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The Natural History and Thermal Ecology of a Population of Spotted Turtles (Clemmys Guttata) and Wood Turtles (Glyptemys Insculpta) in West Virginia

Ariana N. Breisch

THE NATURAL HISTORY AND THERMAL ECOLOGY OF A POPULATION OF SPOTTED TURTLES (*CLEMMYS GUTTATA)* AND WOOD TURTLES (*GLYPTEMYS INSCULPTA)* IN WEST VIRGINIA

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ABSTRACT

“THE NATURAL HISTORY AND THERMAL ECOLOGY OF CLEMMYS AND GLYPTEMYS IN WEST VIRGINIA”

by Ariana N. Breisch

An ecological study was conducted from 19 March 2001 to 2 April 2003 on a population of Spotted Turtles (*Clemmys guttata*) and Wood Turtles (*Glyptemys insculpta*) in West Virginia. Live-trapping, mark-recapture, radio telemetry and temperature data logging techniques were used to gather information on morphometrics, capture success, movements, home range, behavior, and thermal regime during activity and over-wintering seasons.

Twenty-one Spotted Turtles were captured 260 times. Population structure was 42.9% juvenile, 38.1% male, and 19.0% female. Mean home range was 0.52 ha.

Fifty Wood Turtles were captured 230 times. Juveniles were 36%, and males and females were 32% each. Mean Wood Turtle home range was 4.48 ha.

Turtle and environmental temperatures were analyzed. Temperature data loggers revealed that Spotted and Wood Turtle hibernacula were stable throughout winter and stayed above freezing. Lowest temperatures experienced were 0.0°C by Spotted Turtles and -4.5°C by Wood Turtles.

Injuries, abnormalities, and ectoparasites were noted.

ACKNOWLEDGMENTS

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My favorite quote by an old West Virginia fisherman, who saw me out tracking turtles one day: “Young lady, you are in college studying *turtles*? Well, I suppose nowadays they have to let women study *something*.”

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CHAPTER 1

Introduction and Literature Review

Before the results of recent molecular research were published (Holman and Fritz 2001, Feldman and Parham 2002, Parham and Feldman 2002), the genus *Clemmys* was comprised of 4 species of semi-aquatic pond turtles endemic to North America (Carr 1952, McDowell 1964). One member of this genus was the Pacific Pond Turtle (*C. marmorata* Baird and Girard 1852) whose range in the western United States was greatly disjunct from the other species of *Clemmys*. The other members of this genus, the Spotted Turtle (*C. guttata* Schneider 1792), Wood Turtle (*C. insculpta* LeConte 1830), and Bog Turtle (*C. muhlenbergii* Schoepff 1801) were eastern species with overlapping ranges (Ernst et al. 1994).

New molecular research has given support to the belief that the genus *Clemmys* is paraphyletic (Holman and Fritz 2001, Feldman and Parham 2002, 2003). Bickham et al. (1996) and Burke et al. (1996) discussed that the genus *Clemmys* was paraphyletic and suggested that a taxonomic name change may be necessary. Research articles proposing the taxonomic change have only recently entered into literature (Holman and Fritz 2001, Feldman and Parham 2002, Parham and Feldman 2002). Pacific Pond Turtle has a hinged plastron and is very different from its eastern congeners. It was moved into the genus *Actinemys* by Holman and Fritz (2001). Although Bog Turtles resemble Spotted

Turtles in size and appearance, in actuality they are more closely related to Wood Turtles. Wood and Bog Turtles were placed in a separate genus, *Glyptemys* (Holman and Fritz 2001, Parham and Feldman 2002). The Wood Turtle is the type species for this genus. Both Holman and Fritz (2001) and Feldman and Parham (2002) agree that *C. guttata* is a unique species and would remain the type species for *Clemmys*. The 6th edition of the annotated checklist accepts *Glyptemys* as the generic name for Wood and Bog Turtles and will be followed in this text (Crother et al. 2003).

Spotted, Wood, and Bog Turtles are semi-aquatic and may be found sympatrically in association with wet meadows, bogs, fens, and brooks (Ernst et al. 1994). Of these species, only Spotted and Wood Turtles are found in West Virginia (Green 1969, Green and Pauley 1987). The Bog Turtle is found in surrounding states including Pennsylvania, Maryland and Virginia (Ernst et al. 1994), but has not yet been located within West Virginia (WVDNR 2001, per.obs.). Within the state, the range of both Spotted and Wood Turtles is restricted to the eastern panhandle (Green and Pauley 1987). There is only one known location in West Virginia in which Spotted and Wood Turtles occur together (WVDNR 2001).

The Spotted Turtle is a small, black turtle, usually marked with yellow spots on its carapace and appendages, although individuals may be found with few or no spots (Ernst et al. 1994) (Figure 1.1, 1.2). Carapace lengths of up to 125 mm in adult Spotted Turtles have been reported by Ernst et al. (1994), although specimens up to 142.5 mm have been reported (Haxton 1998).

FIGURE 1.1. AN ADULT SPOTTED TURTLE (*C. GUTTATA*) FROM WEST VIRGINIA.

PHOTOGRAPH BY ARIANA N. BREISCH 2001.

FIGURE 1.2. A SPOTTED TURTLE (*C. GUTTATA*) WITH FEW SPOTS.

PHOTOGRAPH BY ARIANA N. BREISCH 2001.

The overall range of *C. guttata* extends from southern Ontario, Quebec and Maine south along the Atlantic coast to Florida and west through Ontario, New York, Pennsylvania, Ohio, northern Indiana, Michigan and northeastern Illinois (Ernst et al. 1994) (Figure 1.3).

The Spotted Turtle is currently found in only 5 sites in West Virginia, located in Jefferson and Hampshire counties (Niederberger and Seidel 1997, WVDNR 2001) (Figure 1.4). A historical location was reported from Berkeley County, although no Spotted Turtles have been reported from this area since 1939 (WVDNR 2001).

The Wood Turtle (*Glyptemys insculpta*) is a medium-sized brownish turtle with a sculptured carapace and yellow, orange, or red coloring on its neck, tail, and ventral surface of the limbs (Ernst et al. 1994) (Figure 1.5). This turtle can obtain a maximum carapace length of 234 mm (Ernst et al. 1994). It is often found in association with woodland streams and rivers. Other habitats that it may utilize include wet meadows, swamps, bogs, and upland fields and pastures that border these streams (Harding and Bloomer 1979, Ross et al. 1991, Ernst et al. 1994).

From Pendleton County, West Virginia, and Rockingham County, Virginia, the overall range of *Glyptemys insculpta* extends north through Nova Scotia and New Brunswick (Ernst et al. 1994) (Figure 1.6). The range extends westward to include southern Quebec, southern Ontario, New York, northern Michigan,

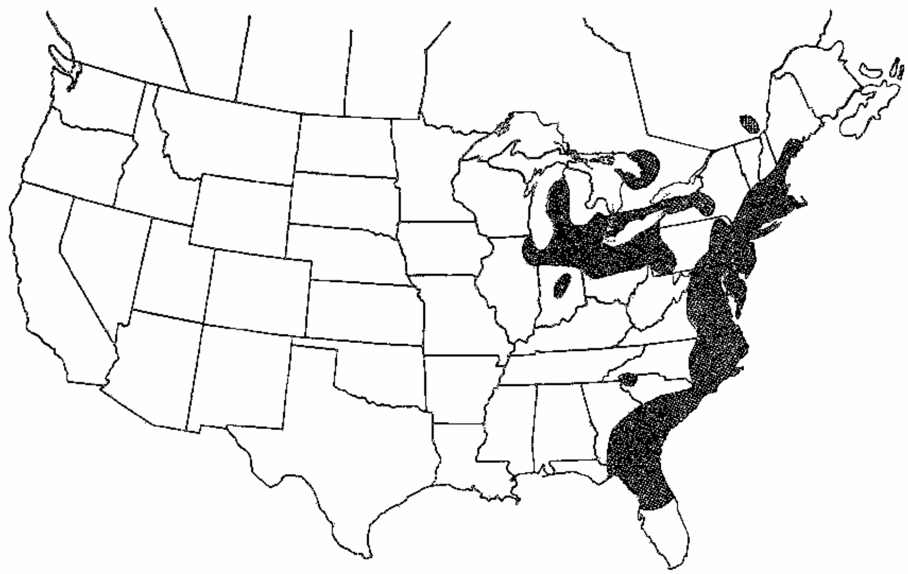

FIGURE 1.3. OVERALL DISTRIBUTION OF *C. GUTTATA*.
ADAPTED FROM ERNST ET AL. 1994.

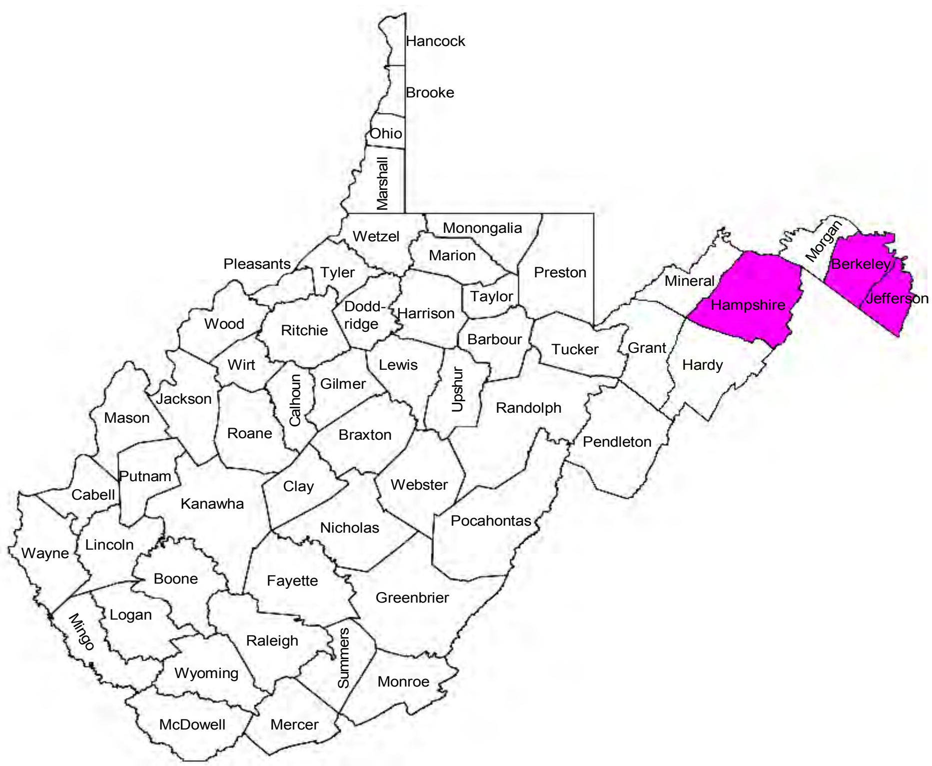

FIGURE 1.4. DISTRIBUTION OF *C. GUTTATA* IN WEST VIRGINIA.

FIGURE 1.5. AN ADULT WOOD TURTLE, *G. INSCULPTA*, FROM WEST VIRGINIA. PHOTOGRAPH BY ARIANA N. BREISCH 2001.

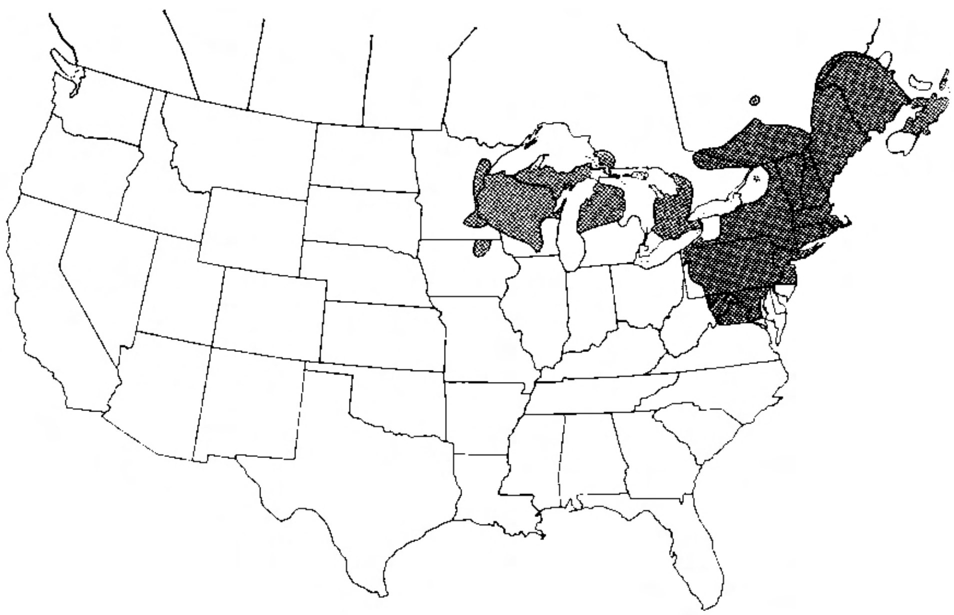

FIGURE 1.6. OVERALL RANGE OF *G. INSCULPTA* IN THE UNITED STATES AND CANADA.

ADAPTED FROM ERNST ET AL. 1994.

Wisconsin, eastern Iowa and eastern Minnesota (Ernst et al. 1994).

Wood Turtles have been found in numerous streams and rivers in 7 counties in the eastern panhandle: Jefferson, Berkeley, Hampshire, Hardy, Morgan, Mineral, and Pendleton counties (Green and Pauley 1987, Niederberger 1993, WVDNR 2001) (Figure 1.7). There has also been a discounted report from Monongalia County (Bond 1931). Wood Turtles in Pendleton County represent the most extreme southern population of *G. insculpta* currently known. Fossil records indicate that Wood Turtles were previously found in more southerly locations, but their range has become restricted northward (Ernst et al. 1994).

Spotted and Wood Turtles are in decline throughout parts of their range (Ernst et al. 1994, Garber and Burger 1995, Tyning 1997, USFWS 2000). Spotted Turtles were once considered the most common turtles in the vicinity of New York City (Breisch 1997) and the state of Massachusetts (Tyning 1997).

The biggest threats to *Clemmys* and *Glyptemys* survival are habitat destruction and collection for the pet trade (Tyning 1997, Ernst et al. 1994, USFWS 2000). Other problems for Spotted Turtles include predation by subsidized predators, overgrazing by livestock, cultivation for agriculture and pollution (Lovich 1989). Agricultural practices also impact Wood Turtles (Saumure and Bider 1998). A 20-year study on Wood Turtle decline in Connecticut in association with human recreation demonstrated human impact on Wood Turtle populations (Garber and Burger 1995).

