINED	TOTAL	PERCENT
Turtle Pond only	38	13	27	78	39.8
Waddell Creek only	32	25	35	92	46.9
Turtle Pond & Waddell Creek	19	4	3	26	13.3
TOTAL	89	42	65	196	
PERCENT	45.4	21.4	33.2		

Table 3: Habitats and sexes of turtles radio-tracked in the Waddell Creek Study Area from 1995 - 1998.

HABITAT	MALES	FEMALES	TOTAL	PERCENT
Turtle Pond only	2	2	4	12.9
Waddell Creek only	10	13	23	74.2
Turtle Pond & Waddell Creek	3	1	4	12.9
TOTAL	15	16	31	
PERCENT	48.4	51.6		

Table 4: Number and percent of radio-tagged turtles overwintering in different regions of the Waddell Creek Study Area. Note: "Tracked" data include turtles radio-located at least once a week throughout an entire season while "Incidental" data include both partial season tracks and incidental captures.

OVERWINTER LOCATION	1995/96				1996/97				1997/98	
	Tracked		Incidental		Tracked		Incidental		Incidental	
	#	%	#	%	#	%	#	%	#	%
Site A: Turtle Pond (summer in pond)	3	18.8	1	12.5	4	14.3	0	0.0	0	0.0
Site A: Turtle Pond (summer in stream)	3	18.8	1	12.5	3	10.7	0	0.0	0	0.0
Site A: East Bank only	3	18.8	1	12.5	4	14.3	0	0.0	3	37.5
Site A: West Bank only	3	18.8	5	62.5	12	42.9	1	50.0	2	25.0
Site A: Both Banks	4	25.0	0	0.0	0	0.0	0	0.0	1	12.5
Site B: East Bank	0	0.0	0	0.0	1	3.6	0	0.0	0	0.0
Site B: West Bank ; Site C: East Bank	0	0.0	0	0.0	1	3.6	0	0.0	0	0.0
Site C: West Bank	0	0.0	0	0.0	2	7.1	1	50.0	2	25.0
Site C: Both Banks	0	0.0	0	0.0	1	3.6	0	0.0	0	0.0
Total # of Turtles	16		8		28		2		8	

Table 5: Types of movements made by radio-tagged turtles at Site A during the 1995/96 and 1996/97 overwintering seasons (based on weekly / twice weekly observations). Data shown include observations made from the time a turtle first moved upland until its final return to the stream. Note: Excludes turtles overwintering in Turtle Pond.

Date	% Fixed	%<1m	%<5m	%<10m	%<25m	%<50m	%>50m	# of Turtles
Sep-95	66.7	11.1	11.1	0.0	0.0	0.0	11.1	2
Oct-95	50.0	0.0	16.7	8.3	8.3	0.0	16.7	3
Nov-95	47.1	5.9	5.9	0.0	23.5	5.9	11.8	3
Dec-95	62.5	0.0	7.5	2.5	10.0	5.0	12.5	10
Jan-96	77.3	0.0	11.4	4.5	2.3	0.0	4.5	10
Feb-96	50.0	5.0	11.7	8.3	11.7	6.7	6.7	10
Mar-96	27.5	2.2	17.6	11.0	22.0	8.8	11.0	10
Apr-96	15.5	6.9	25.9	13.8	20.7	8.6	8.6	9
May-96	45.9	0.0	24.3	0.0	10.8	2.7	16.2	2
Jun-96	50.0	0.0	0.0	50.0	0.0	0.0	0.0	2
Nov-96	52.5	22.5	10.0	5.0	0.0	2.5	7.5	10
Dec-96	47.4	8.4	16.8	6.3	8.4	6.3	6.3	16
Jan-97	58.8	8.4	15.3	6.9	5.3	4.6	0.8	16
Feb-97	80.7	5.9	6.7	4.2	0.8	1.7	0.0	15
Mar-97	60.0	8.0	12.0	6.0	7.0	3.0	4.0	15
Apr-97	40.5	16.7	14.3	0.0	19.0	9.5	0.0	7
May-97	28.6	14.3	42.9	0.0	14.3	0.0	0.0	3

Table 6: Upland habitats used by radio-tagged turtles at Site A during the 1995/96 overwintering season (based on weekly / twice weekly observations). Note: Excludes turtles over-wintering in Turtle Pond. Open squares indicate no turtle use.

		Percent of Upland Turtle Observations in Each Habitat									
Habitat	Percent Available	[illegible] n=2	[illegible] n=2	[illegible]	[illegible] n=10	[illegible] n=10	[illegible] n=16	[illegible]	[illegible]	[illegible] n=2	[illegible] n=2
Upland Marsh	25							8.1	17.3	20.0	50.0
Shrub	2								1.9	56.7	50.0
Upland Pond	6						10.3	16.3	34.6	23.3	0.0
Agricultural Field	2							3.5			
Non-Wetland Herbaceous	16						1.7	1.2	7.7		
Closed Canopy Forest: Ponded Water	3				17.5	25.6	37.9	52.3	17.3		
Closed Canopy Forest: Low Willows	21	100	100	58.3	35.0	18.6	8.6	1.2	7.7		
Closed Canopy Forest: Native Understory	22			41.7	47.5	55.8	41.4	17.4	13.5		
Closed Canopy Forest: German Ivy	3										

Table 7: Upland habitats used by radio-tagged turtles at Site A during the 1996/97 overwintering season (based on weekly / twice weekly observations). Note: Excludes turtles over-wintering in Turtle Pond. Open squares indicate no turtle use.

		Percent of Upland Turtle Observations in Each Habitat						
Habitat	Percent Available	Nov n=10	Dec n=16	Jan n=16	Feb n=15	Mar n=15	Apr n=7	May n=5
Upland Marsh	25	28.3	8.7	7.0	6.7	24.5	46.5	9.1
Shrub	2	5.7						
Upland Pond	6		4.8	7.8	6.7	1.0	30.2	90.9
Agricultural Field	2							
Non-Wetland Herbaceous	16		5.8			1.0		
Closed Canopy Forest: Ponded Water	3	1.9	25.0	27.9	25.0	23.5		
Closed Canopy Forest: Low Willows	21	62.3	29.8	20.9	29.2	28.6	16.3	
Closed Canopy Forest: Native Understory	22	1.9	26.0	36.4	32.5	21.4	7.0	
Closed Canopy Forest: German Ivy	3							

Table 8: Percent of dormancy, resting, basking, and moving behaviors observed among radio-tagged turtles at Site A during the 1995/96 and 1996/97 overwintering seasons (based on weekly / twice weekly observations between 10:00 and 16:00). Data shown include observations made from the time a turtle first moved upland until its final return to the stream. Note: Excludes turtles overwintering in Turtle Pond.

Date	% Dormant	% Resting	% Basking	% Moving	% Undetermined	# of Turtles
Sep-95	25.0	0.0	50.0	12.5	12.5	2
Oct-95	36.4	0.0	18.2	18.2	27.3	3
Nov-95	66.7	6.7	6.7	13.3	6.7	3
Dec-95	80.5	4.9	0.0	12.2	2.4	10
Jan-96	86.1	2.8	0.0	5.6	5.6	10
Feb-96	55.1	18.4	10.2	16.3	0.0	10
Mar-96	26.5	52.9	16.2	4.4	0.0	10
Apr-96	2.6	69.2	25.6	2.6	0.0	9
May-96	0.0	66.7	14.3	4.8	14.3	2
Nov-96	78.0	7.3	12.2	2.4	0.0	10
Dec-96	88.1	9.0	1.5	1.5	0.0	16
Jan-97	89.3	6.6	2.5	0.8	0.8	16
Feb-97	86.4	6.2	7.4	0.0	0.0	15
Mar-97	54.9	15.5	29.6	0.0	0.0	15
Apr-97	32.6	18.6	41.9	7.0	0.0	7
May-97	0.0	11.1	88.9	0.0	0.0	3

FIGURES

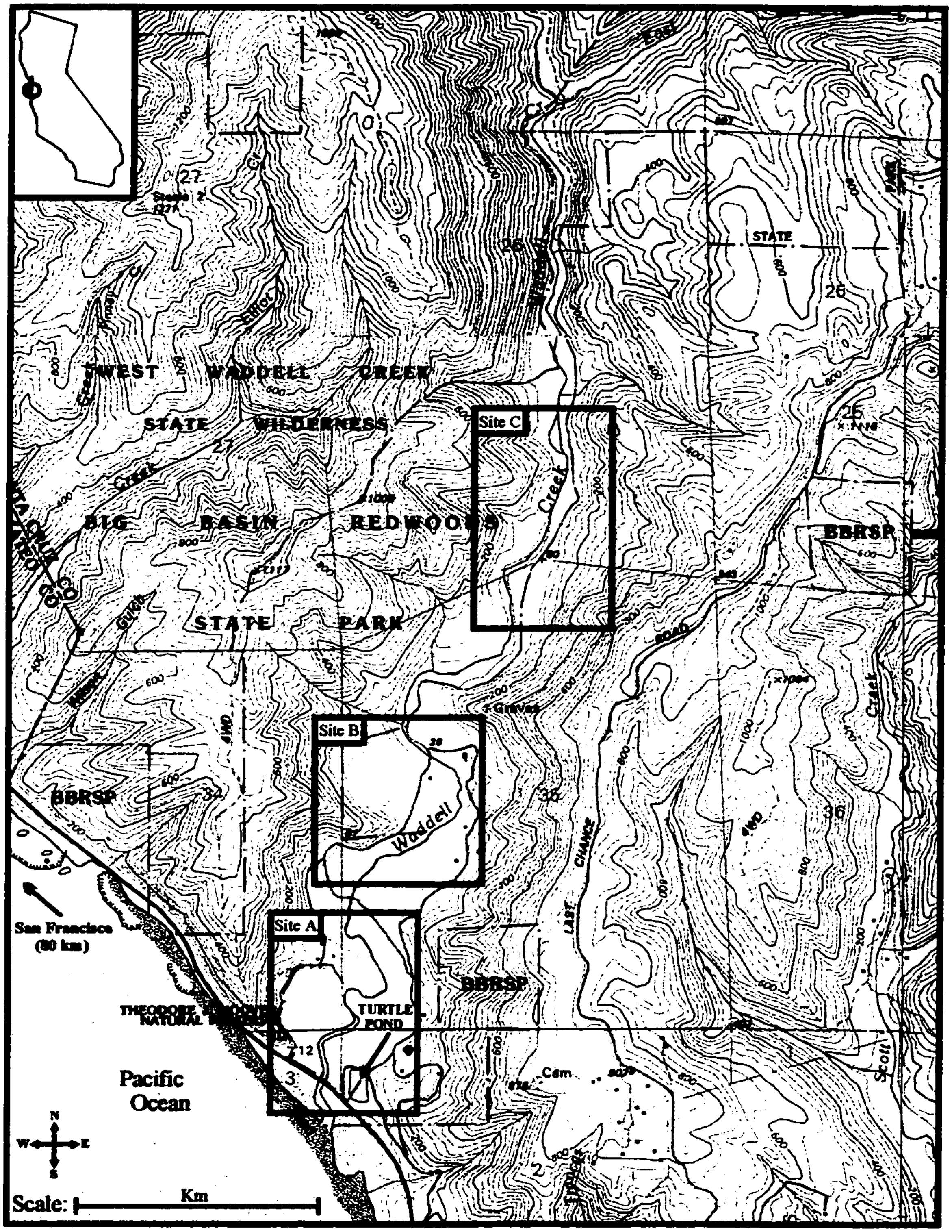

Figure 1: Waddell Creek study area in Santa Cruz County, California, with the three sites used by radio-tagged turtles for overwintering during 1995 - 1997 (USGS topographic map - Ano Nuevo Quadrangle, CA, 7.5 Minute Series, 1991).