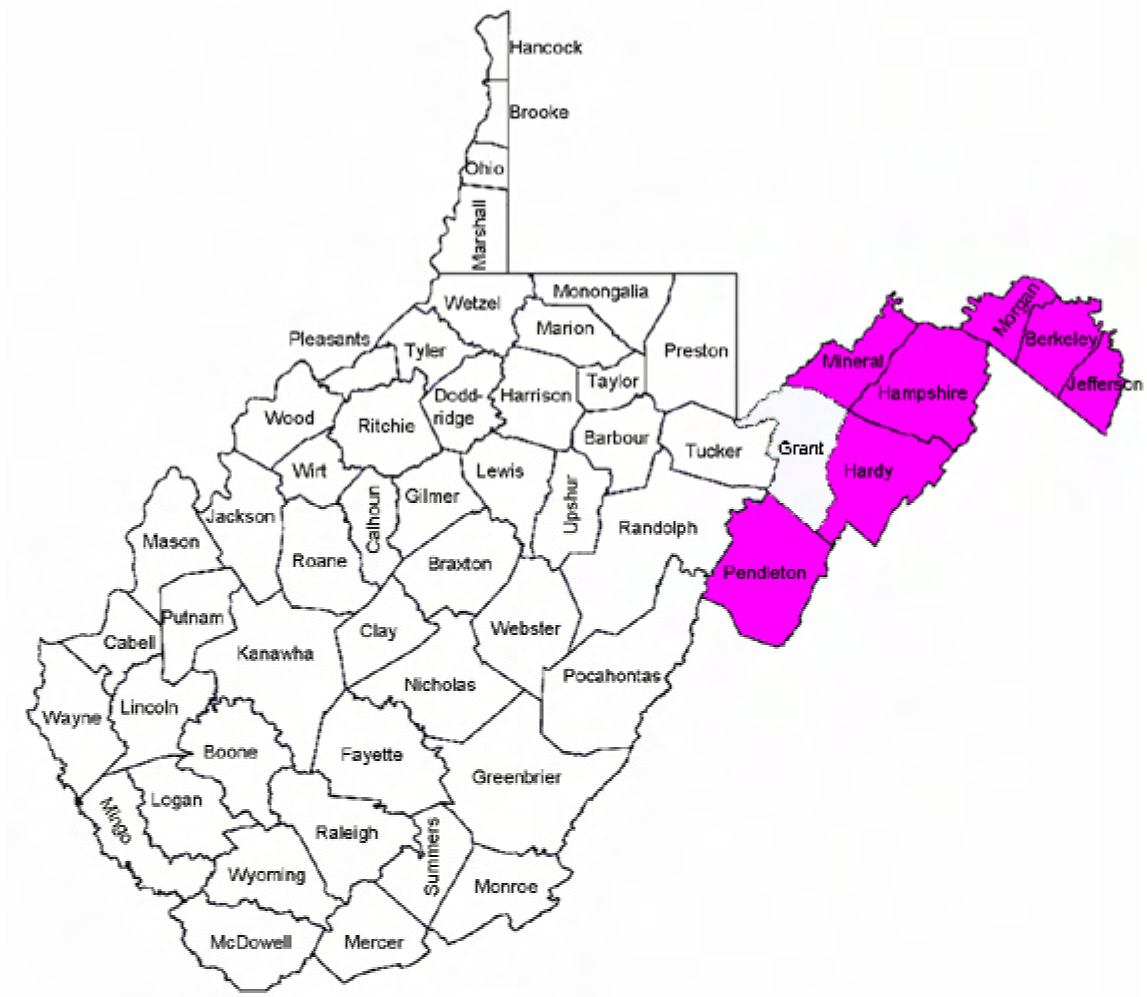

FIGURE 1.7. DISTRIBUTION OF WOOD TURTLES, *G. INSCULPTA*, IN WEST VIRGINIA.

Spotted and Wood Turtles have varying degrees of protection within the states they inhabit. The Spotted Turtle is currently a species of special concern in West Virginia. It is listed by the West Virginia Natural Heritage Program as an S1 species in West Virginia, which means that it is extremely rare, critically imperiled and vulnerable to extirpation within the state (WVDNR 2001). Although its status is ever changing, it appears secure in some states, while listed as special concern, threatened, or endangered in others (Levell 1997).

In West Virginia, the Wood Turtle is also a species of special concern. It is listed as an S2 species, which means that it is very rare and vulnerable to extirpation in the state (WVDNR 2001). Wood Turtles are endangered, threatened, or special concern in some states, although they appear secure in others (Levell 1997).

Wood Turtles and Spotted Turtles have been little studied in West Virginia. Niederberger (1993) conducted a mark-recapture and telemetry study on *G. insculpta* and unpublished studies were also done on these turtles by Constantz (1988) and Fisher (WVDNR pers. comm.) in the eastern panhandle. Humphries (2002) performed an unpublished mark-recapture study on *C. guttata*. An unpublished, two-month radio telemetry study of 6 released Spotted Turtles was the only telemetry work that has been done with this species in West Virginia (Knight et al. 1985). No radio telemetry work was conducted on a natively occurring population of *C. guttata* in West Virginia, so little was known of their daily activity, movement and over-wintering patterns in this state. There is only one location in West Virginia where *C. guttata* and *G. insculpta* occur sympatrically. This study is the first to compare the overlap in habitat use, movements and behavior of Spotted and Wood Turtles in West Virginia.

Ecological studies of Spotted and Wood Turtles have been conducted in many other areas. The ecology of *C. guttata* was reported from Pennsylvania (Ernst 1976) and Massachusetts (Belmore 1980). Home range of Spotted Turtles was studied in Pennsylvania (Ernst 1970) and Ohio (Lewis and Faulhaber 1999). Spotted Turtle habitat selection was studied in Massachusetts (Graham 1995, Milam and Melvin 2001), Connecticut (Perillo 1997), and Ontario (Haxton and Berrill 1999). Growth at the northern limit of the distribution of this species has also been recorded (Litzgus and Brooks 1998). Morphology and population structure have been documented in South Carolina (Litzgus and Mousseau 2004).

Ecology of Wood Turtles has been studied in areas such as Maine (Compton 1999), New Hampshire (Tuttle 1996, Tuttle and Carroll 1997), Connecticut (Garber 1988), New York (Breisch pers. comm., Tuttle (pers. comm.), New Jersey (Farrell and Graham 1991, Harding and Bloomer 1979), Pennsylvania (Ernst 2001), West Virginia (Niederberger 1993), Michigan (Harding and Bloomer 1979), Wisconsin (Ross et al. 1991), and Quebec (Walde et al. 2003). Habitat studies were performed in Pennsylvania (Kaufmann 1992), Michigan (Ewert et al. 1998) and Canada (Quinn and Tate 1991). Home range was studied in Pennsylvania (Kaufmann 1995), New Hampshire (Tuttle and Carroll 2003) and Wisconsin (Ross et al. 1991). Research on body size and growth was conducted on populations from Pennsylvania and Virginia (Lovich et al. 1990) and Canada (Brooks et al. 1992, Daigle 1997).

Since temperature plays an important role in the life cycle of exotherms like turtles, temperature tolerances, preferences and thermoregulation have been studied (Brattstrom 1965, Hutchison et al. 1966, Brattstrom and Collins 1972, Nutting and Graham 1993). There have been several studies on the relationship between temperature and activity patterns of pond turtles (Ernst 1972, Ernst 1982, Ernst 1986, Ernst et al. 1989, Di Trani and Zuffi 1997). Little work has been published using data loggers to continuously monitor the thermal regime of Wood and Spotted turtles throughout their ranges. Hibernacula temperatures of Spotted Turtles were recorded using data loggers in Ohio (Lewis and Ritzenthaler 1997) and near the northern limit of their range (Litzgus et al. 1999). The use of data loggers was applied to Blanding's Turtles (*Emydoidea blandingii*) in Minnesota to record patterns in body temperature (Sajwal and Lang 2000).

The main objective of this study was to expand knowledge of the ecology and distribution of Spotted and Wood Turtles in West Virginia using live trapping, mark-recapture, radio telemetry, and temperature data logging techniques. Specific goals include characterization of habitat, capture success, morphometrics, movements, home range, behavior, and thermal regime during activity and over-wintering seasons. Analysis of distribution and habitat requirements of known Spotted and Wood Turtle sites could lead to the discovery of new sites or range extensions of these species and is important in developing management plans to benefit these species.

CHAPTER 2:
Study Area

This study took place in an undisclosed location in the eastern panhandle of West Virginia. This site is the only known location in West Virginia where *Clemmys guttata* and *Glyptemys insculpta* are known to coexist. Previously, no formal studies had been conducted on this population. Elevation at the site was approximately 262 m. The area was along a stream corridor in a valley and was bordered on 2 sides by approximately 400 m high ridges. A road-killed male Wood Turtle was found near the top of one of the ridges, which indicates that turtles can disperse over these high elevations. The stream channel at the study area connected to a river about 0.75 km downstream from the study site, which provides a corridor for dispersal. Soils consisted of Atkins silt loam, which is a poorly drained soil found in floodplains (USDA 1978). Flora and fauna encountered at the site during the study are listed in Appendices I and II.

Due to the sensitive nature of these species, the study area maps have been stylized in order to protect the integrity of the research site. The study area consisted of a 3 km stretch of trout stream that ran through a large fishing pond (S on Figure 2.1, Figure 2.2). The stream averaged 5 m wide and was a mixture of sandy or rocky bottom habitats. Dominant canopy along the shoreline consisted of Sycamore (*Platanus occidentalis*), Red Maple (*Acer rubrum*), River Birch (*Betula nigra*) and Rhododendron (*Rhododendron* sp.)

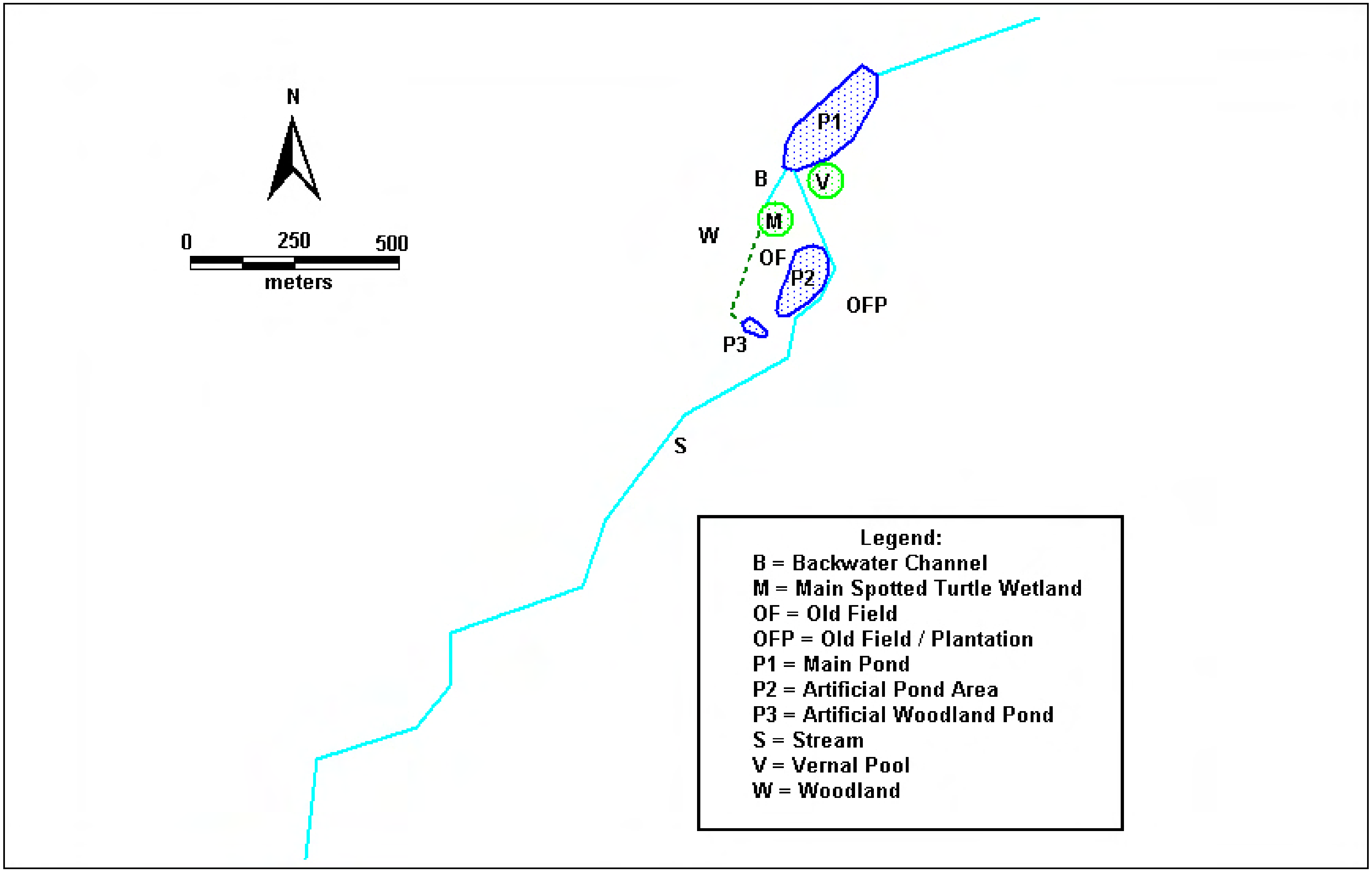

FIGURE 2.1. MAP OF STUDY AREA.

FIGURE 2.2. *G. INSCULPTA* STREAM.

PHOTOGRAPH BY ARIANA N. BREISCH 2002.

FIGURE 2.3. WETLAND INHABITED BY *C. GUTTATA*.

PHOTOGRAPH BY ARIANA N. BREISCH 2002.

(Appendix I). Tree roots and beaver dams created many hibernacula and refugia along the bank for *G. insculpta* (Figure 2.2). Pools created by naturally dammed water along the stream ranged in depth from 1 to 3 m. In addition to Wood Turtles, other wildlife in the stream or along the banks were Rainbow Trout (*Oncorhynchus mykiss)*, Brook Trout (*Salvelinus fontinalis)*, American Beavers (*Castor canadensis*), Northern Watersnakes (*Nerodia sipedon*), Canada Geese (*Anser canadensis*), Eastern Ribbonsnakes (*Thamnophis sauritus*), and Great Blue Herons (*Ardea herodias*) (Appendix II).

The main pond had a surface area of 1.5 ha (P1 on Figure 2.1). This area was used by wildlife such as Canada Geese, Great Blue Herons, Mallards (*Anas platyrhynchus*), Wood Ducks (*Aix sponsa*), Hooded Mergansers (*Lophodytes cucullatus*), Belted Kingfishers (*Ceryle alcyon*), Eastern Snapping Turtles (*Chelydra serpentina*), Stinkpots (*Sternotherus odoratus*), Painted Turtles (*Chrysemys picta*), Wood Turtles, and Beaver (Appendix II). The pond was mostly open water with some water lilies and a soft, mucky bottom.

Upland habitat for Wood Turtles was an old field / shrubby area (OFP on Figure 2.1). East and slightly down slope of a mowed field was a dense Multiflora Rose (*Rosa multiflora*) thicket. Southeast of the thicket was an old field with tall forbs and grasses. Vegetation in this area included daisy fleabane. South of the mowed field was an old pine plantation.

The main Spotted Turtle area was a 0.09 ha seasonally flooded sedge meadow located between the stream and hillside forest (M on Figure 2.1, Figure 2.3). It was upstream (south) of the main pond. A channel of seasonally open water arced around the north end of the wetland and connected the Spotted Turtle wetland to the main pond by a series of channels. This main channel varied in depth from 1.5 m in the spring to a few cms on wet mud in mid-summer. The main channel was divided into main channel east (M east), main north (M north), main west (M west), main towards woods (M woods), and main at the intersection with backwater channel (MT). Dominant vegetation in the open sedge meadow consisted of Tussock Sedge (*Carex stricta*), Common Smartweed (*Polygonum hydropiper*), Halberdleaf Tearthumb (*Polygonum arifolium*), American Burreed (*Sparganium* americanum), Common Rush (*Juncus effusus*), Yard Rush (*Juncus tenuis*) and Woolgrass (*Scirpus cyperinus*) (Appendix I). The channel towards the woods (M woods) was about 0.5 m deep through soft mud and was bordered by Black Willow (*Salix nigra*), Smooth Alder (*Alnus serrulata*), Skunk Cabbage (*Symphlocarpus foetidus*), Sensitive Fern (*Onoclea sensibilis*) and Broad-leaved Cattail (*Typha latifolia*). A shaded area west of the backwater channel was damp and dominated by *Sphagnum sp.* and Skunk Cabbage. The permanently flooded backwater channel ran north-south and connected the main Spotted Turtle wetland channel with the backwater area of the main pond. These 2 areas were the border between the main wetland and woodland. Other wildlife species in the Spotted Turtles' sedge meadow / backwater area included Wood Turtles, Eastern Snapping Turtles, Red-spotted Newts (*Notophthalmus v. viridescens*), Spotted Salamanders (*Ambystoma maculatum*), Northern Green Frogs (*Rana clamitans melanota*), Eastern American Toads (*Bufo a. americanus*) and Gray Treefrogs (*Hyla versicolor*)

(Appendix II). An old field (OF on Figure 2.1) and woodland (W on Figure 2.1) were adjacent to the main spotted turtle wetland. The OF was divided into OF1, which was north of the main wetland, and OF2 which was immediately south of the main wetland. The woodland (W) included a *Sphagnum* area in addition to upland sites.