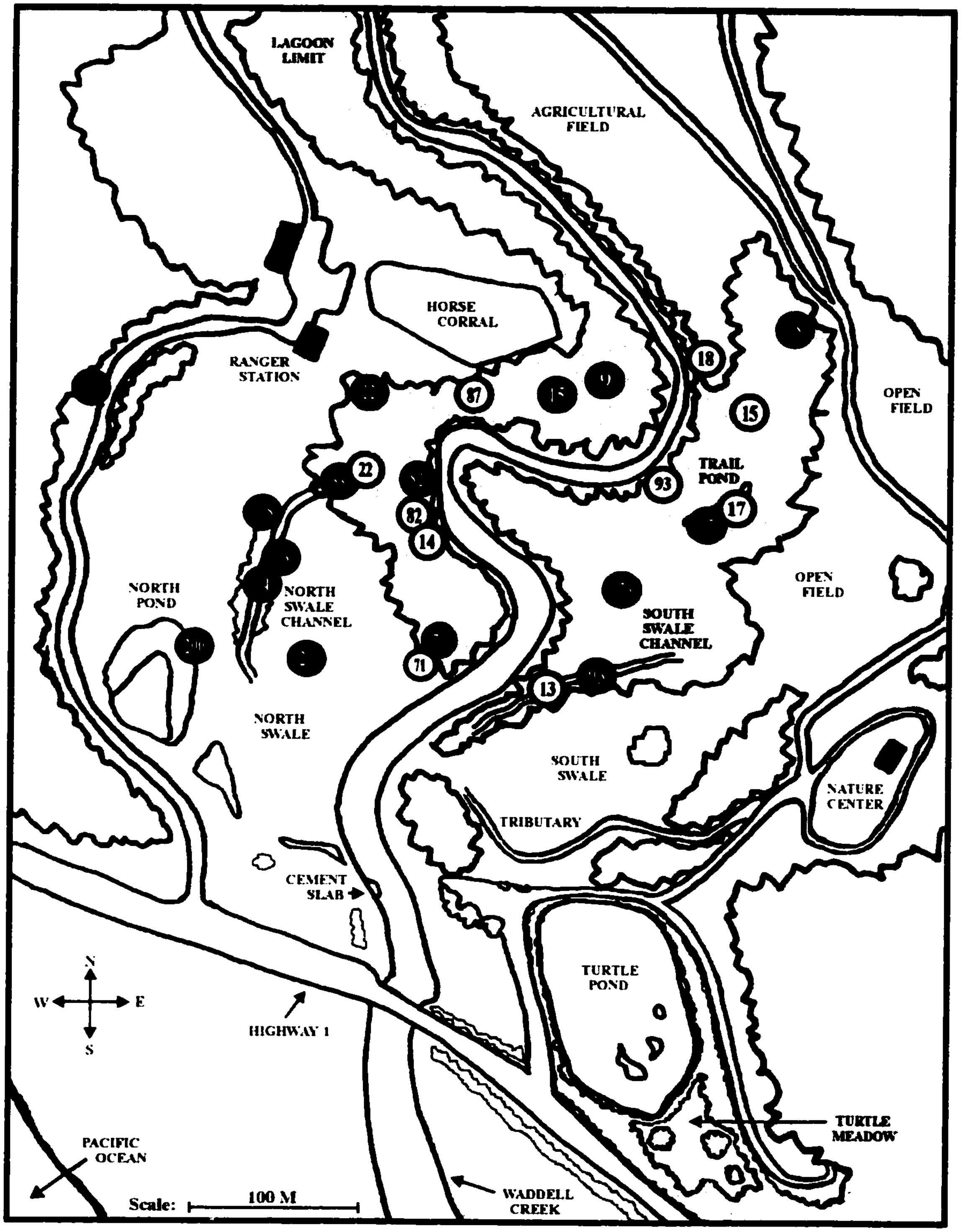

Figure 2: Waddell Creek Site A consisting of channel meters 0 to 1000 upstream of the Highway 1 bridge with the locations of overwintering sites used in microhabitat analysis. White circles represent 1995/96 locations while black circles indicate 1996/97 locations. Numbers inside circles correspond to turtle notch number. Shaded areas represent closed canopy forest. Solid areas are buildings.

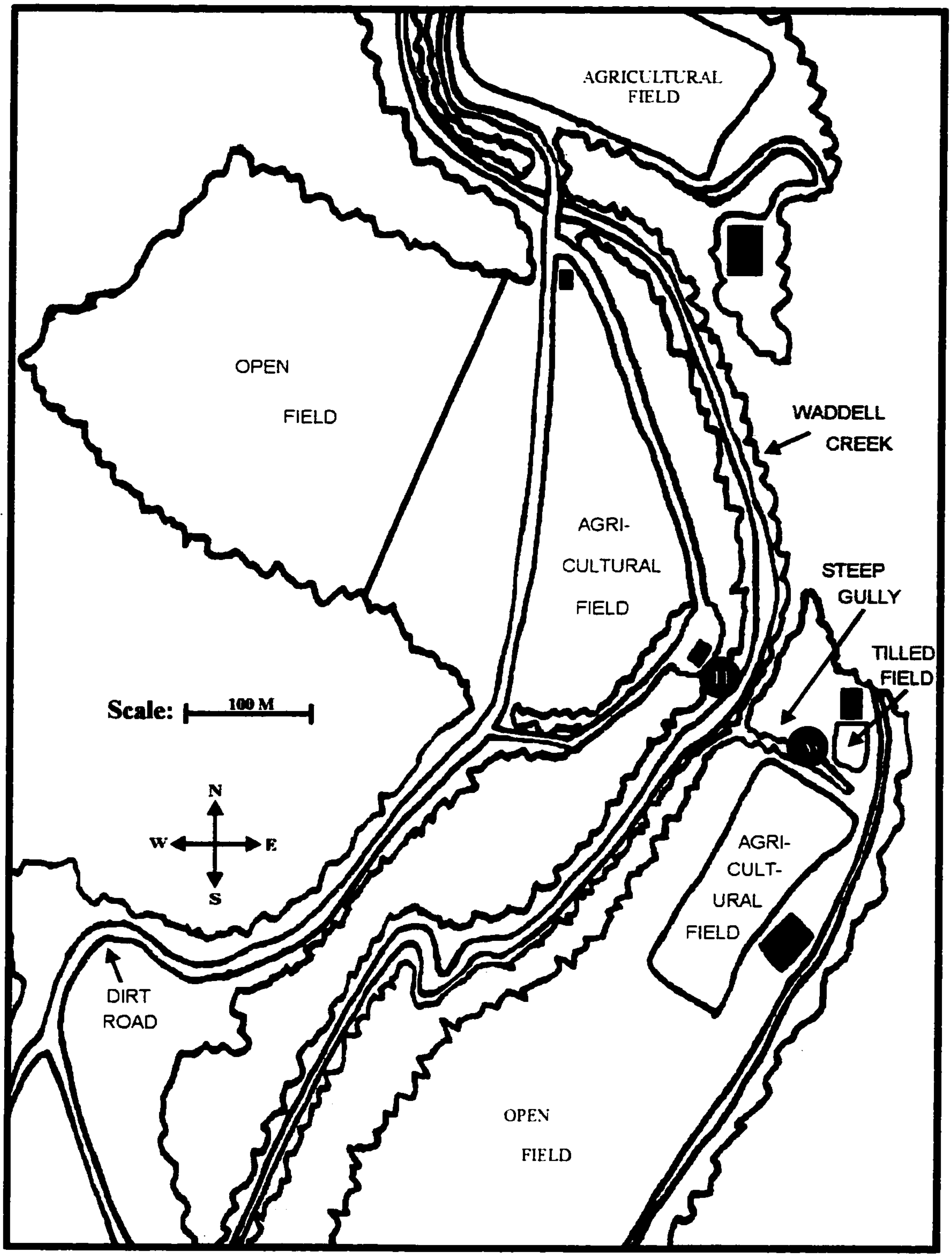

Figure 3: Waddell Creek Site B consisting of channel meters 1200 to 2500 upstream of the Highway 1 bridge with the locations of 1996/97 overwintering sites used in micro-habitat analysis. Numbers inside circles correspond to turtle notch number. Shaded areas represent closed canopy forest. Solid areas are buildings.

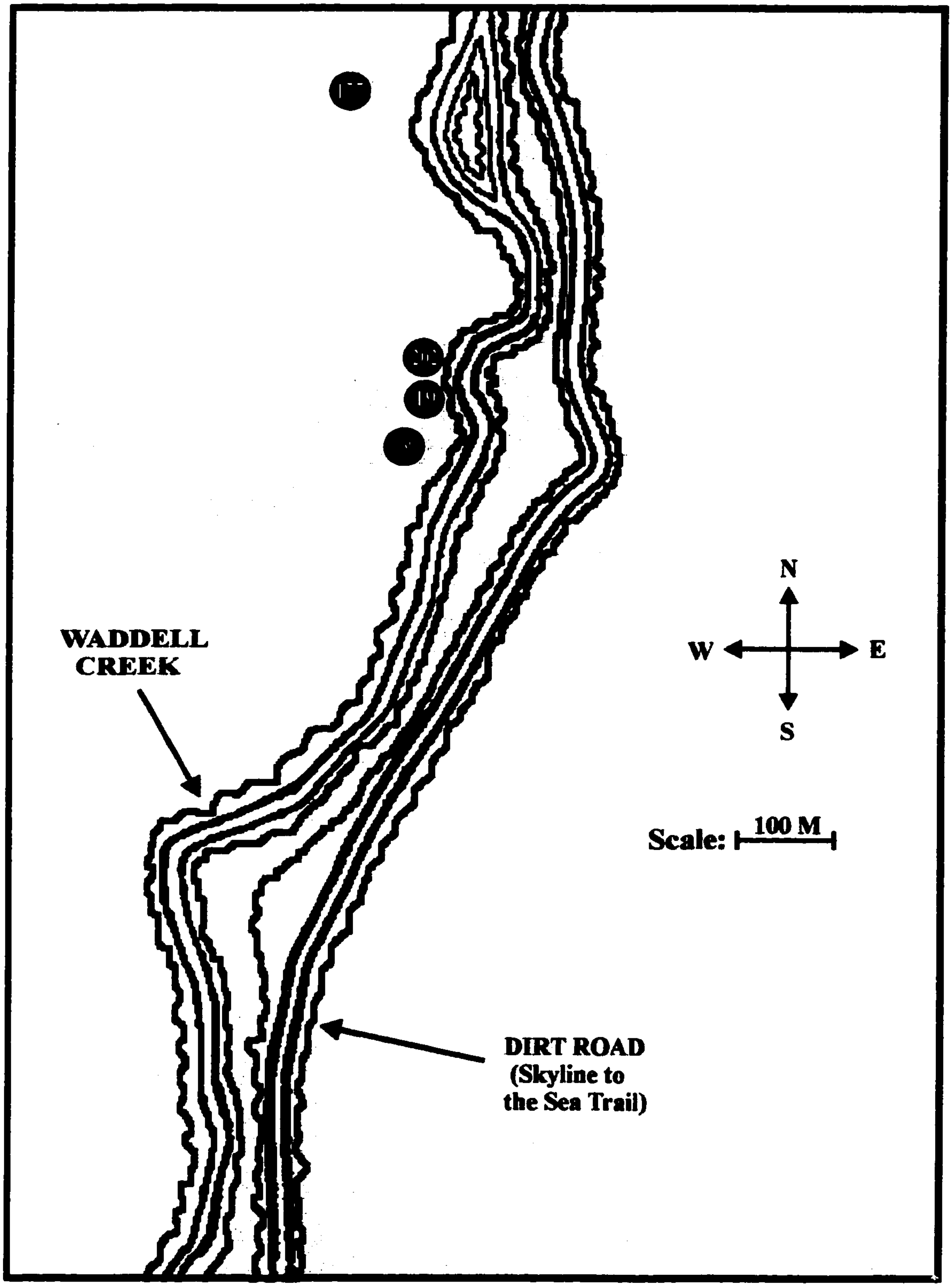

Figure 4: Waddell Creek Site C consisting of channel meters 3100 to 4100 upstream of the Highway 1 bridge with the locations of 1996/97 overwintering sites used in micro-habitat analysis. Numbers inside circles correspond to turtle notch number. Shaded areas represent closed canopy forest.

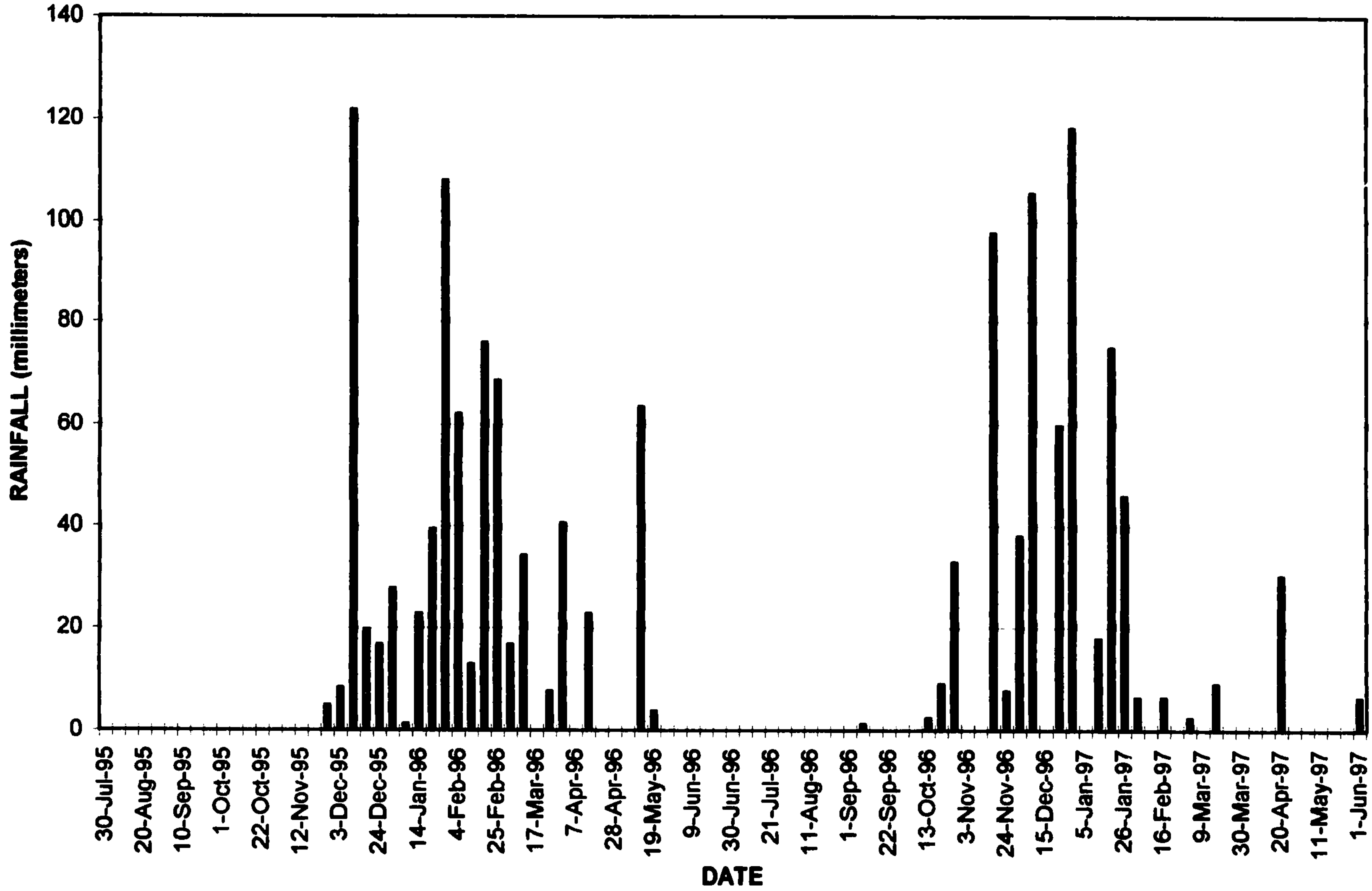

Figure 5: Total weekly rainfall at Waddell Creek near Highway 1 from July 1995 - June 1997 (data from 30 Jul 95 - 16 Dec 95 estimated from City of Santa Cruz).

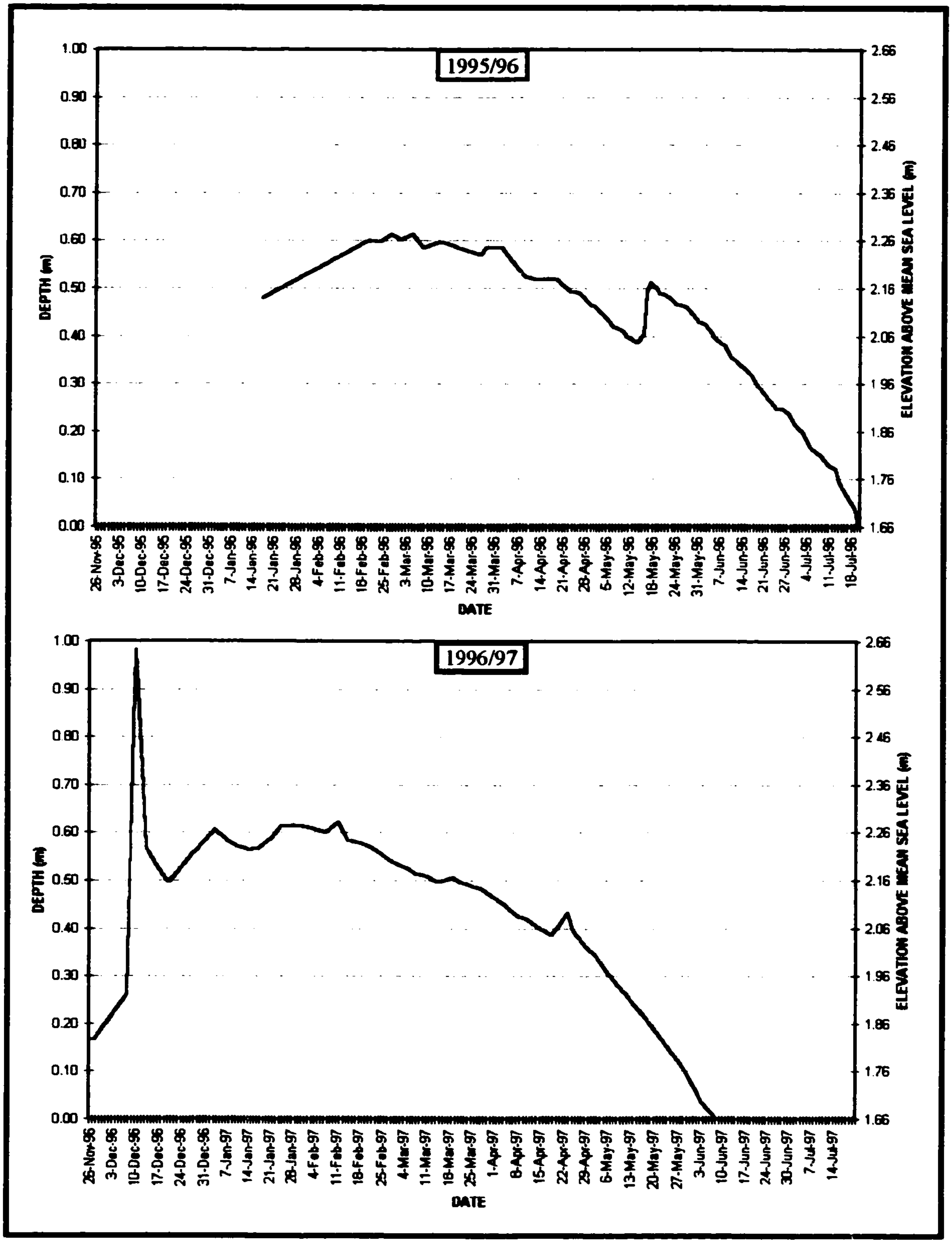

Figure 6: North Pond water level fluctuation during the 1995/96 and 1996/97 overwintering seasons. Note: North Pond was dry by early June in 1997 versus July in 1996.

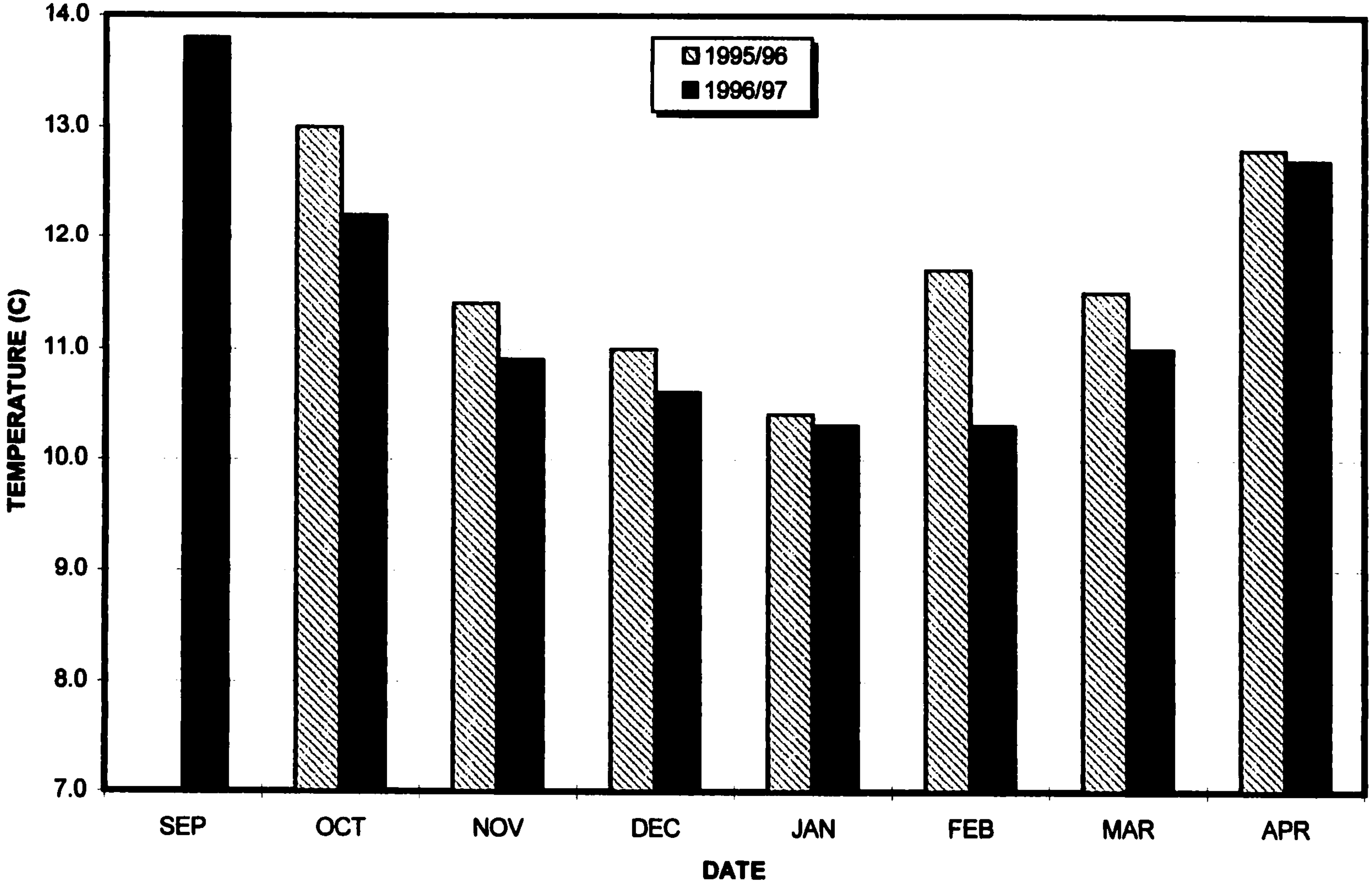

Figure 7: Mean monthly air temperatures (in shade at Turtle Pond) during the 1995/96 and 1996/97 overwintering seasons. Note: No data available for September 1995.

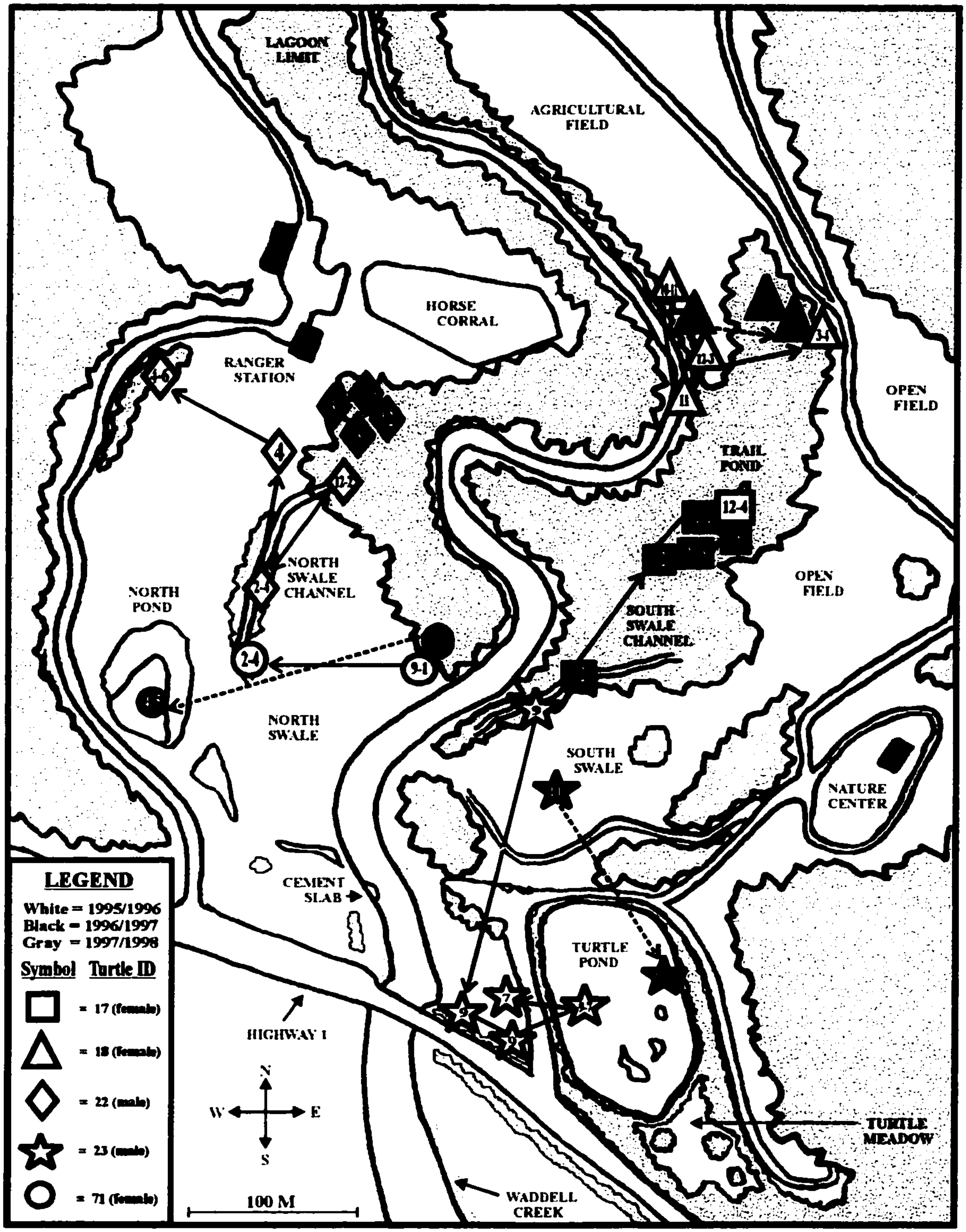

Figure 8: Location and movement of turtles #17, #18, #22, #23 and #71 at Site A during both the 1995/96 and 1996/97 overwintering seasons. Incidental capture data for turtle #18 in December 1997 also shown. Numbers within symbols indicate month (Note: Lines connecting symbols do not necessarily represent path traveled by turtle).