The second Spotted Turtle area was also seasonally flooded. The vernal pool was located southeast of the main pond and was separated from the Spotted Turtle wetland by the stream (V on Figure 2.1). This small (0.12 ha) seasonally flooded area provided over-wintering, nesting, and summering habitat for some of the Spotted Turtles. In the spring and after rain events, water levels were up to nearly 1 m deep. The area completely dried during the summer months. Vegetation in this area included *Salix nigra, Scirpus cyperinus, Juncus tenuis,* and *Polygonum hydropiper* (Appendix I). Summering Spotted Turtles also used the adjacent upland area along a small earthen mound that was covered with Queen Anne's Lace (*Daucus carota*), Common Dodder (*Cuscuta gronovii*), Bedstraw (*Galium* spp.), Common Teasel (*Dipsacus sylvestris*), Common Joe-Pye Weed (*Eupatorium fistulosum*), wild sunflower (*Helianthus* spp.), grasses, and Multiflora Rose. Other wildlife species found in association with this area were the Snapping Turtle, Wood Frog (*Rana sylvatica*), Spotted Salamander, and Jefferson Salamander (*Ambystoma jeffersonianum*) (Appendix II).

A series of 8 artificial ponds were located southeast of the sedge meadow, 10 to 15 m from the west side of the stream (P2 and P3 on Figure 2.1). These ponds had been used for rearing fish. Five were partially to mostly forested and shady and 3 were open and unforested along the edges. They were all rectangular in shape and their sizes ranged from 0.06 to 0.09 ha in area. Wood Frogs, Painted Turtles, Snapping Turtles, Wood Ducks, Ribbonsnakes, and Red-winged Blackbirds (*Agelaius phoeniceus*) were just a few of the species commonly seen using this area.

CHAPTER 3:
Methods and Materials

This study was conducted from 19 March 2001 through 2 April 2003. Each field day a daily site report was filled out that recorded habitat and environmental parameters such as air, water, and substrate temperatures, cloud cover, and precipitation (Appendix III).

Turtle Trapping and Hand Capture:

A combination of methods was used to locate *Clemmys guttata* and *Glyptemys insculpta* in this study, which included hand capture, and live-trapping using baited and unbaited box traps. Hand captures consisted of traversing streams, wetlands, and fields to find visible turtles, and probing in deep mud and water or under sedge tussocks to locate hidden turtles.

Three types of traps were used: a baited box trap, an unbaited funnel box trap, and a hoop trap. The baited box trap measured 30 cm × 30 cm × 60 cm and had a 10 cm × 10 cm funnel at one end with a raccoon guard (Figure 3.1). This trap was baited with sardines in vegetable oil. The second type of trap was a small box trap measuring 10 cm × 10 cm × 35 cm with 30 cm wings on each end to guide the turtles through hinged doors into the trap (Figure 3.2). The doors could only be pushed open from the outside so once the turtles were inside, they could not escape. This was a passive trap and required no bait. The third type of trap was a 60 cm hoop trap and was only set in the stream. Traps were placed partially submerged in water within the wetlands or

FIGURE 3.1. BAITED BOX TRAP USED TO CAPTURE *C. GUTTATA*.
PHOTOGRAPH BY ARIANA N. BREISCH 2001.

FIGURE 3.2. SMALL, UNBAITED PASSIVE BOX TRAP USED TO CAPTURE *C. GUTTATA*.

PHOTOGRAPH BY ARIANA N. BREISCH 2001.

stream, leaving an air space at the top for the turtles to breathe. Traps were numbered and daily trap reports were filled out to record turtle captures (Appendix IV).

Turtle Marking and Morphometrics:

An individual turtle data sheet was filled out for each turtle to record morphometric and capture data (Appendix V). The first time a turtle was captured, the carapace was notched with a triangular file using a modified Cagle marking system (Cagle 1939) (Figure 3.3).

Morphometrics were measured on Spotted and Wood Turtles using similar methods. Upon capture, gender, weight, and number of annuli were recorded. Gender was determined by presence of secondary sex characteristics and females were checked to see if they were gravid. Male Spotted Turtles have a slightly concave plastron, cloaca past the carapacial margin, a long, thick tail, brown eyes and a tan chin (Ernst et al. 1994). Females have a flat or convex plastron, a shorter tail, vent past the marginal rim, orange eyes, and a yellow chin (Ernst et al. 1994). Spotted Turtles were considered juvenile when their carapace length was less than 80 mm (Ernst 1970, Ernst et al. 1994). Male Wood Turtles have a concave plastron, prominent foreleg scales, long, thick tail, and cloaca beyond the marginal rim (Ernst et al. 1994). Females have flat plastrons. Wood Turtles were considered juvenile when they weighed less than 600 g and had carapace lengths of less than 165 mm.

Depending on the turtle's size, their mass was measured with a 30-, 300-, 1000, or 2,500-gram Pesola scale by suspending the turtle in a plastic or mesh

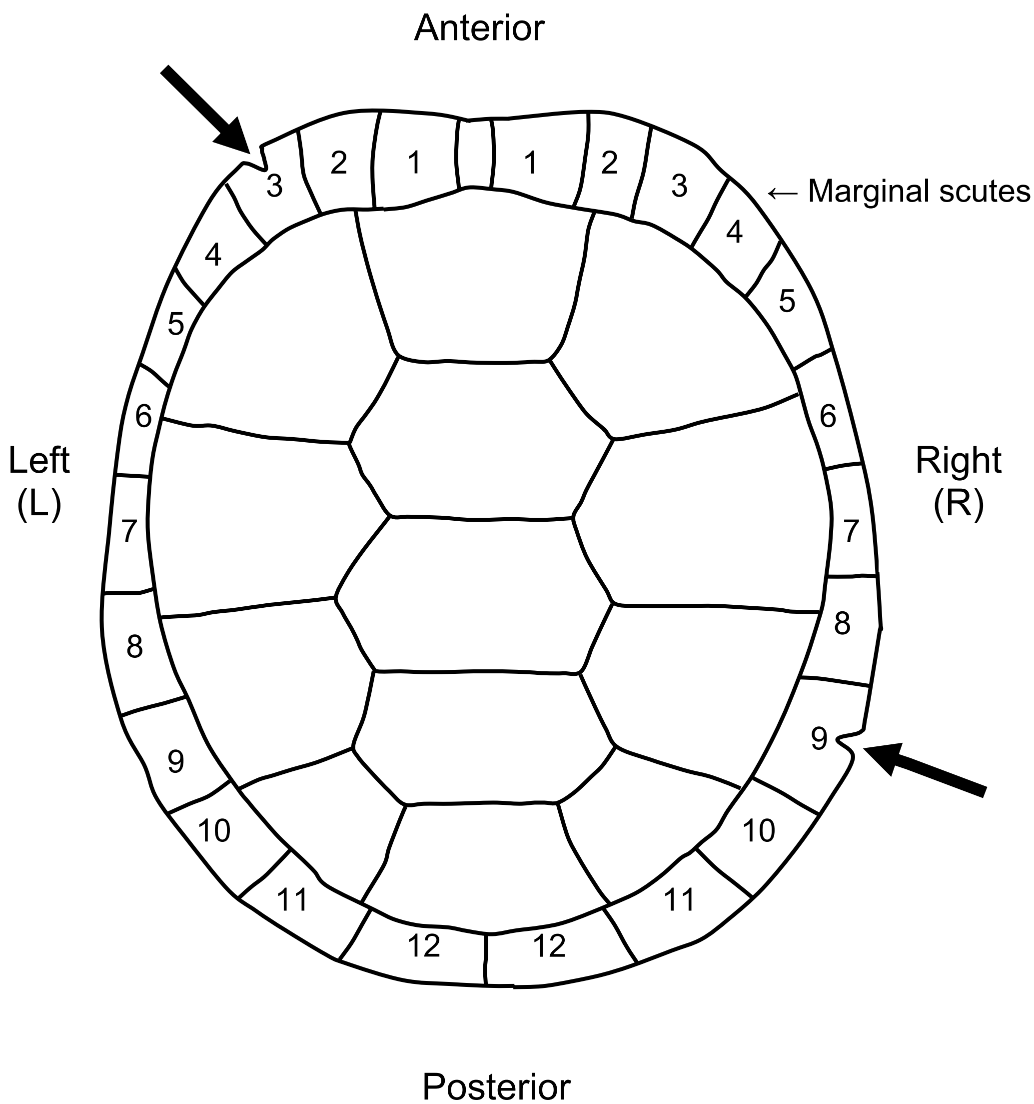

FIGURE 3.3. MODIFIED CAGLE METHOD USED TO MARK *C. GUTTATA* AND *G. INSCULPTA* (CAGLE 1939).
EXAMPLE GIVEN IS MARKED L3R9.

bag. The maximum carapace length, carapace width, dorsal-ventral height at the bridge, plastron length, and plastron width posterior to the bridge were measured using tree calipers for adult Wood Turtles (accurate to 1 mm) and dial calipers (accurate to 0.1 mm) for Spotted Turtles and small Wood Turtles.

A sketch was made of abnormalities and injuries to the carapace and plastron. Notes were taken of amputated, mutilated, or abnormal appendages or other atypical characteristics. Ectoparasites were noted, collected and identified. Leeches were removed from the turtles so reinfestation could be documented.

Radio telemetry Techniques:

Radio telemetry was used to track turtles to determine their home ranges, seasonal movements, habitat use and behaviors. Six Wood Turtles and 8 Spotted Turtles were radio tracked.

In May and June, 4 adult female *G. insculpta* weighing over 600 grams were outfitted with transmitters. No adult males were found at this time of the year so only females were radio tracked through the summer. Two males were outfitted with transmitters when they were found in October. Wood Turtle transmitters (made by John Kenty, NYSDEC) measured approximately 53.1 mm long by 18.5 mm wide by 10.2 mm high and weighed 14 g before application of epoxy. These transmitters had a battery life of one year and the signal could be detected at a distance of 1,000 m.

In May and June 2001, 8 adult Spotted Turtles (3 females and 5 males) were fitted with Bog Turtle-sized transmitters made by L.L. Electronics, Illinois. They measured approximately 24.5 mm long by 14.4 mm wide by 8.6 mm high and weighed 4.2 g before application of epoxy. With the application of epoxy, the total package weighed 7.3 to 8 g. These transmitters had a battery life of about 4 months and could be detected at a distance of approximately 200 m. In the fall, turtles were fitted with refurbished transmitters that held 2 batteries in order to extend the life of the transmitter through the winter months. These larger transmitters had the same width and height but were 36.1 mm long. They weighed 6.8 g before the application of epoxy and approximately 12 to 13 g with epoxy. They were removed between 29 March and 4 April 2002.

Transmitters were secured to the carapace of both species with fast drying waterproof epoxy or plumber's epoxy using the method described by Eckler et al. (1990) (Figures 3.4 and 3.5). The whip antenna (6" for *C. guttata*, 12" for *G. insculpta*) was secured around the marginals with epoxy so it would not hinder turtle movements by dragging behind and getting caught in rocks or vegetation. Plumber's epoxy secured the transmitter immediately to the carapace and was completely set within 3 hours. The 5-minute epoxy required at least 12 hours of drying time before turtles could be released. White epoxy or gray plumber's epoxy was colored with a black permanent marker to better match the carapace and make turtles less conspicuous. Turtles were tracked at least twice a week from mid-May to mid-August. Thereafter, they were tracked every 1 to 2 months. Location, behavior, and other notes were taken each time turtles were located.

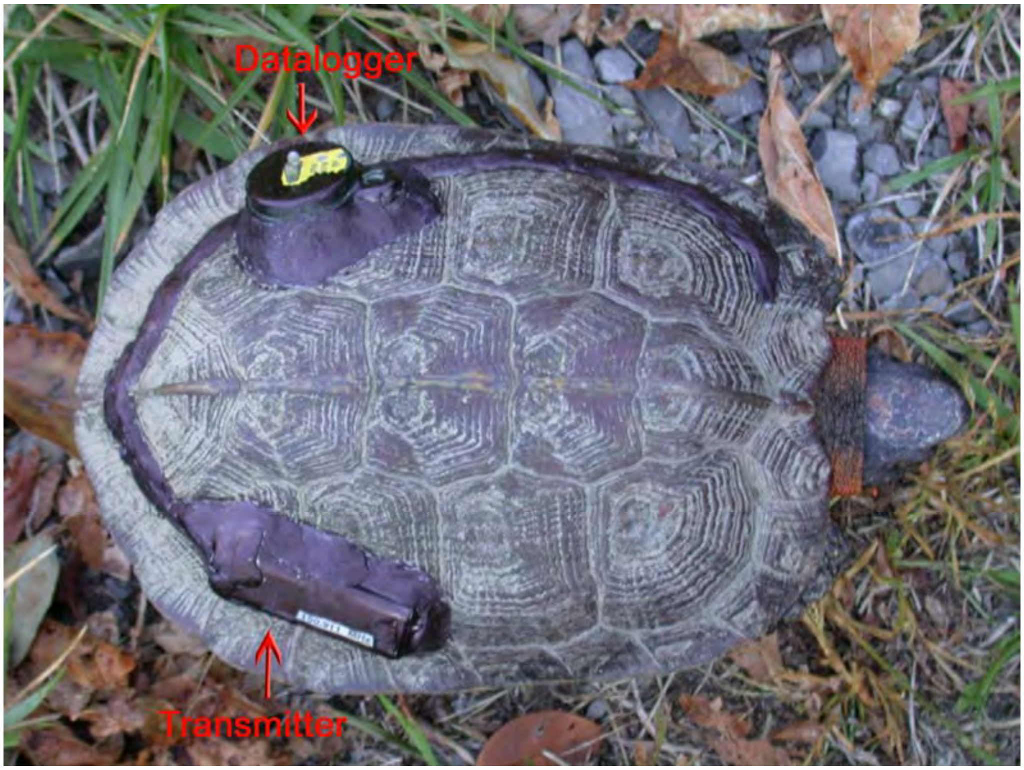

FIGURE 3.4. A TRANSMITTER ATTACHED TO THE CARAPACE OF *G. INSCULPTA*. PHOTOGRAPH BY ARIANA N. BREISCH 2001.

FIGURE 3.5. A TRANSMITTER ATTACHED TO THE CARAPACE OF *C. GUTTATA*. PHOTOGRAPH BY ARIANA N. BREISCH 2001.

Each location a turtle was found was plotted onto a study area map that was created using MapInfo software. Minimum convex polygons were used to estimate home range size (Mohr 1947, Mohr and Stumpf 1966). Outer most GPS capture points were connected by lines and MapInfo calculated the area within the polygons to estimate area size the turtles used. This data was also used to identify which areas turtles most frequented, as well as lengths of their daily movements and distances from one another.

Temperature Data-logging Techniques:

The thermal ecology portion of this study began 12 June 2001 and continued through 12 October 2002. Nineteen waterproof Onset StowAway® TidbiT® data loggers were used to record temperatures at various locations every hour. These loggers measured 40 mm long × 30 mm wide × 16 mm high and weighed 19 g. Battery life of data loggers enabled them to take temperature readings every hour for 1 year. Data loggers had an accuracy of ± 0.2°C. Typical response time in water was 3 minutes and 30 minutes in air.

Loggers recorded the external temperature of 4 Spotted Turtles and 6 Wood Turtles, 2 Spotted Turtle hibernacula, 2 Wood Turtle hibernacula, the stream, and 4 locations of air temperatures. A map of locations environmental loggers were set can be seen in Figure 3.6.