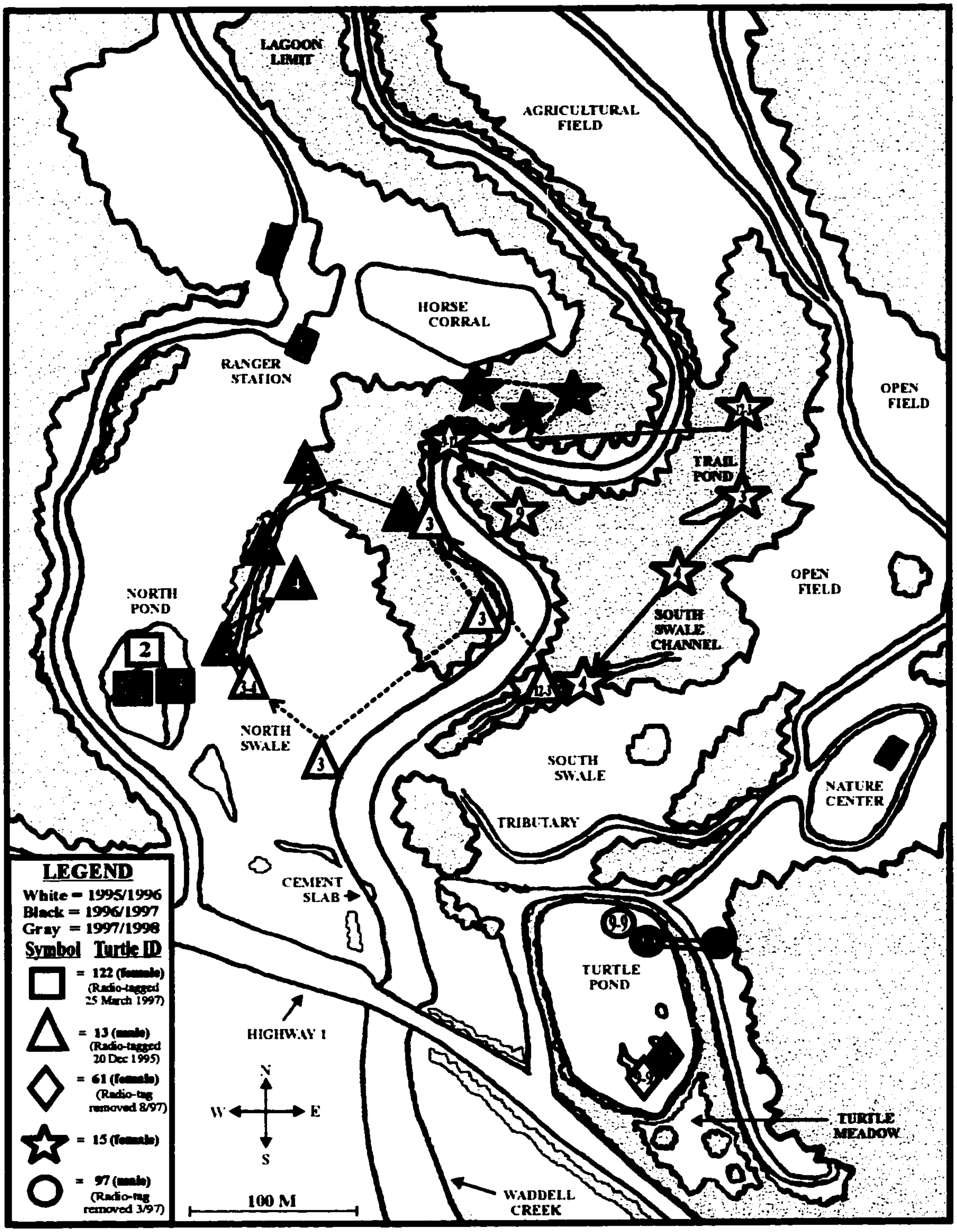

Figure 9: Location and movement of turtles #122, #13, #61, #15 and #97 at Site A during both the 1995/96 and 1996/97 overwintering seasons. Capture location of turtle #122 in July 1998 also shown. Numbers within symbols indicate month (Note: Lines connecting symbols do not necessarily represent path traveled by turtle).

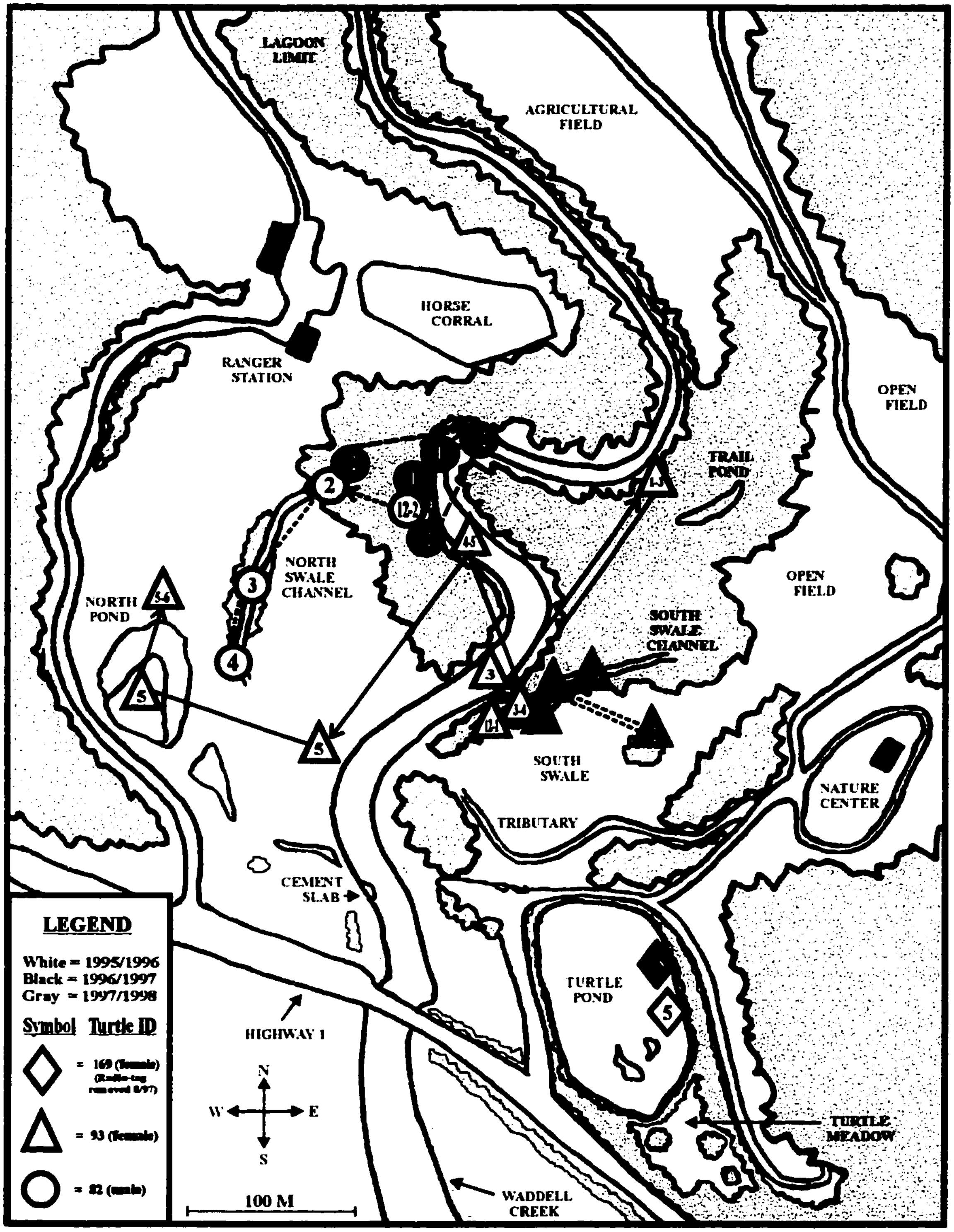

Figure 10: Location and movement of turtles #169, #93 and #82 at Site A during both the 1995/96 and 1996/97 over-wintering seasons. Tracking data for turtle #93 in Nov/Dec 1997 also shown. Numbers within symbols indicate month (Note: Lines connecting symbols do not necessarily represent path traveled by turtle).

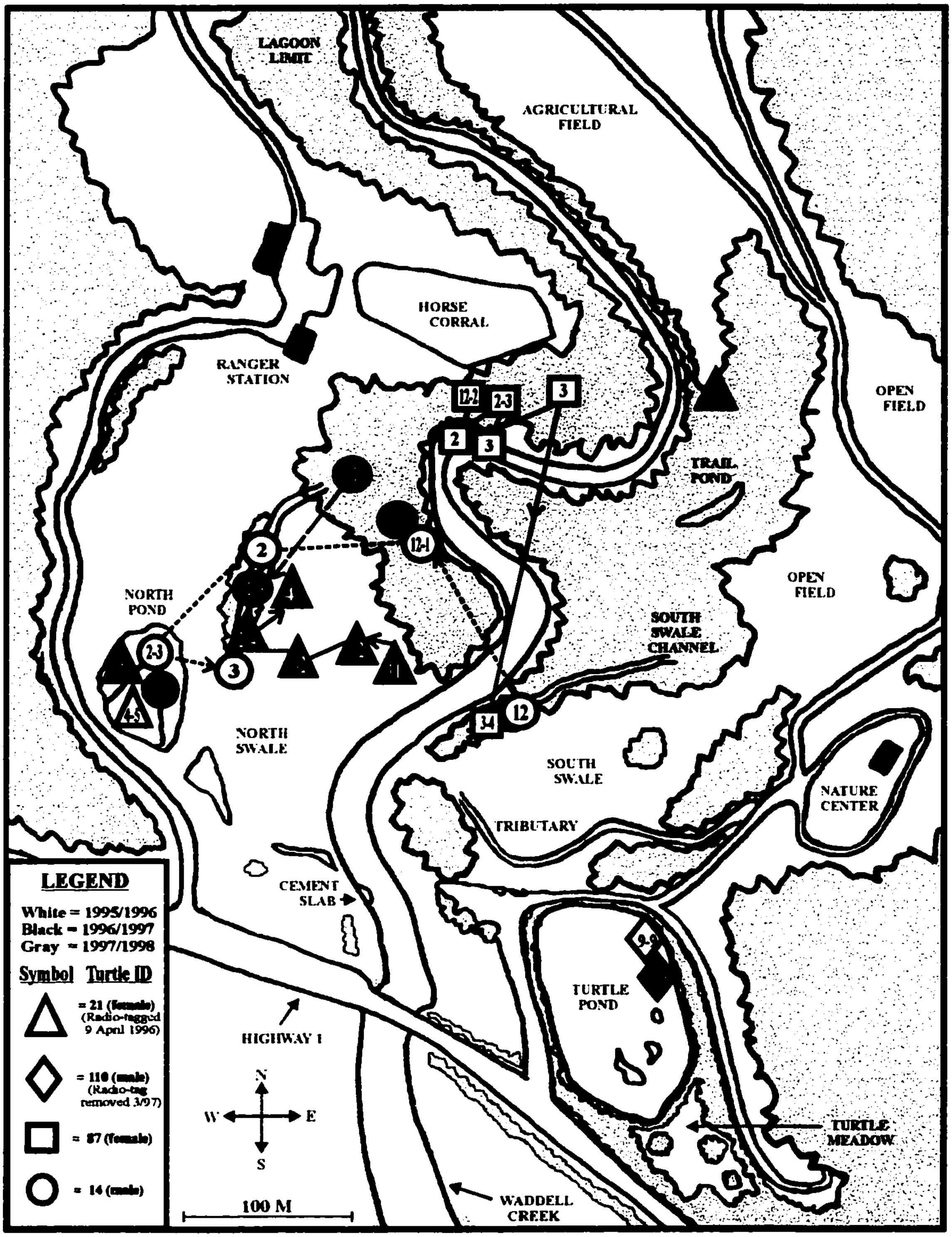

Figure 11: Location and movement of turtles #21, #110, #87 and #14 at Site A during both the 1995/96 and 1996/97 overwintering seasons (1995/96 data only for #87). Tracking data for turtles #21 and #14 in 1997/98 also shown. Numbers within symbols indicate month (Note: Lines connecting symbols do not necessarily represent path traveled by turtle).

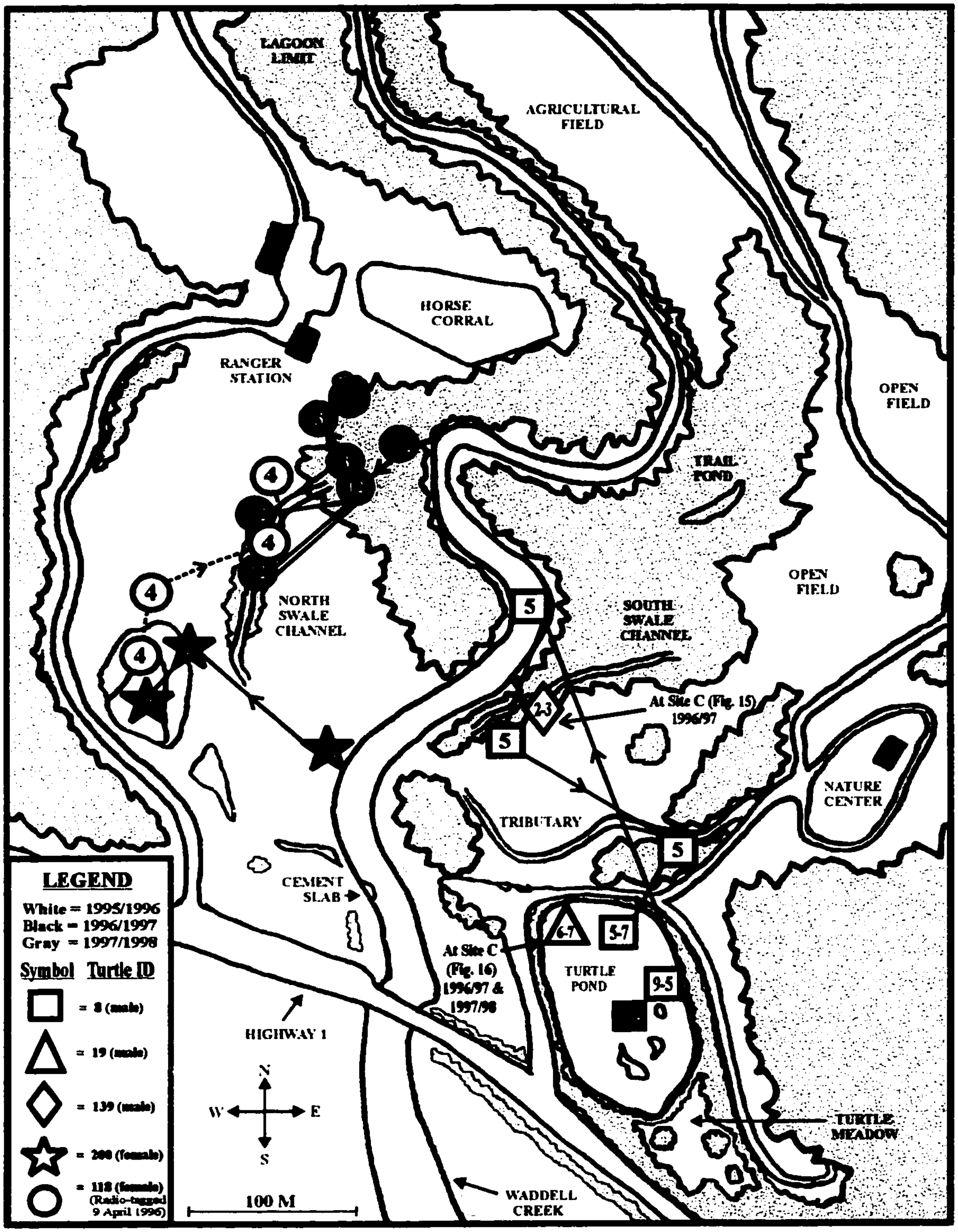

Figure 12: Location and movement of turtles #8, #19, #139, #200 and #118 at Site A during the 1995/96 and/or 1996/97 overwintering seasons. Tracking data for turtle #118 in Nov/Dec 1997 also shown. Numbers within symbols indicate month (Note: Lines connecting symbols do not necessarily represent path traveled by turtle).

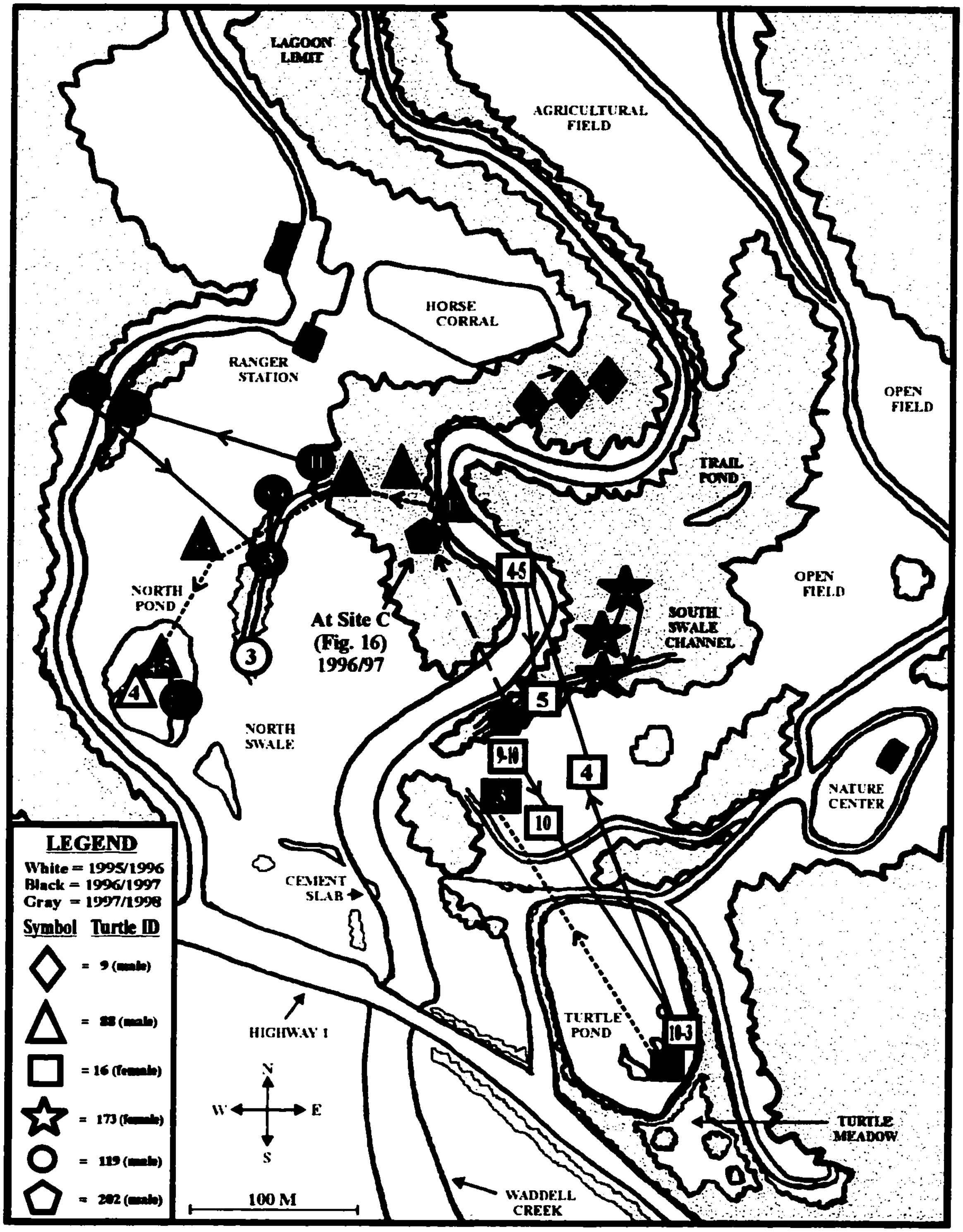

Figure 13: Location and movement of turtles #9, #88, #16, #173 and #119 at Site A during the 1995/96 and/or 1996/97 overwintering seasons. Tracking data for turtle #202 in Nov/Dec 1997 and incidental capture location of turtle #119 in Jun 1998 also shown. Numbers within symbols indicate month (Note: Lines connecting

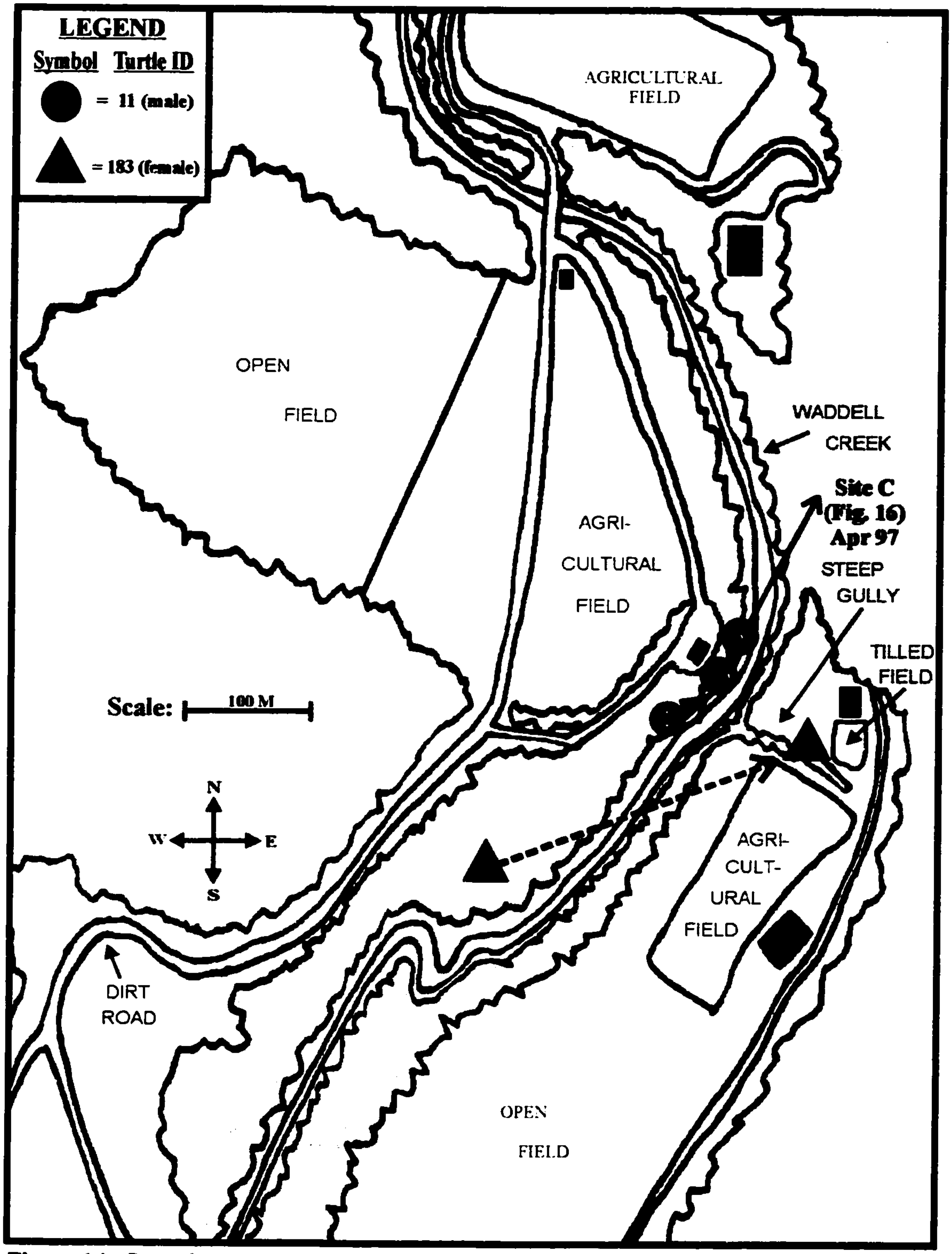

Figure 14: Location and movement of turtles #11 and #183 at Site B during the 1996/97 overwintering season. Numbers within symbols indicate month (Note: Lines connecting symbols do not necessarily represent path traveled by turtle).

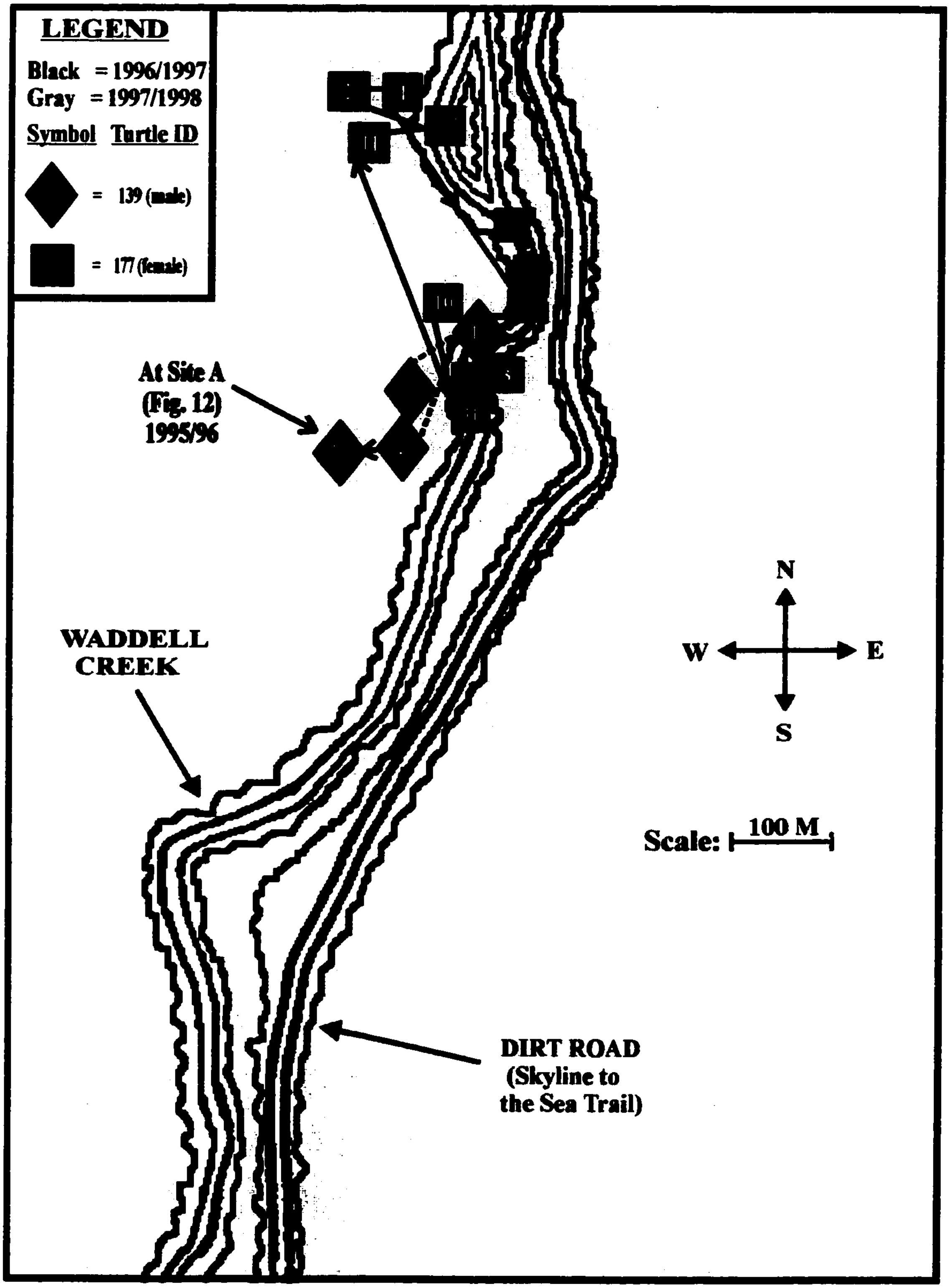

Figure 15: Location and movement of turtles #139 and #177 at Site C during the 1996/97 overwintering season. Tracking data for turtle #177 in Nov/Dec 1997 also shown. Numbers within symbols indicate month (Note: Lines connecting symbols do not necessarily represent path traveled by turtle).