In mid-June 2001, data loggers were attached to 4 female transmittered Wood Turtles (Figure 3.7). Temperatures were recorded on these turtles for 1 year and were removed at the end of June 2002. No males were found until 20

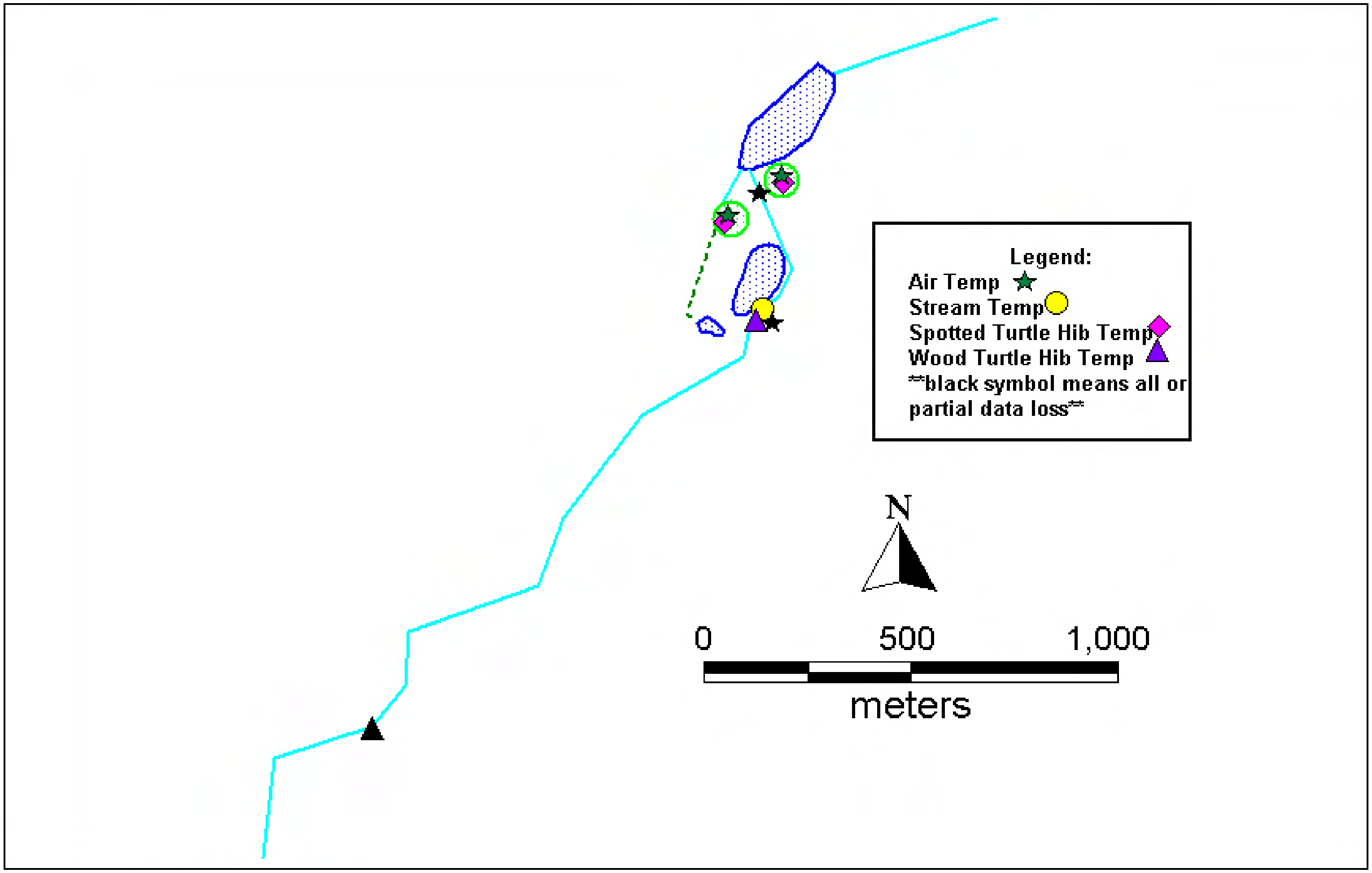

FIGURE 3.6. THE LOCATIONS OF TEMPERATURE-RECORDING DATA LOGGERS IN THE STUDY AREA.

FIGURE 3.7. A CLOSE-UP OF A DATALOGGER ATTACHED TO A WOOD TURTLE. PHOTOGRAPH BY ARIANA N. BREISCH 2001.

FIGURE 3.8. A DATALOGGER ATTACHED TO A SPOTTED TURTLE. PHOTOGRAPH BY ARIANA N. BREISCH 2001.

October 2001 and at that time data loggers were attached to 2 males. These data loggers were removed 12 October 2002.

Due to their small size, Spotted Turtles only carried data loggers during the over-wintering period so their movements would not be hindered. Data loggers were placed on these turtles after they had retreated into hibernation (15 November 2001) and were removed upon emergence (29 March to 4 April 2002). Data loggers were attached to 4 Spotted Turtles (3 males, 1 female) (Figure 18). Data loggers were attached to the carapaces of the turtles with waterproof, fast-drying epoxy or plumber's epoxy. Care was taken to make sure packages were smooth so there were no edges on which turtles could get caught. After the epoxy dried, it was colored with a black permanent marker to make the epoxy less conspicuous.

The fifth Spotted Turtle (Cg#09) that was radio tracked in the fall was too small to carry a data logger. However, a data logger was attached to a string and placed into the hibernaculum he occupied. A string was attached to another data logger that was placed in the mud in his hibernaculum in the vernal pool area.

Air temperatures were recorded with data loggers at the vernal pool area, Spotted Turtle wetland, and 2 places along the stream. Data loggers were attached 4 feet high to the north side of a tree. They were tied with a string and taped with black electrical tape to make them less noticeable.

One data logger was placed in an old Wood Turtle hibernaculum that was used the previous year but was unoccupied in winter 2001-02. A data logger was tied to a large rock in the middle of the stream near this hibernaculum. The purpose of this was to record differences in temperature between the main part of the stream and the hibernaculum under the root system along the bank. Another data logger was placed into a currently used Wood Turtle hibernaculum 1 mile upstream.

Data were downloaded in September and October 2001, and March, June and October 2002. Data logger temperatures were compared to the daily highs and lows of a weather station located about half an hour from the study site from June through October 2001. Field verified habitat data from the known locations of turtles were compared to habitat use predicted by these temperature graphs. Environmental temperatures recorded during the winter months were compared to each other and to the turtles' temperatures.

CHAPTER 4:
Population Evaluation and Morphometrics

INTRODUCTION

Morphology of Spotted Turtles has been reported in Ontario (Haxton 1998, Haxton and Berrill 1999, Litzgus and Brooks 1998), Massachusetts (Belmore 1980, Graham 1995), and Pennsylvania (Ernst 1976). One study recorded morphology of this species in West Virginia but has not yet been published (Humphries 2002). Morphometrics of Wood Turtles has been documented in New Hampshire (Tuttle 1996), New Jersey (Harding and Bloomer 1979, Farrell and Graham 1991), Pennsylvania (Lovich et al. 1990, Ernst 2001), West Virginia (Niederberger 1993, Niederberger and Seidel 1999), Michigan (Harding and Bloomer 1979), Wisconsin (Ross et al. 1991), and Ontario (Brooks et al. 1992).

The objective of this study was to evaluate the population structure and morphometrics of a population of Spotted and Wood Turtles in West Virginia.

RESULTS

Spotted Turtles:

Twenty-one Spotted Turtles were found in this study; 8 males (38.1%), 4 females (19.0%), and 9 juveniles (42.9%) (Figure 4.1). The sex ratio was 2:1. There was no significant difference in the exact probability of an 8:4 result ($p=0.3011$).

Annuli of adult Spotted Turtles ranged from 1 annulus to a smooth, worn plastron, indicating an old adult. Figure 4.2 depicts the frequency of juvenile

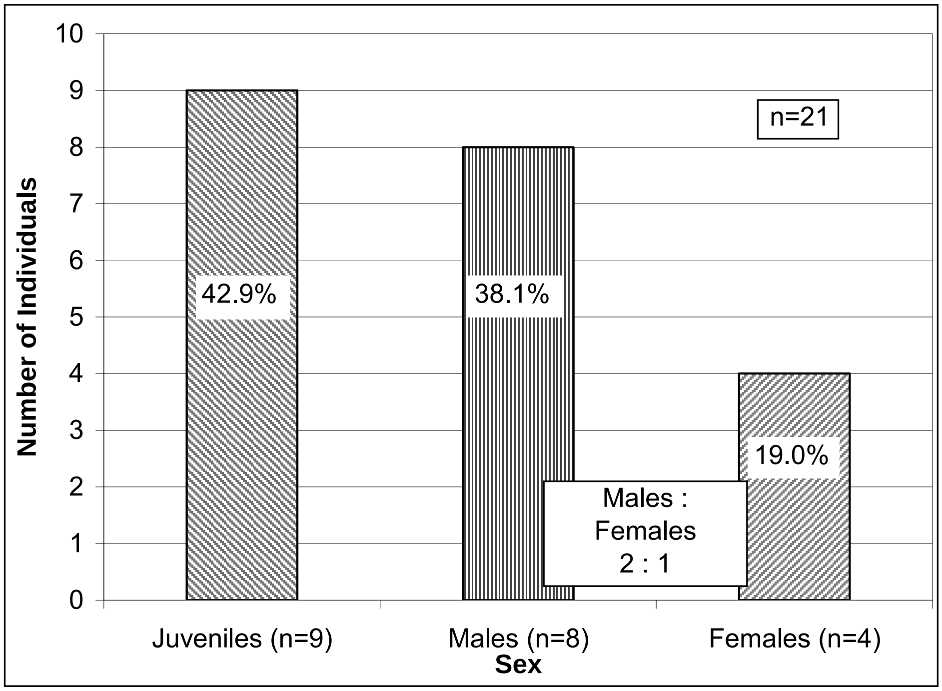

FIGURE 4.1. FREQUENCY OF MALE, FEMALE, AND JUVENILE SPOTTED TURTLES.

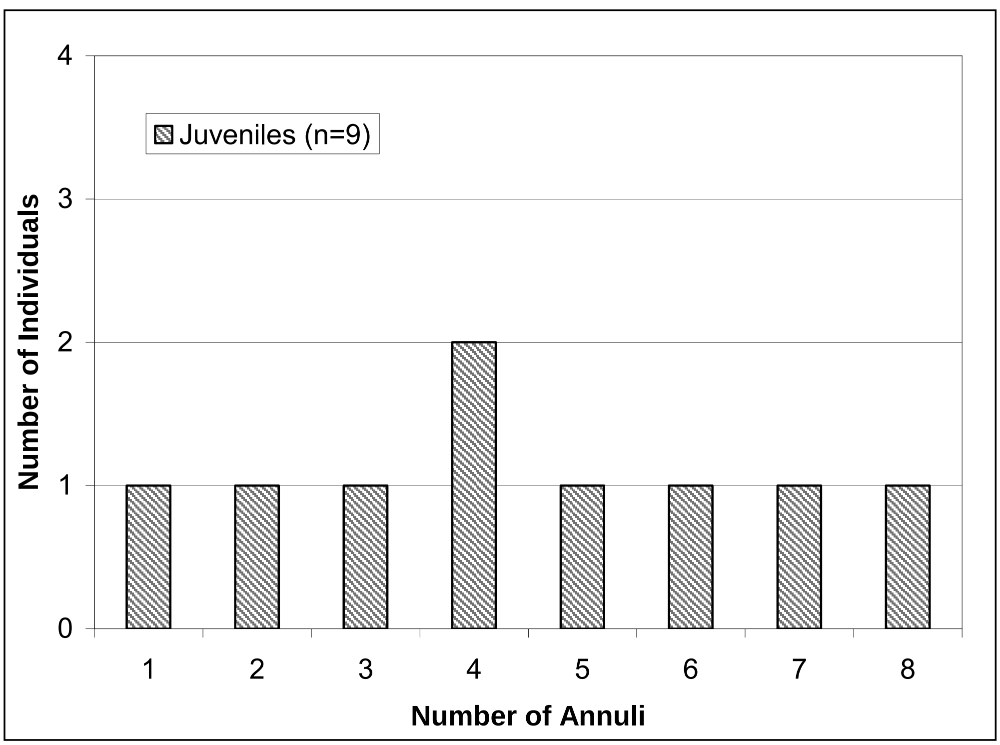

FIGURE 4.2. FREQUENCY OF JUVENILE SPOTTED TURTLES BY NUMBER OF ANNULI.

Spotted Turtles by number of annuli. The relationship between the number of growth annuli and carapace length is illustrated in Figure 4.3. Figure 4.4 represents the frequency of male, female, and juvenile Spotted Turtles by carapace length (CL) . The smallest turtle in this study was a 13 g one-year old with a CL of 44 mm. The largest CL recorded was a male with CL 112.9 mm, and largest mass was another male weighing 210 g.

Mean morphometric measurements were calculated for all adult *C. guttata* due to their small sample size (n=12) (Table 4.1a). Mean mass of all adults was 161.9 +/- 32.6 g (range 107 – 210 g). Mean carapace length and carapace width were 101.5 +/- 7.9 mm (range 86.7 – 112.9 mm) and 80.3 +/- 4.7 mm (range 72 – 86.7 mm), respectively. Dorsal-ventral height of all adults had a mean of 37.1 +/- 2.9 mm (range 33.4 – 41.5 mm). Mean plastron length was 88.6 +/- 6.2 mm (range 77.7 – 99 mm) and mean plastron width was 56.5 +/- 3.7 (range 50.1 – 61.6 mm).

Morphometrics were also calculated for male and female *C. guttata*. The 8 male Spotted Turtles had a mean mass of 164.3 +/- 31.8 g (Table 4.1b). Their mass ranged from 108 to 210 g. Male carapace length had a mean of 102.6 +/- 8.1 mm (range 86.7 – 112.9 mm). Mean carapace width of the males 80.5+/-4.8 mm (range 72 – 86.7 mm). Mean male dorsal-ventral height was 36.6 +/-2.7 (range 33.4 - 41.4 mm). Mean male plastron length was 88.1+/-5.7 mm (range 77.7 – 96.1 mm). Mean male plastron width was 56.0+/-3.2 mm (range 50.1 - 59.1 mm).

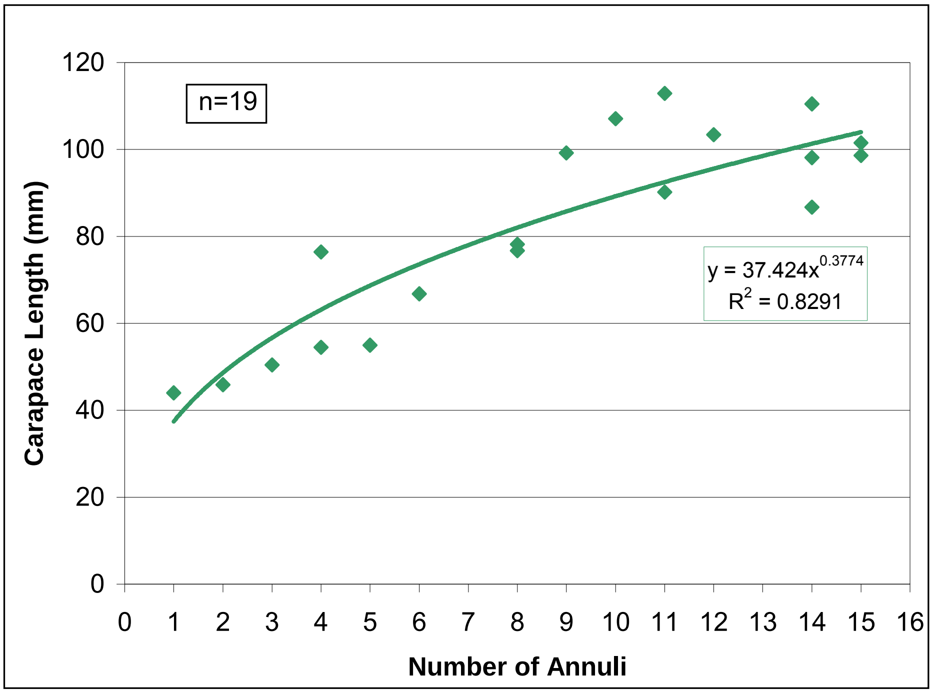

FIGURE 4.3. RELATIONSHIP BETWEEN THE NUMBER OF GROWTH ANNULI AND CARAPACE LENGTH IN SPOTTED TURTLES.