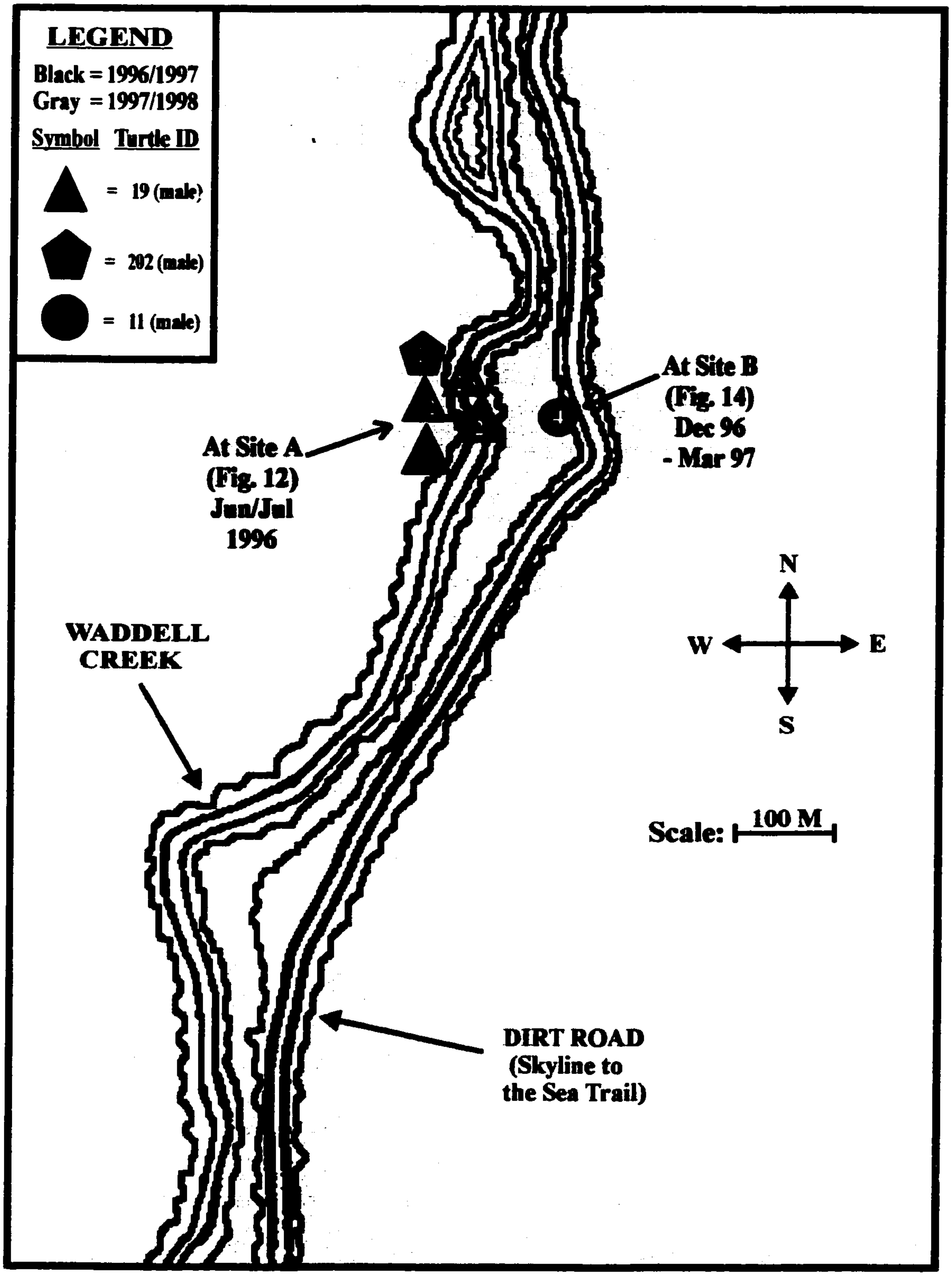

Figure 16: Location and movement of turtles #19, #202 and #11 at Site C during the 1996/97 overwintering season. Tracking data for turtle #19 in December 1997 also shown. Numbers within symbols indicate month (Note: Lines connecting symbols do not necessarily represent path traveled by turtle).

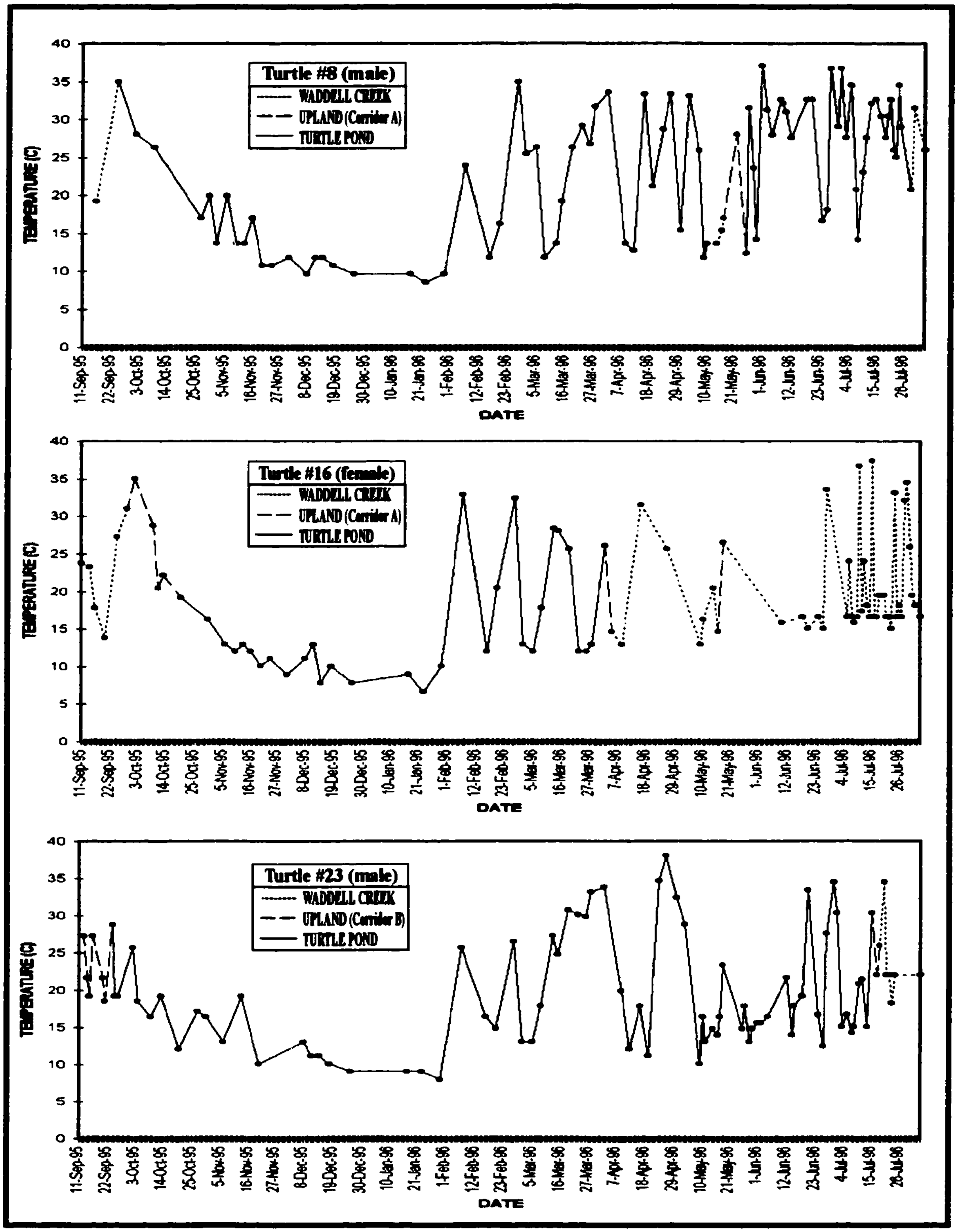

Figure 17: Comparison of transmitter temperature and location of three turtles moving between Waddell Creek and Turtle Pond during the 1995/96 overwintering season. All observations made between 10:00 and 16:00.

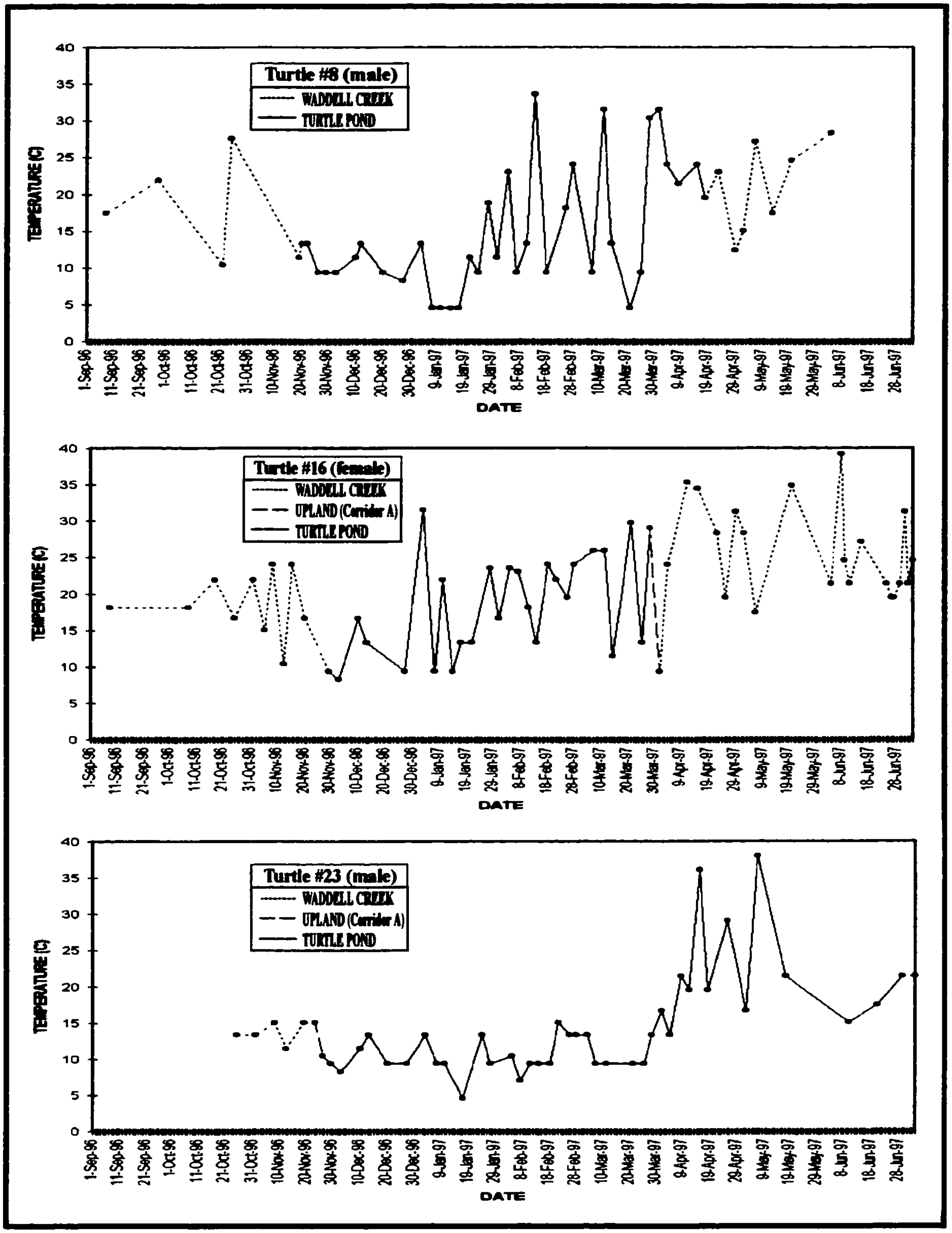

Figure 18: Comparison of transmitter temperature and location of three turtles moving between Waddell Creek and Turtle Pond during the 1996/97 overwintering season. All observations made between 10:00 and 16:00.

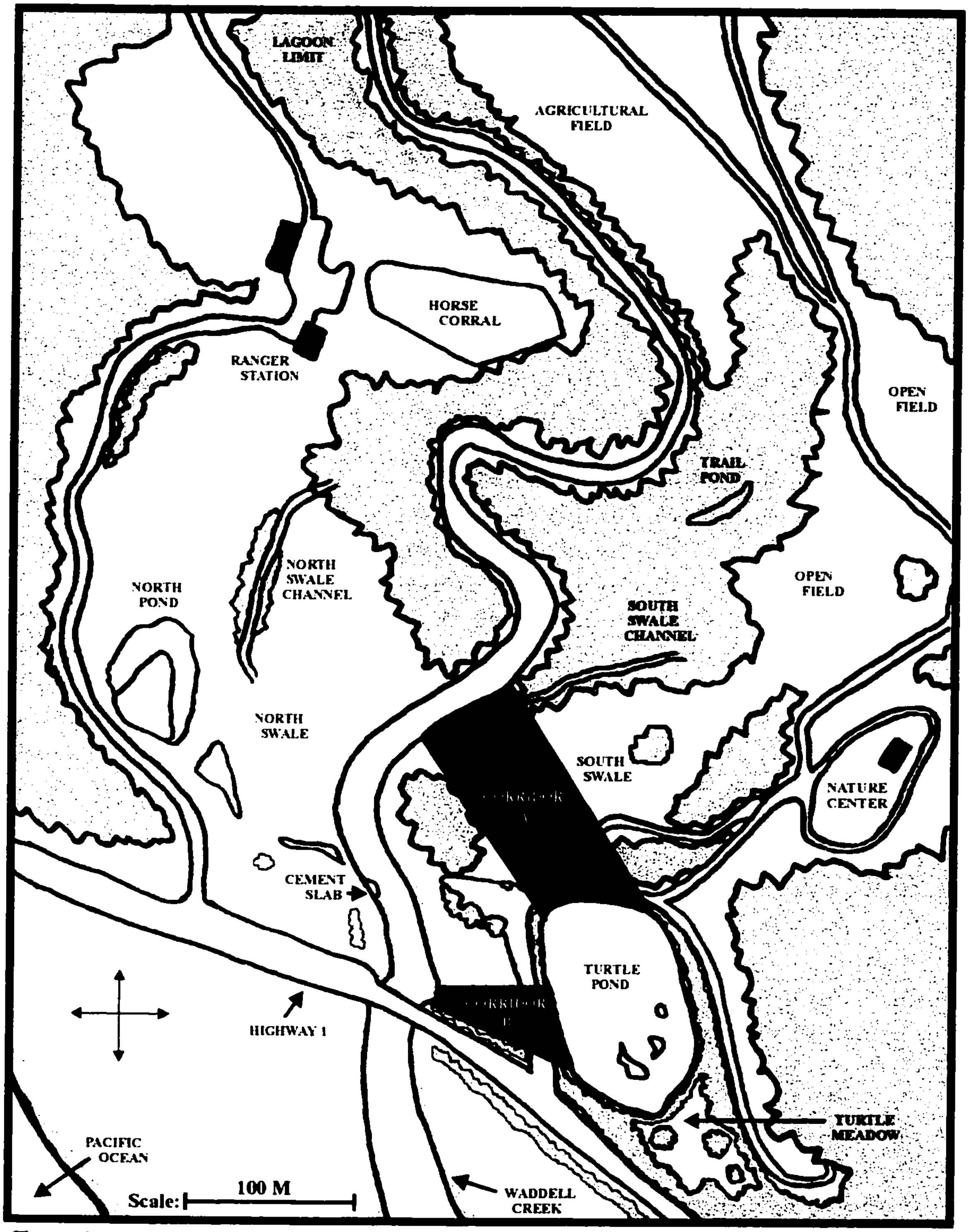

Figure 19: Two corridors used by radio-tagged turtles moving between Waddell Creek and Turtle Pond during the 1995 - 1997 study (Corridor A = South Swale; Corridor B = Toe of Hwy 1 embankment).