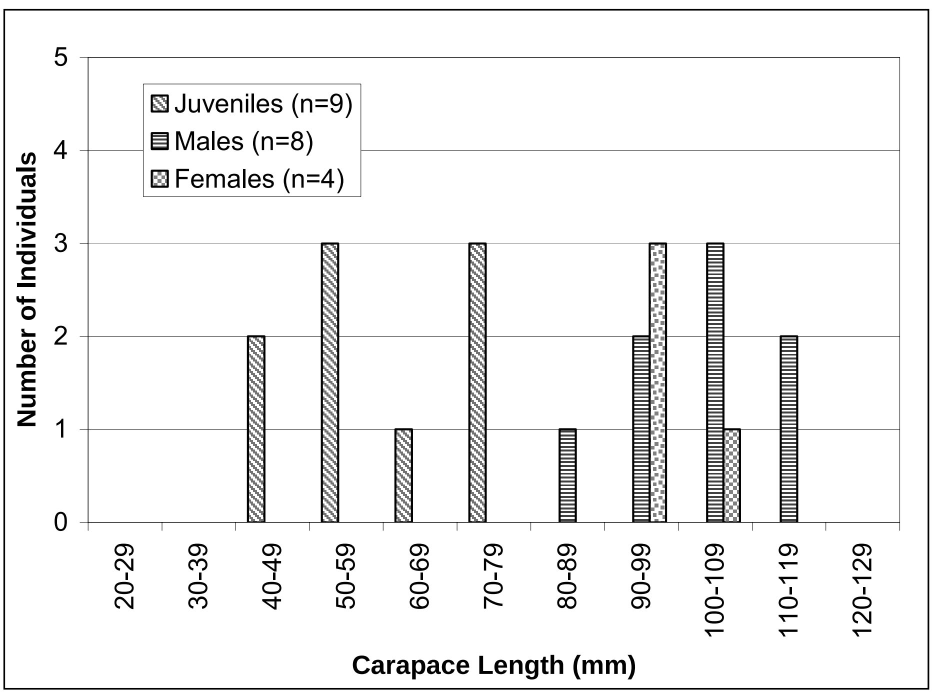

FIGURE 4.4. FREQUENCY OF MALE, FEMALE, AND JUVENILE SPOTTED TURTLES BY CARAPACE LENGTH IN SPOTTED TURTLES.

TABLES 4.1 A, B, C, AND D. MEAN +/- 1 STANDARD DEVIATION, MINIMUM, AND MAXIMUM MORPHOMETRIC MEASUREMENTS FOR ALL ADULTS (MALES AND FEMALES COMBINED), MALE, FEMALE, AND JUVENILE SPOTTED TURTLES IN WEST VIRGINIA.

TABLE 4.1A. ALL ADULT SPOTTED TURTLES (N=12).

	Mass (g)	Carapace Length (mm)	Carapace Width (mm)	Dorsal-Ventral Height (mm)	Plastron Length (mm)	Plastron Width (mm)
Mean +/- 1 SD	161.9 +/- 32.6	101.5 +/- 7.9	80.3 +/- 4.7	37.1 +/- 2.9	88.6 +/- 6.2	56.5 +/- 3.7
Range	107 – 210	86.7 – 112.9	72 – 86.7	33.4 – 41.5	77.7 – 99	50.1 – 61.6

TABLE 4.1B. MALE SPOTTED TURTLES (N=8).

	Mass (g)	Carapace Length (mm)	Carapace Width (mm)	Dorsal-Ventral Height (mm)	Plastron Length (mm)	Plastron Width (mm)
Mean +/- 1 SD	164.3 +/- 31.8	102.6 +/- 8.1	80.5 +/- 4.8	36.6 +/- 2.7	88.1 +/- 5.7	56.0 +/- 3.2
Range	108 - 210	86.7 – 112.9	72 – 86.7	33.4 – 41.4	77.7 – 96.1	50.1 – 59.1

TABLE 4.1C. FEMALE SPOTTED TURTLES (N=4).

	Mass (g)	Carapace Length (mm)	Carapace Width (mm)	Dorsal-Ventral Height (mm)	Plastron Length (mm)	Plastron Width (mm)
Mean +/- 1 SD	157.3 +/- 38.8	99.2 +/- 8.1	80.1 +/- 5.1	38.2 +/- 3.3	89.6 +/- 7.9	57.4 +/- 5.0
Range	107 - 198	90.2 – 109.8	72.5 – 83.7	33.8 – 41.5	79.7 - 99	50.2 – 61.6

TABLE 4.1D. JUVENILE SPOTTED TURTLES (N=9).

	Mass (g)	Carapace Length (mm)	Carapace Width (mm)	Dorsal-Ventral Height (mm)	Plastron Length (mm)	Plastron Width (mm)
Mean +/- 1 SD	41.3 +/- 24.1	60.9 +/- 13.8	54.0 +/- 10.1	23.2 +/- 5.2	54.7 +/- 15.0	35.1 +/- 8.7
Range	13 - 79	44 – 78.2	40.4 – 66.7	15.3 - 30	37.1 - 78	23 - 46

The mean mass of the 4 female Spotted Turtles was 157.3 g +/- 38.8 g and their mass ranged from 107 to 198 g (Table 4.1c). Female CL had a mean of 99.2 +/- 8.1 mm (range 90.2 – 109.8 mm). Mean female carapace width (CW) was 80.1+/-5.1 mm (range 72.5 – 83.7 mm). Mean female dorsal-ventral height (DVH) was 38.2 +/-3.3 mm (range 33.8 - 41.5 mm). Plastron length (PL) had a mean of 89.6 +/- 7.9 mm (range 79.7 – 99 mm). Mean plastron width (PW) was 57.4 +/- 5.0 mm (range 50.2 - 61.6 mm).

Juvenile Spotted Turtles had a mean mass of 41.3 +/- 24.1 mm (range 13 – 79 g) (Table 4.1d). Mean juvenile CL was 60.9 +/- 13.8 (range 44 – 78.2 mm). Mean CW was 54.0 +/- 10.1 mm (range 40.4 - 66.7 mm). Juvenile mean DVH was 23.2 +/- 5.2 mm (range 15.3 - 30 mm). Mean juvenile PL was 54.7+/-15.0 mm (range 37.1 – 78 mm). Juvenile mean PW was 35.1 +/- 8.7 mm (range 23 – 46 mm).

Two-sample t-tests showed there was no significant difference ($P > 0.05$) between the morphometric measurements of male and female *C. guttata* (mass ($P = 0.77$), CL ($P = 0.51$), CW ($P = 0.92$), DVH ($P = 0.44$), PL ($P = 0.74$), and PW ($P = 0.64$)). The sexual dimorphism index (SDI) of *C. guttata* was -1.04, -1.03, -1.00, -0.96, -0.98, and -0.98 for mass, CL, CW, DVH, PL, and PW, respectively (Table 4.2). Negative SDI numbers indicate that the male was the larger sex. Measurements greater than numeral 1.00 indicated males were larger for that characteristic and results smaller than 1.00 showed that females were larger for that characteristic. Although the SDI indicated males had a tendency for larger mass, CL, and CW, while females had larger DVH, PL, and PW, these differences were not statistically significant.

TABLE 4.2. SEXUAL DIMORPHISM INDEX (SDI) FOR VARIOUS MORPHOMETRIC MEASUREMENTS OF SPOTTED AND WOOD TURTLES.

Morphometric Measurement	Spotted Turtle	Wood Turtle
Mass	-1.04	-1.10
Carapace Length (CL)	-1.03	-1.06
Carapace Width (CW)	-1.00	-1.03
Dorsal-Vental Height (DVH)	-0.96	-0.98
Plastron Length (PL)	-0.98	-1.01
Plastron Width (PW)	-0.98	-1.00

Two-sample t-tests comparing the relationship between morphometric measurements of male and female Spotted Turtles revealed that 2 combinations exceeded the level of significance ($P < 0.05$) (Table 4.3). There was a significant difference between the sexes for the relationships of CL vs. DVH ($P = 0.02$) (Figure 4.5) and CL vs. PL ($P = 0.002$) (Figure 4.6). There was no significant difference between males and females in the relationship between CL vs. PW ($P = 0.055$) (Figure 4.7), CL vs. CW ($P = 0.28$) (Figure 4.8), CL vs. mass ($P = 0.85$) (Figure 4.9) or DVH vs. mass ($P = 0.43$) (Figure 4.10). There was no significant difference between males and females for the rest of the combinations comparing CL, CW, DVH, PL, PW and mass (Table 4.3).

TABLE 4.3. P-VALUES ($P<0.05$) FROM TWO-SAMPLE T-TESTS OF MORPHOMETRIC RELATIONSHIPS IN SPOTTED TURTLES FROM WEST VIRGINIA.

Red shaded squares indicate a significant difference ($P < 0.05$) between males and females, white squares have no significant difference between males and females, and gray-shaded squares are redundant crosses.

	Carapace Length	**Carapace Width**	**Dorsal-Ventral Height**	**Plastron Length**	**Plastron Width**	**Mass**
Carapace Length		0.28	0.02	0.002	0.055	0.85
Carapace Width			0.08	0.37	0.13	0.68
Dorsal-Ventral Height				0.27	0.40	0.43
Plastron Length					0.72	0.56
Plastron Width						0.52

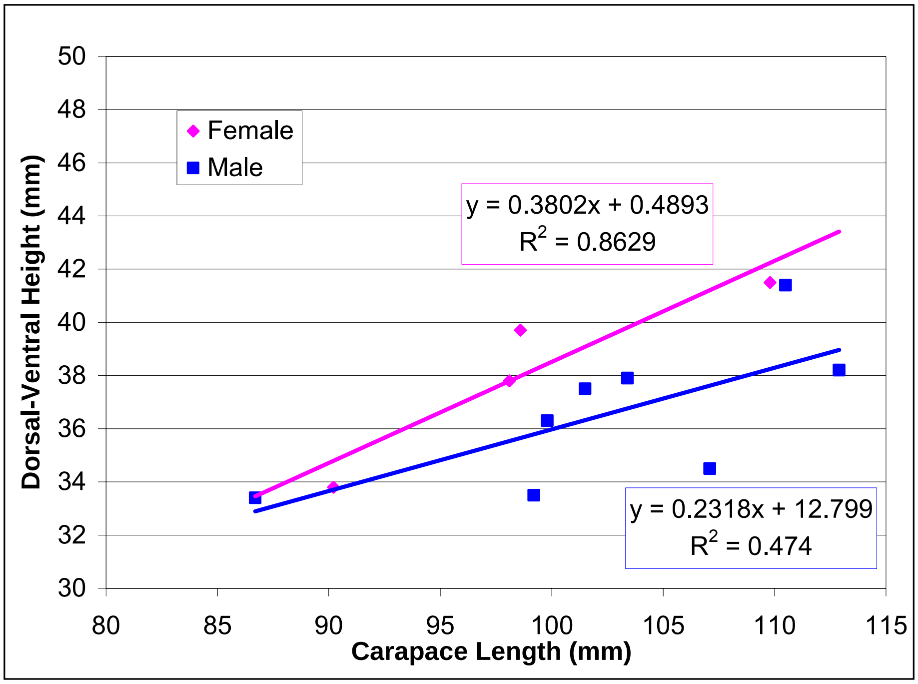

FIGURE 4.5. RELATIONSHIP BETWEEN CARAPACE LENGTH VERSUS DORSAL-VENTRAL HEIGHT IN MALE AND FEMALE SPOTTED TURTLES (P=0.02).

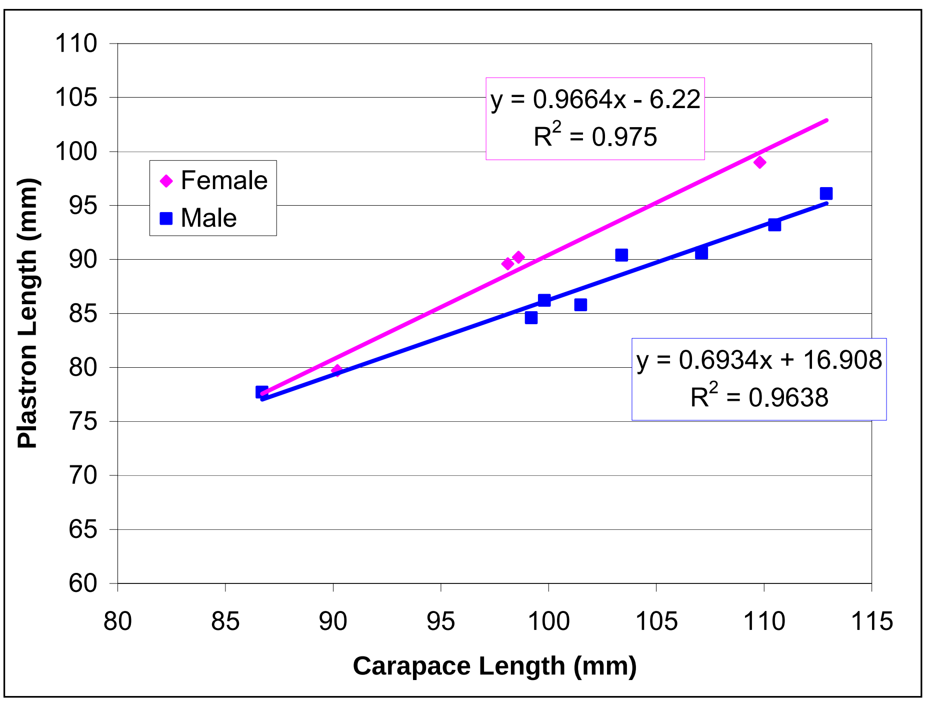

FIGURE 4.6. RELATIONSHIP BETWEEN CARAPACE LENGTH VERSUS PLASTRON LENGTH IN MALE AND FEMALE SPOTTED TURTLES (P=0.002).

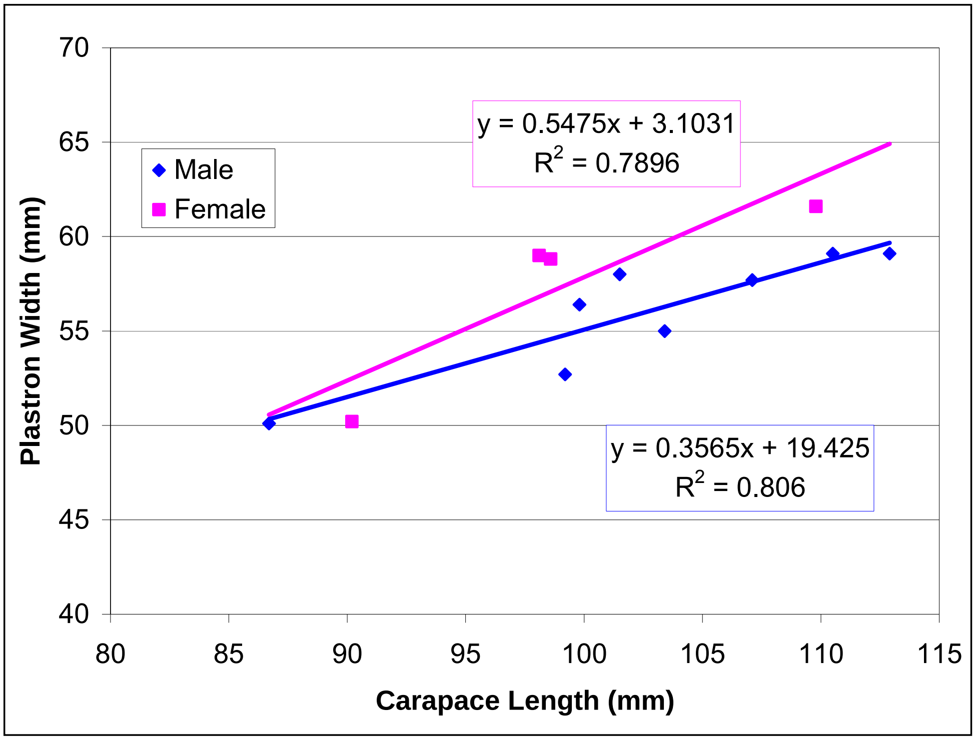

FIGURE 4.7. RELATIONSHIP BETWEEN CARAPACE LENGTH VERSUS PLASTRON WIDTH IN MALE AND FEMALE SPOTTED TURTLES (P=0.055).

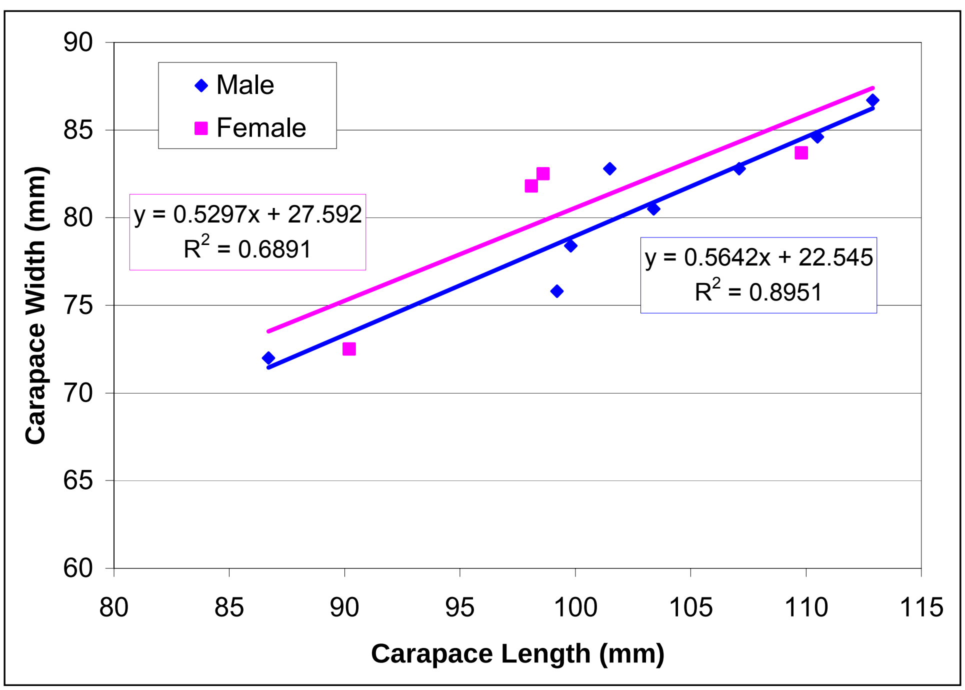

FIGURE 4.8. RELATIONSHIP BETWEEN CARAPACE LENGTH VERSUS CARAPACE WIDTH IN MALE AND FEMALE SPOTTED TURTLES (P=0.28).

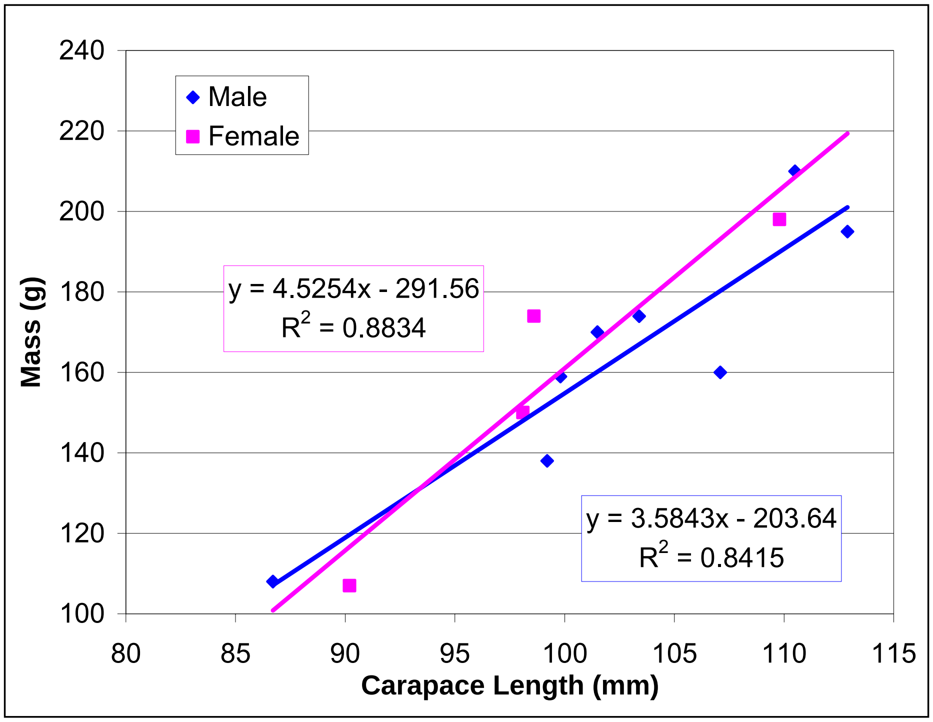

FIGURE 4.9. RELATIONSHIP BETWEEN CARAPACE LENGTH VERSUS MASS IN MALE AND FEMALE SPOTTED TURTLES (P=0.85).

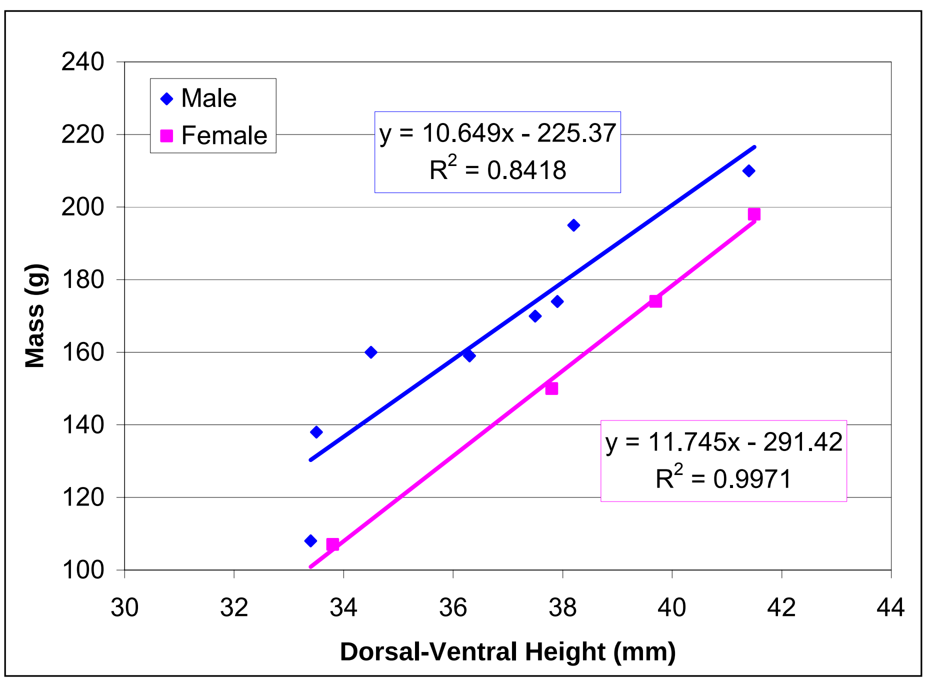

FIGURE 4.10. RELATIONSHIP BETWEEN DORSAL-VENTRAL HEIGHT VERSUS MASS IN MALE AND FEMALE SPOTTED TURTLES (P=0.43).

Sample size numbers for Spotted Turtles were very low, so there is not much weight in the significance of these findings. A larger sample size is needed.

Wood Turtles:

Fifty Wood Turtles were captured during this study. Eighteen (36%) were juveniles, 16 (32%) were males, and 16 (32%) were females (Figure 4.11). Sex ratio of male to female *G. insculpta* was 1:1. The juvenile to adult ratio was 1:1.18.

The annuli of adult Wood Turtles ranged from 1 annulus to an adult male with a smooth (annuli worn away) plastron and front half of carapace, indicating he was a very old adult. The frequency of juvenile Wood Turtles by number of annuli can be seen in Figure 4.12. The relationship between the number of growth annuli versus CL and the number of growth annuli versus mass are shown in Figures 4.13 and 4.14. The frequency of juvenile, male, and female Wood Turtles by CL and by mass are shown in Figures 4.15 and 4.16.

Mean morphometric measurements were calculated for all adult male and female *G. insculpta* combined (Table 4.4a). Mean mass of Wood Turtles was 889.5 +/- 178.3 g (600 – 1275 g, N=30). Mean CL was 185.2 +/- 2.1 mm (164 – 206.5 mm, N=32). CW had a mean of 139.1 +/- 8.1 mm (121 – 150 mm, N=32). Mean DVH was 68.8 +/- 5.8 mm (58 – 83 mm, N=32). Wood Turtles had a mean PL of 169.9 +/- 9.8 mm (149 – 191 mm, N=32) and mean PW of 94.4 +/- 5.5 mm (83 – 103 mm, N=29).

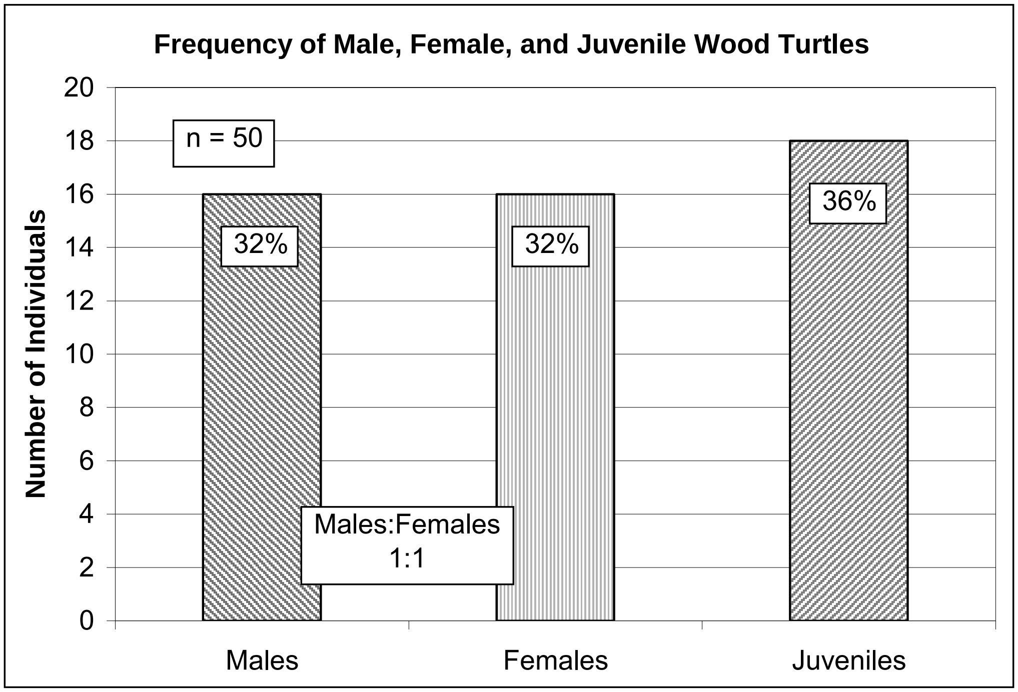

FIGURE 4.11. FREQUENCY OF MALE, FEMALE, AND JUVENILE WOOD TURTLES IN WEST VIRGINIA.

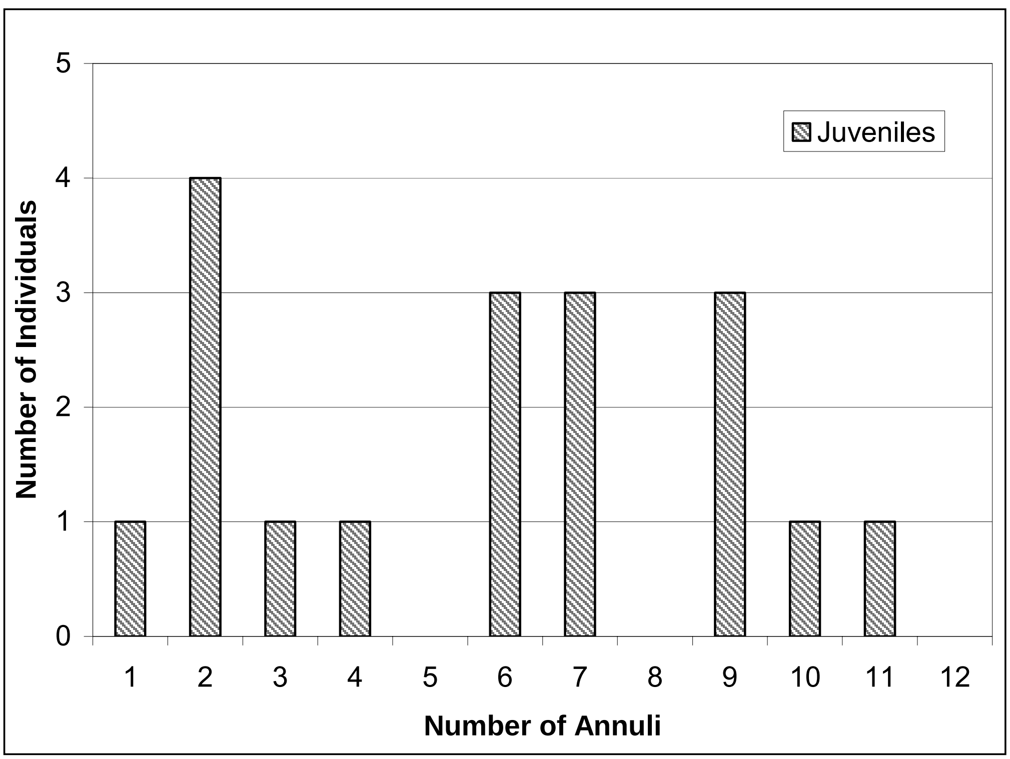

FIGURE 4.12. FREQUENCY OF JUVENILE WOOD TURTLES BY NUMBER OF ANNULI.

Male *G. insculpta* had a mean mass of 932.3 +/-178.2 g (600-1150 g, N=15) (Table 4.4b). Mean male CL was 190.6+/-12.2 mm (165 - 206.5 mm, N=16) and mean male CW was 141.1+/-7.8 mm (121 – 150 mm, N=16). Mean DVH for males was 68.3+/-6.0 mm (58 - 77 mm, N=16). Mean male PL and PW were 171.1+/-9.0 mm (153 - 182.5 mm) and 94.5+/-4.8 mm (85 - 101 mm, N=14), respectively.

Female Wood Turtles had a mean mass of 846.7+/-173.7g (66 - 1275 g, N=15) (Table 4.4c). Mean female CL and CW were 179.9+/-9.6 mm (164 - 199 mm, N=16) and 137.2+/-8.1 mm (122 - 148 mm, N=16), respectively. Mean female DVH was 69.4+/-5.8 mm (63 - 83 mm, N=16). Female PL had a mean of 168.7+/-10.7 mm (149 – 191 mm, N=16). Mean female PW was 94.4+/-6.2 mm (83 – 103 mm, N=15).