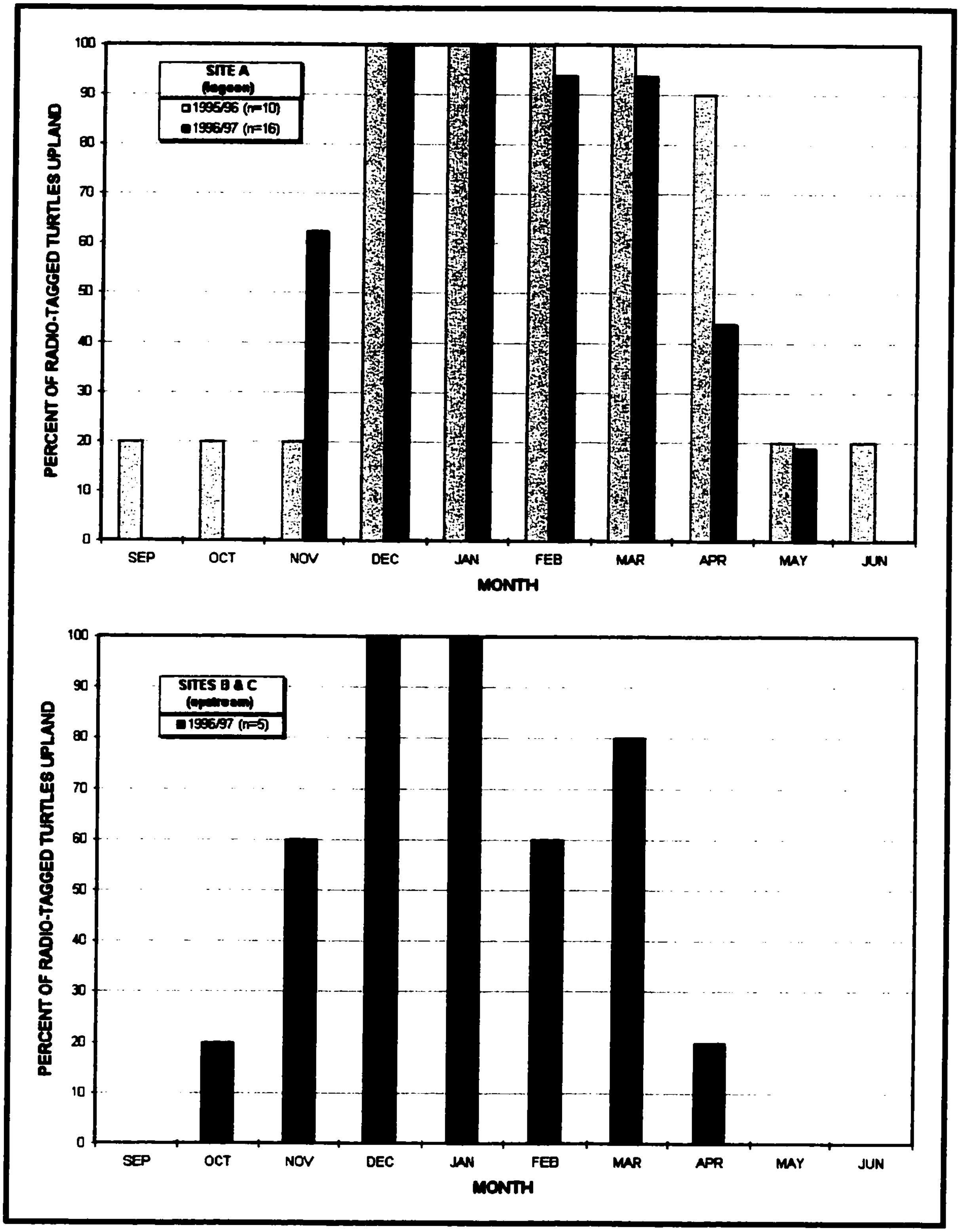

Figure 20: Percent of radio-tagged turtles from Waddell Creek that were located upland each month during the 1995/96 and 1996/97 overwintering seasons (based on weekly / twice weekly observations). Note: Excludes turtles that overwintered in Turtle Pond.

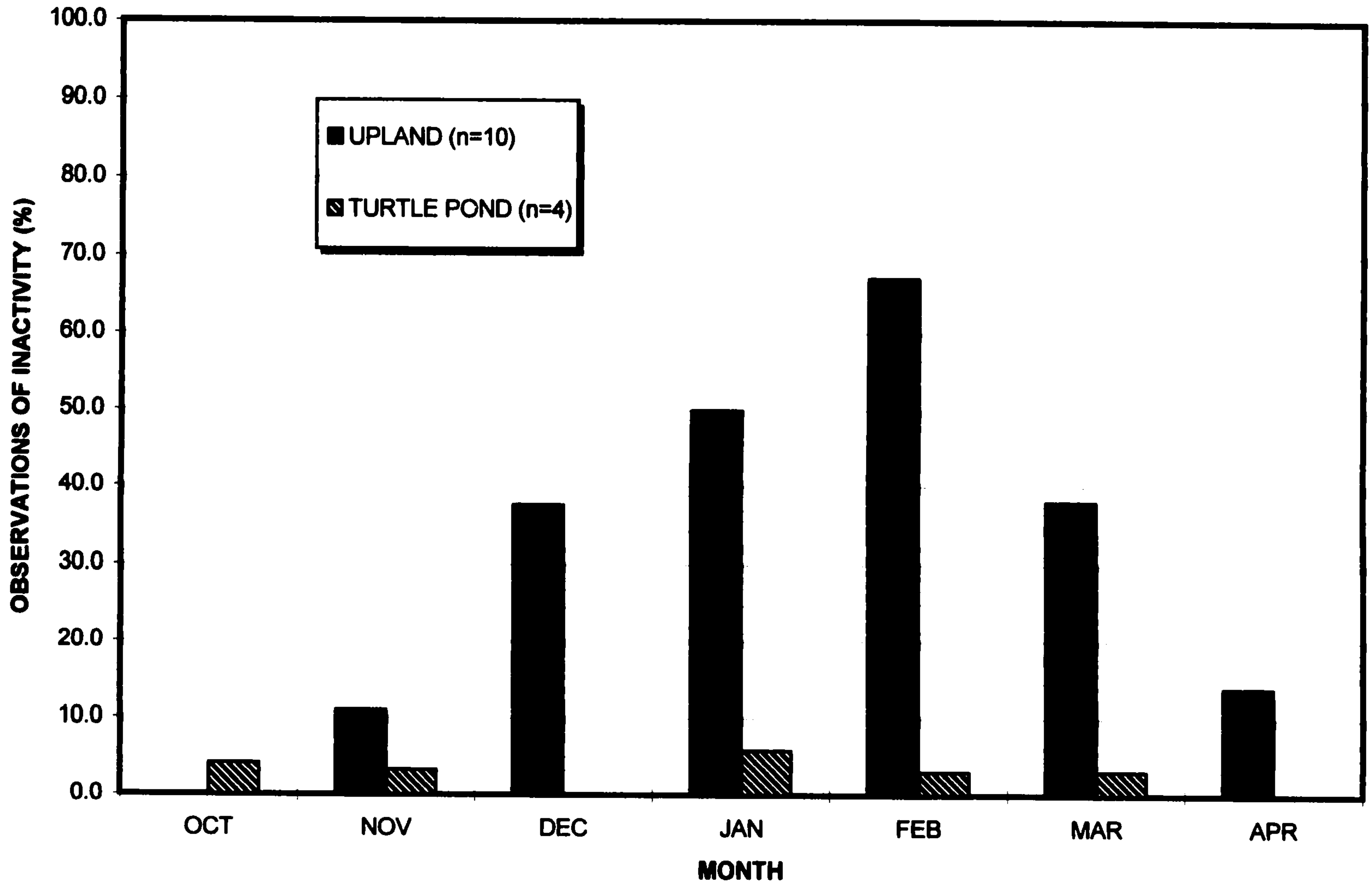

Figure 21: Observations of inactivity during the 1996/97 overwintering season (based on weekly / twice weekly sampling of 14 turtles wearing transmitter motion sensors).

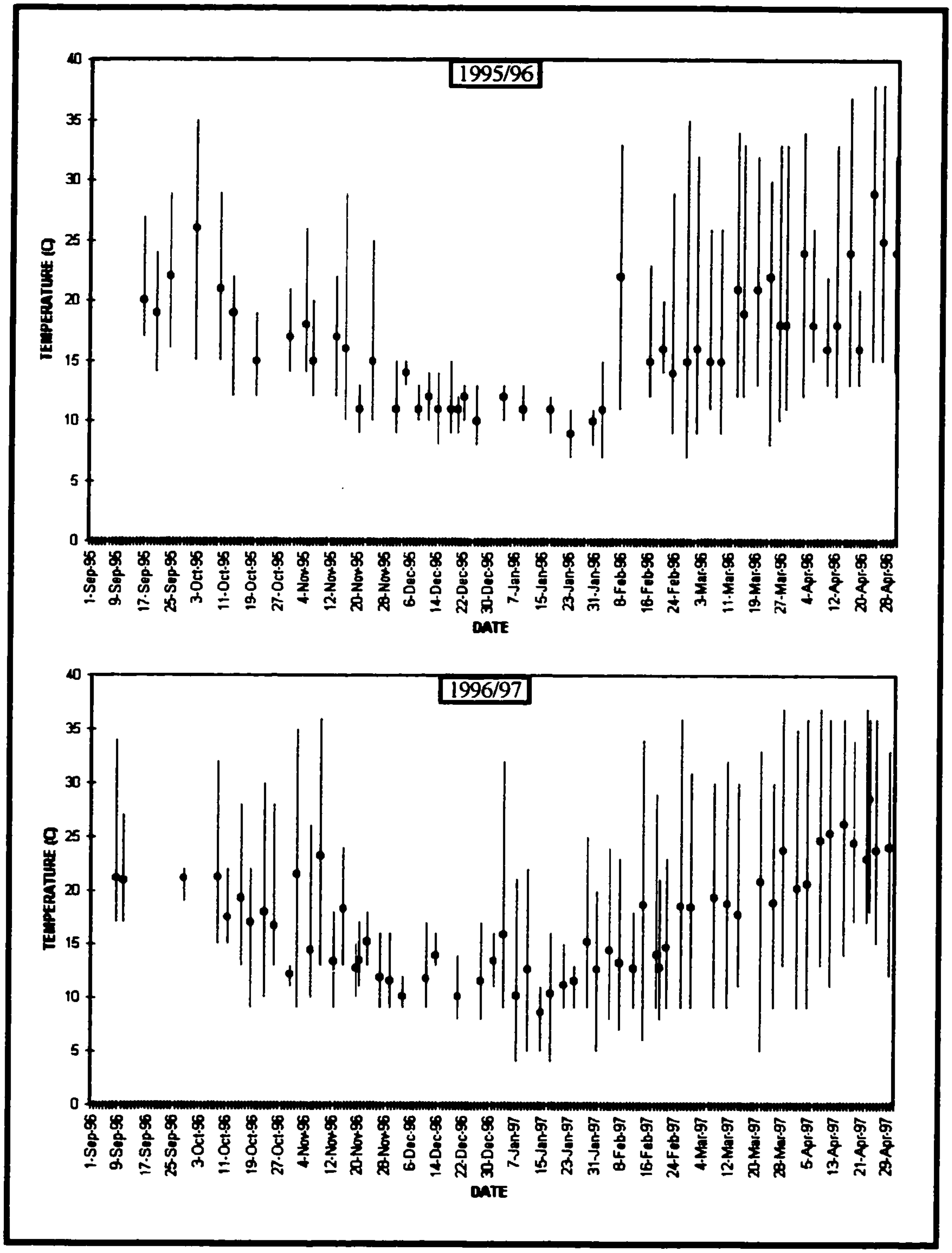

Figure 22: Mean and range for transmitter temperatures of radio-tagged turtles at Site A during the 1995/96 and 1996/97 overwintering seasons (data shown include only those dates with observations of five or more (maximum = 24) turtles between 10:00 & 16:00).