Mean mass of juvenile Wood Turtles was 268.6+/-177.7 g (50 – 570 g, N=18) (Table 4.4d). Mean CL was 120.3+/-28.1 mm (72.3 – 164 mm, N=18). Mean CW was 93.1+/-18.6 mm (60.5 – 121 mm, N=18). Mean DVH was 44.4+/-10.2 mm (26.5 – 58 mm, N=18). The mean PL was 111.3+/-27.9 mm (63 – 155 mm, N=18). Mean PW was 62.0+/-14.8 mm (36.6 - 82 mm, N=18).

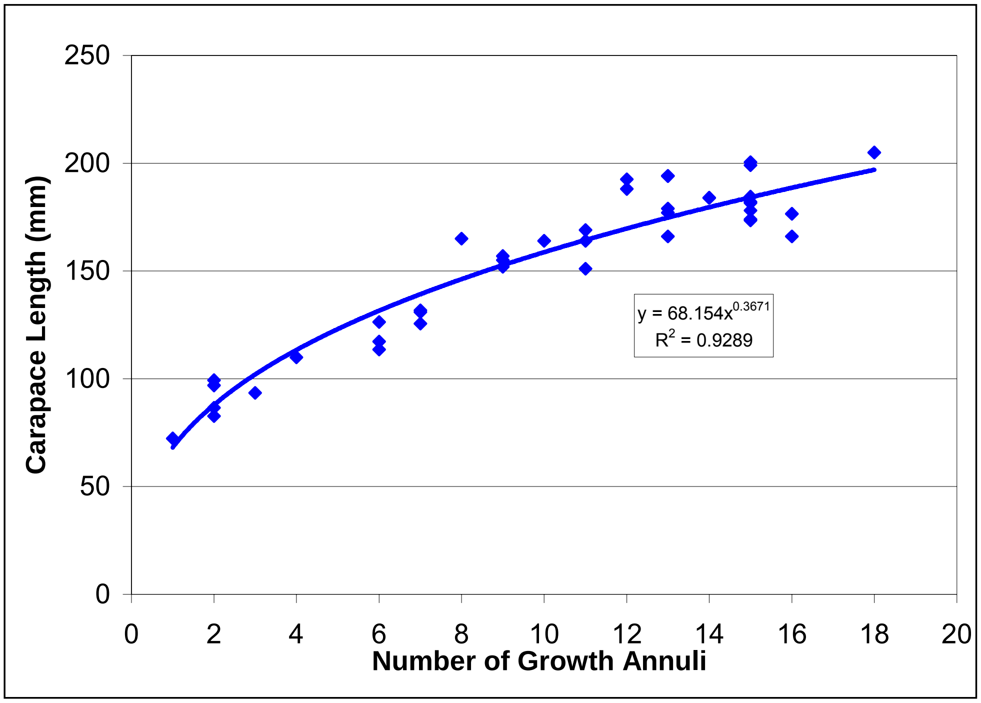

FIGURE 4.13. RELATIONSHIP BETWEEN THE NUMBER OF GROWTH ANNULI AND CARAPACE LENGTH IN WOOD TURTLES FROM WEST VIRGINIA.

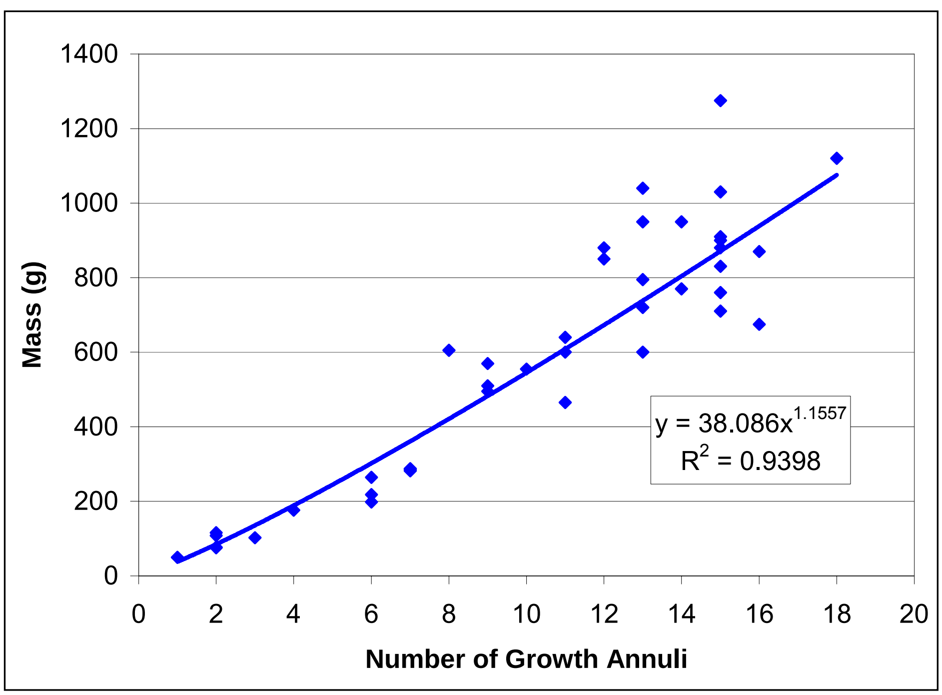

FIGURE 4.14. RELATIONSHIP BETWEEN THE NUMBER OF GROWTH ANNULI AND MASS IN WOOD TURTLES FROM WEST VIRGINIA.

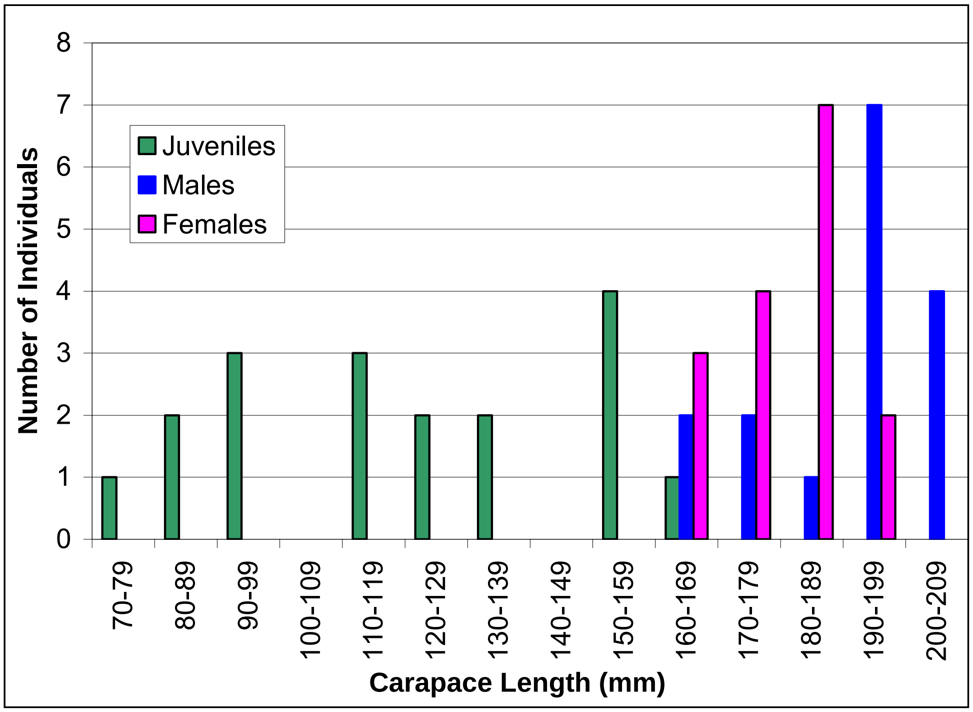

FIGURE 4.15. FREQUENCY OF JUVENILE, MALE, AND FEMALE WOOD TURTLES BY CARAPACE LENGTH.

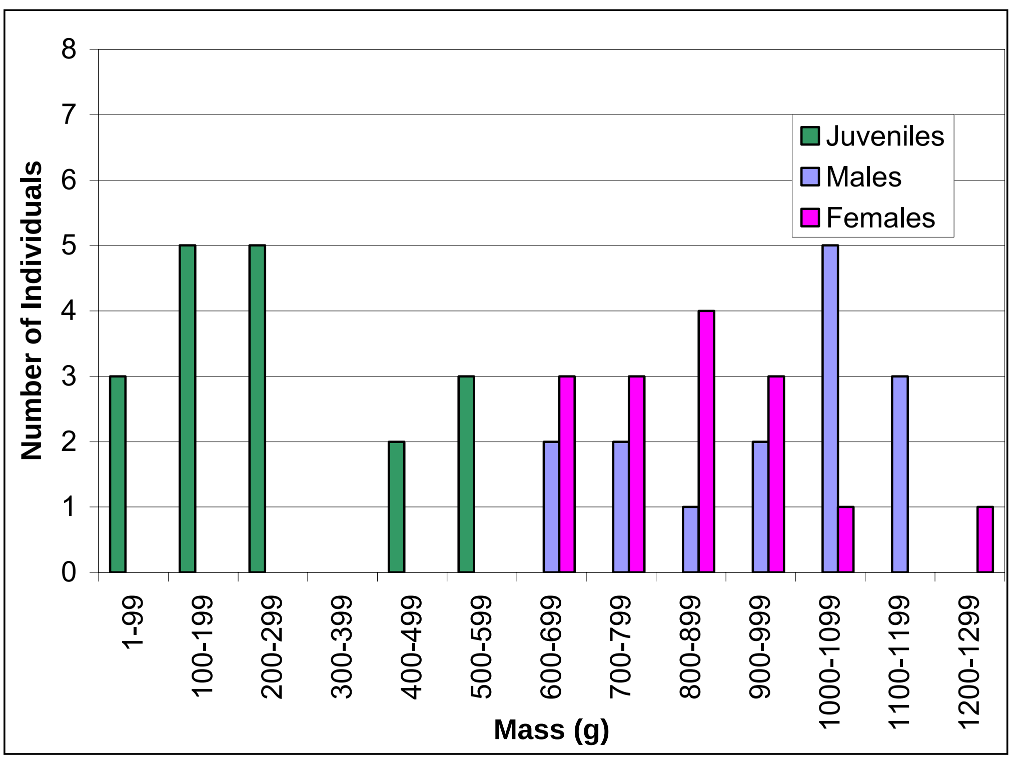

FIGURE 4.16. FREQUENCY OF JUVENILE, MALE, AND FEMALE WOOD TURTLES BY MASS.

TABLE 4.4 A, B, C, AND D. MEAN +/- 1 STANDARD DEVIATION, MINIMUM, AND MAXIMUM MORPHOMETRIC MEASUREMENTS OF ALL ADULTS (MALES AND FEMALES COMBINED), MALE, FEMALE, AND JUVENILE WOOD TURTLES IN WEST VIRGINIA.

TABLE 4.4A. ALL ADULT WOOD TURTLES.

	Mass (g) (n=30)	Carapace Length (mm) (n=32)	Carapace Width (mm) (n=32)	Dorsal-Ventral Height (mm) (n=32)	Plastron Length (mm) (n=32)	Plastron Width (mm) (n=29)
Mean +/- 1 SD	889.5 +/- 178.3	185.2 +/- 2.1	139.1 +/- 8.1	68.8 +/- 5.8	169.9 +/- 9.8	94.4 +/- 5.5
Range	600 – 1275	164 – 206.5	121 – 150	58 – 83	149 – 191	83 - 103

TABLE 4.4B. MALE WOOD TURTLES.

	Mass (g) (n=15)	Carapace Length (mm) (n=16)	Carapace Width (mm) (n=16)	Dorsal-Ventral Height (mm) (n=16)	Plastron Length (mm) (n=16)	Plastron Width (mm) (n=14)
Mean +/- 1 SD	932.3 +/- 178.2	190.6 +/- 12.2	141.1 +/- 7.8	68.3 +/- 6.0	171.1 +/- 9.0	94.5 +/- 4.8
Range	600 – 1150	165 – 206.5	121 - 150	58 – 77	153 – 182.5	85 - 101

TABLE 4.4C. FEMALE WOOD TURTLES.

	Mass (g) (n=15)	Carapace Length (mm) (n=16)	Carapace Width (mm) (n=16)	Dorsal-Ventral Height (mm) (n=16)	Plastron Length (mm) (n=16)	Plastron Width (mm) (n=15)
Mean +/- 1 SD	846.7 +/- 173.7	179.9 +/- 9.6	137.2 +/- 8.1	69.4 +/- 5.8	168.7 +/- 10.7	94.4 +/- 6.2
Range	600 – 1275	164 - 199	122 - 148	63 – 83	149 - 191	83 - 103

TABLE 4.4D. JUVENILE WOOD TURTLES.

	Mass (g) (n=18)	Carapace Length (mm) (n=18)	Carapace Width (mm) (n=18)	Dorsal-Ventral Height (mm) (n=32)	Plastron Length (mm) (n=18)	Plastron Width (mm) (n=18)
Mean +/- 1 SD	268.6 +/- 177.7	120.3 +/- 28.1	93.1 +/- 18.6	44.4 +/- 10.2	111.3 +/- 27.9	62.0 +/- 14.8
Range	50 – 570	72.3 - 164	60.5 - 121	26.5 – 58	63 - 155	36.6 - 82

Two-Sample t-tests showed male CL was significantly larger than female CL ($P = 0.01$). There was no significant difference between males and females for mass ($P = 0.19$), CW ($P = 0.16$), DVH ($P = 0.59$), PL ($P = 0.49$) or PW ($P = 0.96$). The SDI index for mass = -1.10, CL = -1.06, DVH = -0.98, PL = -1.01, and PL = -1.00 (Table 4.2). Although statistics showed that only the CL was significantly different between the sexes, the SDI showed the tendency for males to have larger mass, CW, and PL. The SDI of PL was equal between the males and females, and females had a larger DVH.

Two-sample t-tests comparing the relationship between morphometric measurements of male and female Wood Turtles revealed that 7 combinations exceeded the level significance ($P < 0.05$) (Table 4.5). The relationship of CL to CW was significantly different between males and females ($P = 0.008$) (Figure 4.19). There was a significant difference between males and females in the relationship of CL versus DVH ($P = 0.0005$) (Figure 4.20). There was a significant difference between males and females in the correlation of CL to PL ($P = 0.0$) and CL to PW ($P = 0.0004$) (Figures 4.21 and 4.22). Males and females differed significantly when CW was compared to DVH ($P = 0.03$) and PW ($P = 0.005$) (Figure 4.23 and 4.24). The comparison of DVH to mass also differed significantly between male and female *G. insculpta* ($P = 0.04$) (Figure 4.25). There was no significant difference between male and female *G. insculpta* in CL versus mass ($P = 0.53$) (Figure 4.26). There was no significant difference between males and females in the remaining combinations of CW, DVH, PL, PW, and mass ($P > 0.05$) (Table 4.5).

TABLE 4.5. P-VALUES OF TWO-SAMPLE T-TESTS OF MORPHOMETRIC RELATIONSHIPS IN WOOD TURTLES FROM WEST VIRGINIA.

The red shaded squares indicate a significant difference between males and females, white squares have no significant difference between males and females, and gray-shaded squares are redundant crosses.