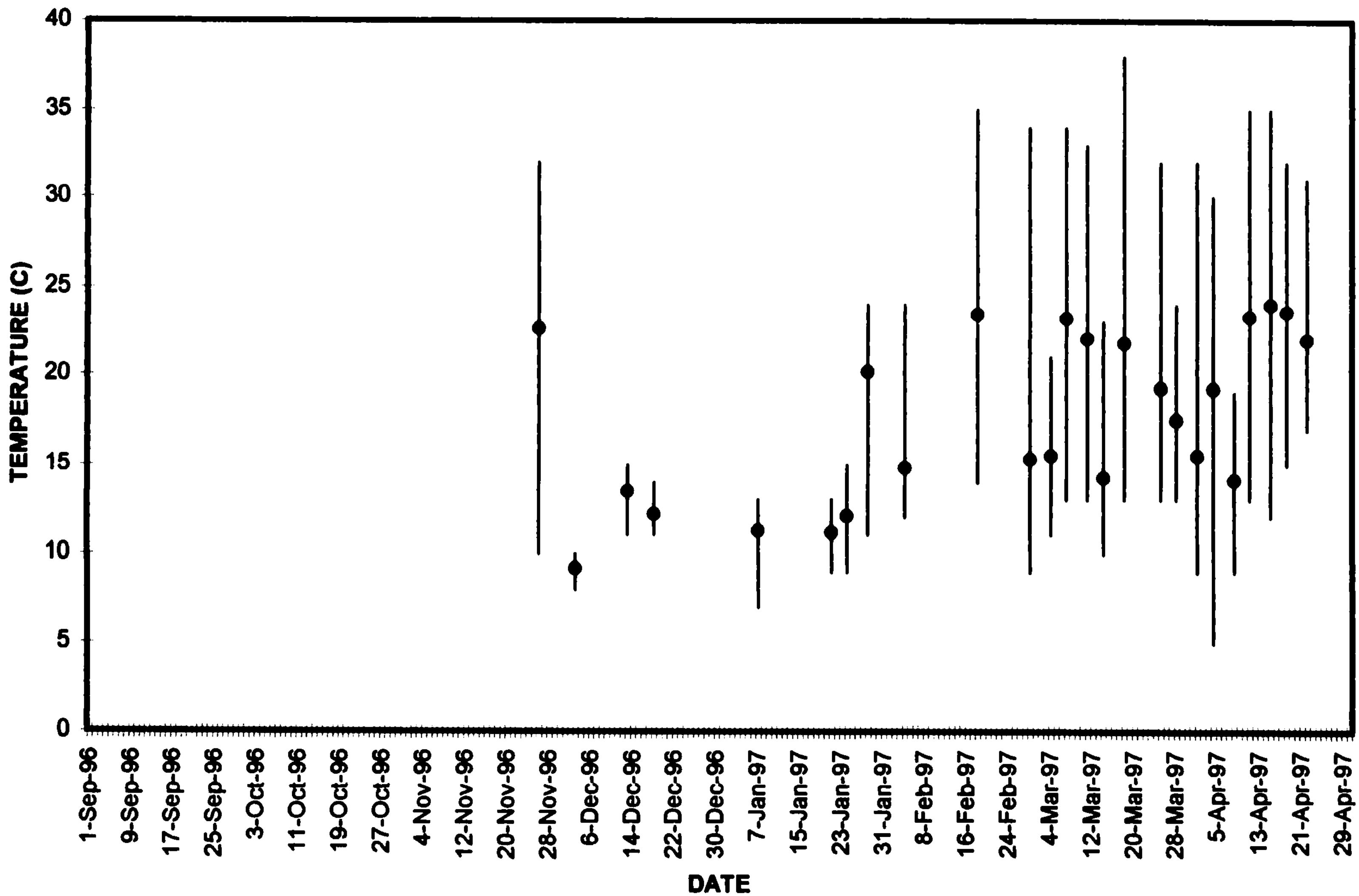

Figure 23: Mean and range for transmitter temperatures of radio-tagged turtles at Sites B and C during the 1996/97 overwintering season (data shown include only those dates with observations of five turtles between 10:00 and 16:00).

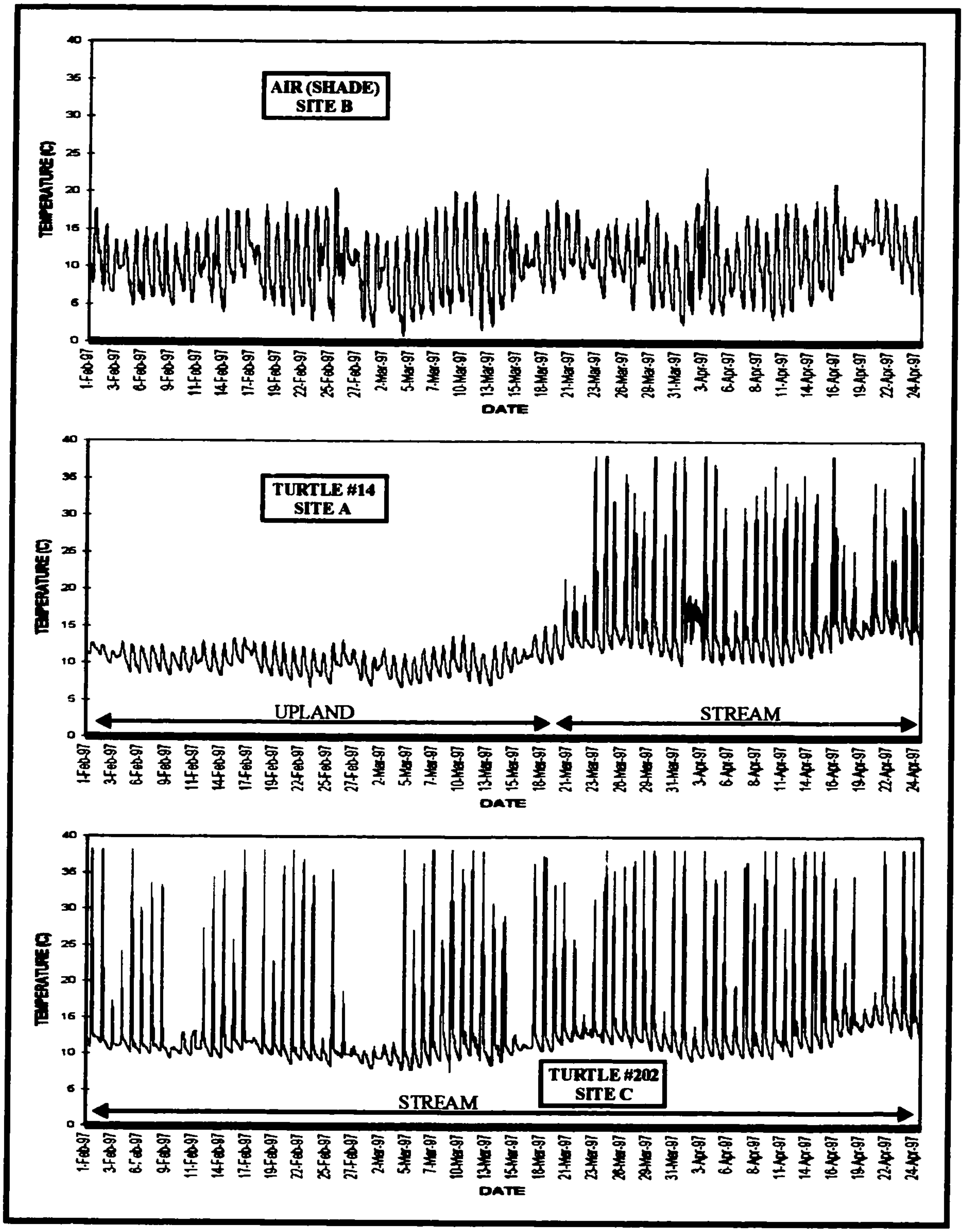

Figure 24: Comparison of air temperature and temperatures recorded by temperature recorders worn by two different turtles during the 1996/97 overwintering season.

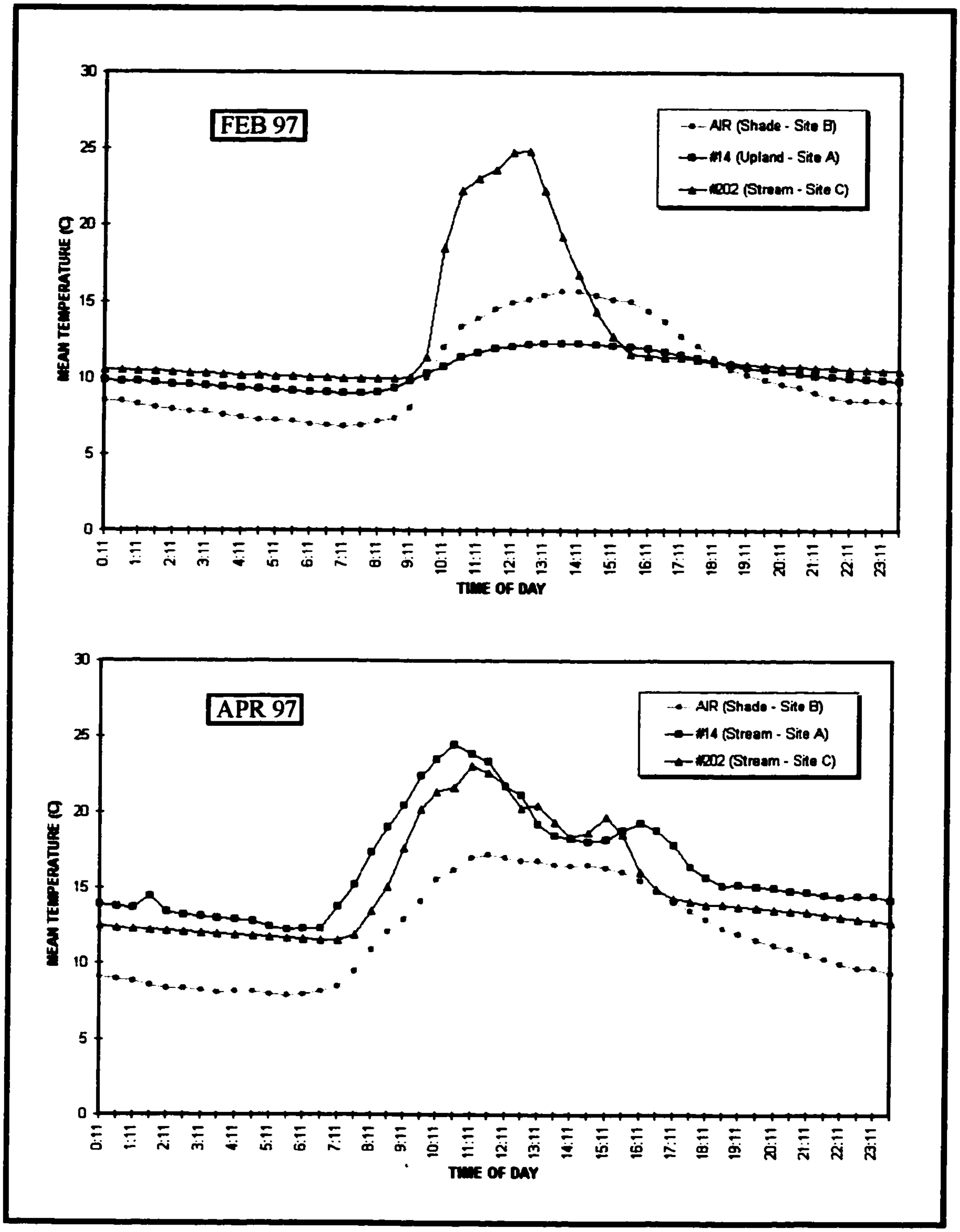

Figure 25: Mean temperatures for recorders attached to turtles #14 and #202 and for shaded air during February and April 1997.

San Jose State University
Institutional Animal Care and Use Committee

LETTER OF OFFICIAL PROTOCOL REVIEW

Date: April 15, 1995

Dear JERRY SMITH:

The animal care and use portion of your research proposal indicated below was reviewed by the Institutional Animal Care and Use Committee (IACUC). The IACUC Protocol Number indicated below should be used when ordering animals for this study, and on grant and contract proposals to fund this study. This protocol number may be used ONLY by the principal investigator and other participants included in the protocol. **The IACUC must be notified in writing of any proposed changes to this approved protocol, and approval must be granted in writing before any change is instituted.**

If you have any questions, please contact Dr. Miriam Saltmarch at **924-3118.**

APPROVAL FOR THE IACUC COMMITTEE

Miriam Saltmarch, Ph.D., Chair, IACUC

PROTOCOL #: 658

INVESTIGATOR NAME: JERRY SMITH/JAE ABEL/CAROLINE DAVIS

TITLE OF PROTOCOL: Pond Turtle, Red-legged Frog and Garter Snake Population Status and Habitat Use

Approval Date: April 15, 1995 **Expiration Date:** April 15, 1998

Species To Be Used: Turtle, Frog and Snake **Total No. of Animals:** 100 to 1000

Principal Investigator: JERRY SMITH

Department: Biological Sciences **Phone:** 4-4855

Co-Investigator: JAE ABEL/CAROLINE DAVIS/KIT CRUMP

XXXXX This application was approved without modification.

_____ This application was approved with the following mandatory changes:

_____ This application was not approved for the following reasons:

cc: University Animal Care Office
Chair: Investigator's Department, or Departmental Animal Committee

SJSU/UAC/12/96 rev.

IMAGE EVALUATION TEST TARGET (QA-3)

150mm

6″

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Fax: 716/288-5989