	Carapace Length	Carapace Width	Dorsal-Ventral Height	Plastron Length	Plastron Width	Mass
Carapace Length		0.008	0.0005	0	0.0004	0.53
Carapace Width			0.03	0.16	0.005	0.28
Dorsal-Ventral Height				0.14	0.32	0.04
Plastron Length					0.26	0.20
Plastron Width						0.20

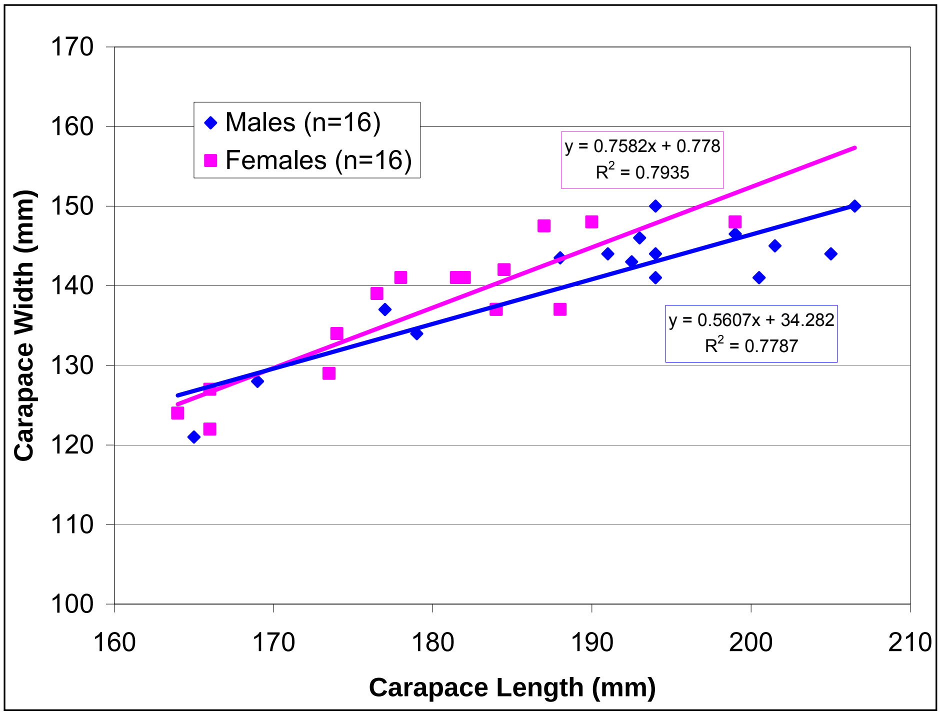

FIGURE 4.17. THE RELATIONSHIP OF CARAPACE LENGTH TO CARAPACE WIDTH WAS SIGNIFICANTLY DIFFERENT BETWEEN MALE AND FEMALE *G. INSCULPTA* (P=0.008).

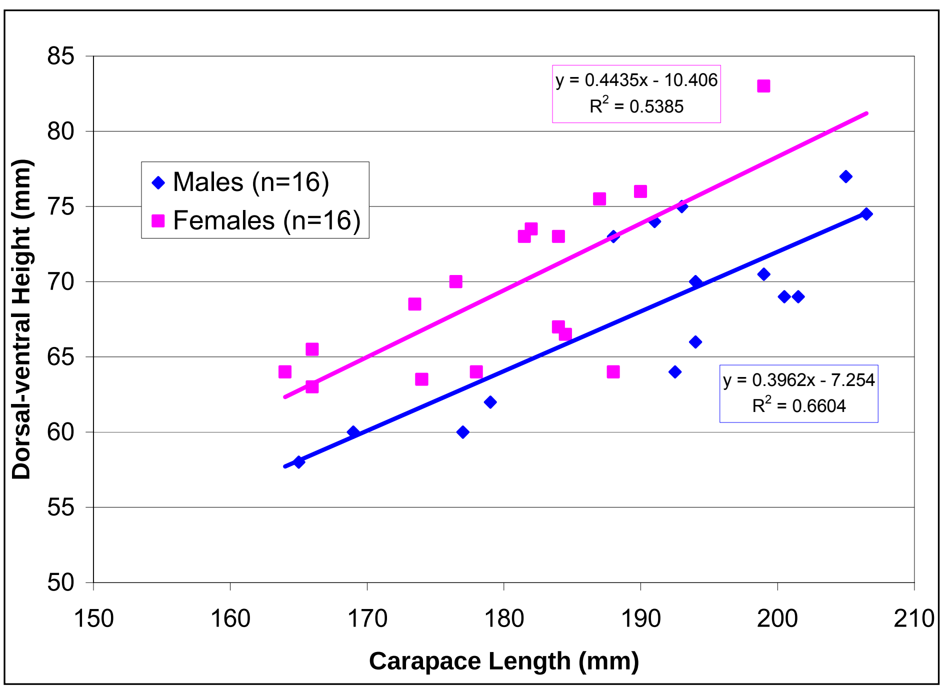

FIGURE 4.18. THE RELATIONSHIP OF CARAPACE LENGTH VERSUS DORSAL-VENTRAL HEIGHT IN *G. INSCULPTA* (P=0.0005).

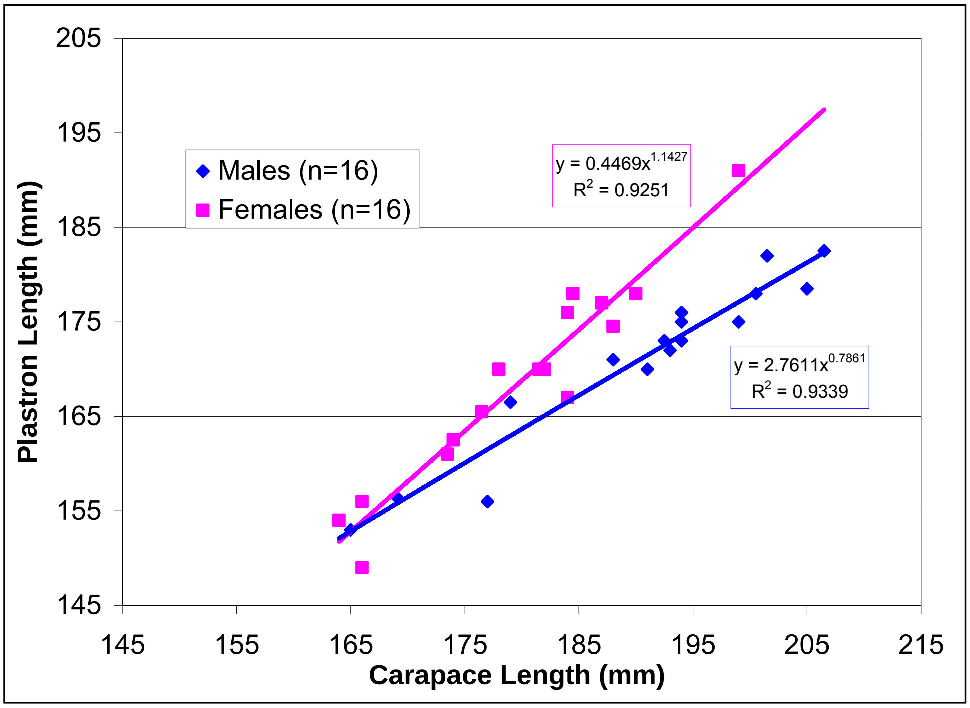

FIGURE 4.19. THE RELATIONSHIP BETWEEN CARAPACE LENGTH AND PLASTRON LENGTH BETWEEN MALE AND FEMALE *G. INSCULPTA* (P=0.0).

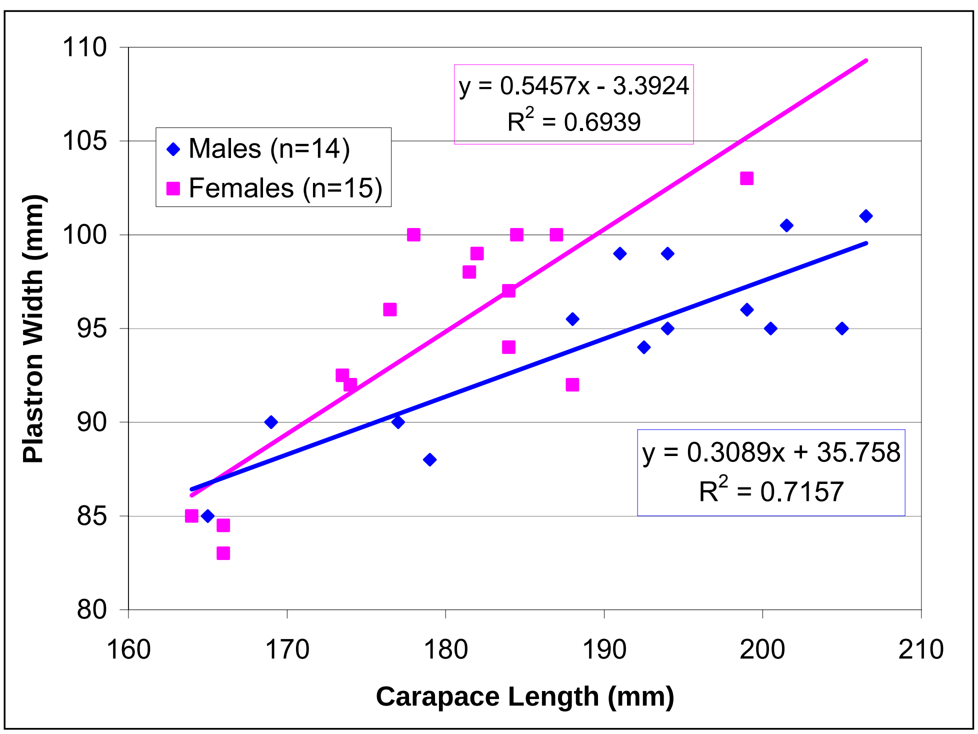

FIGURE 4.20. THE RELATIONSHIP BETWEEN CARAPACE LENGTH AND PLASTRON WIDTH IN MALE AND FEMALE *G. INSCULPTA* (P=0.0004).

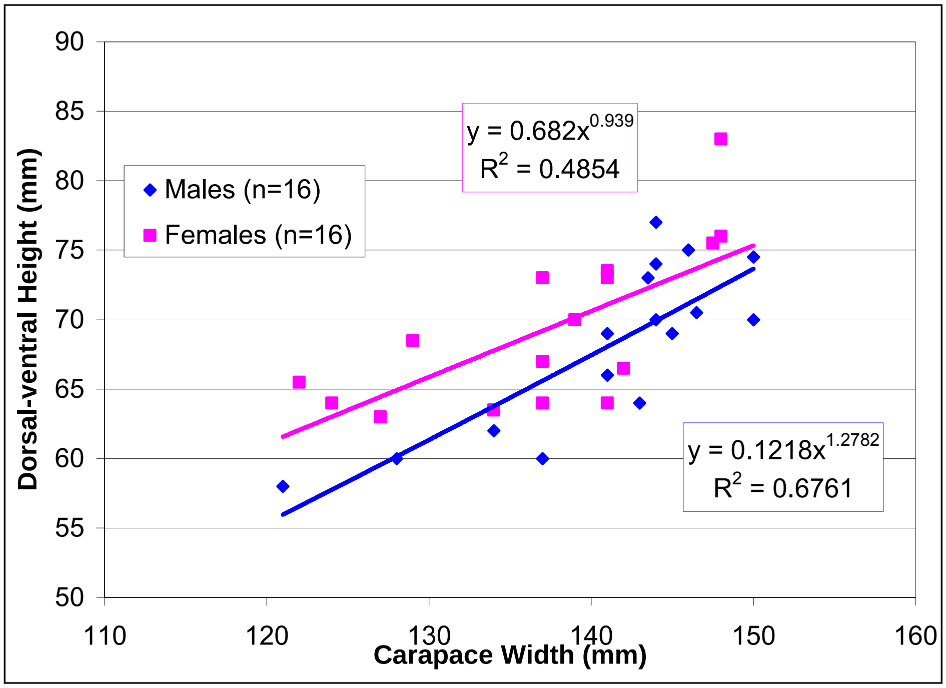

FIGURE 4.21. THE RELATIONSHIP BETWEEN CARAPACE WIDTH AND DORSAL-VENTRAL HEIGHT IN MALE AND FEMALE *G. INSCULPTA* (P=0.03).

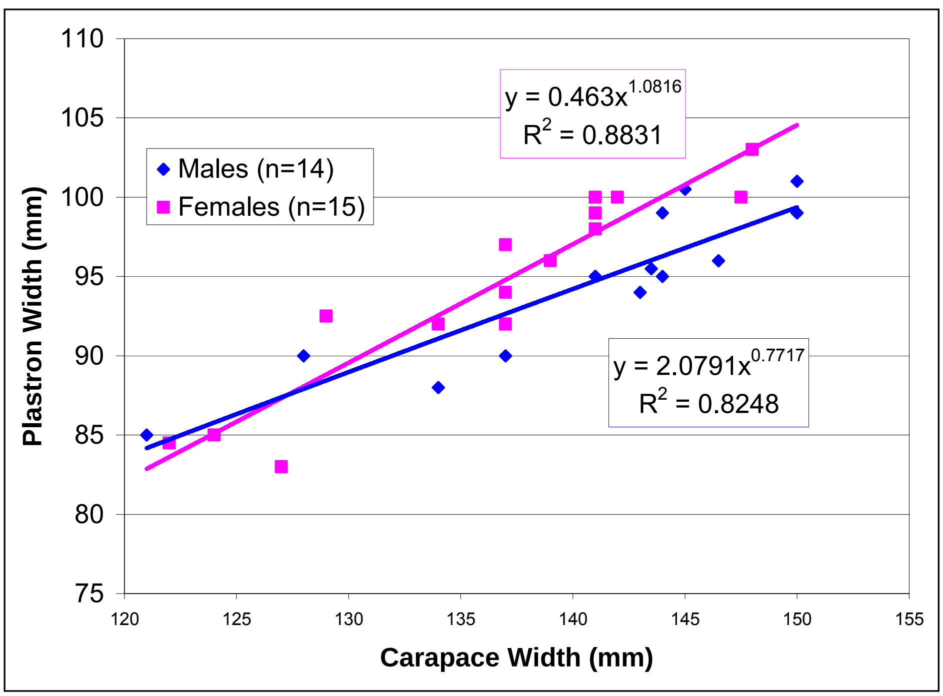

FIGURE 4.22. THE RELATIONSHIP BETWEEN CARAPACE WIDTH AND PLASTRON WIDTH IN MALE AND FEMALE *G. INSCULPTA* (P=0.005).

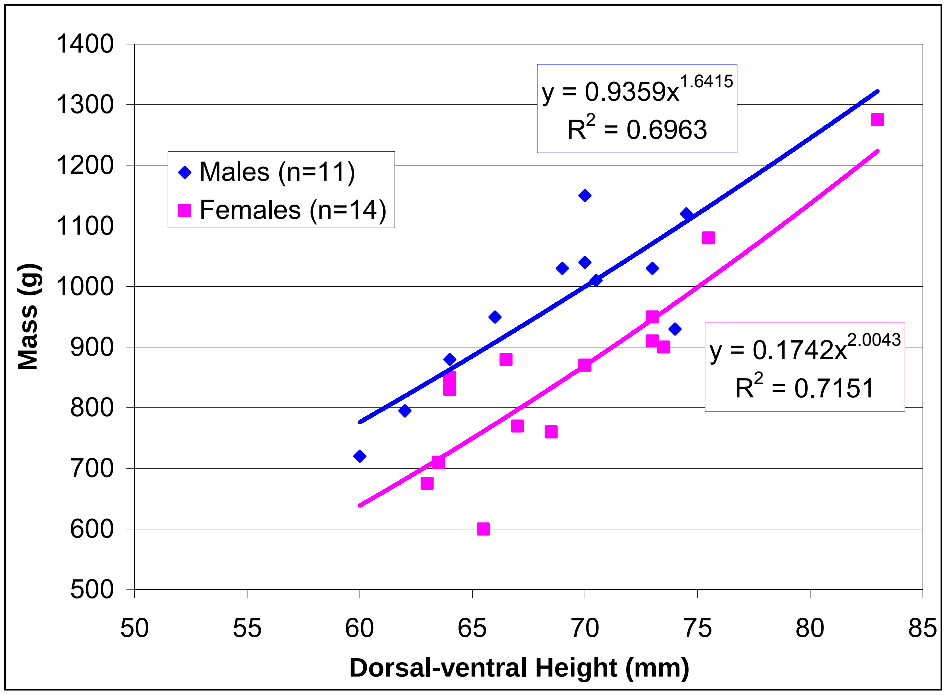

FIGURE 4.23. THE RELATIONSHIP BETWEEN DORSAL-VENTRAL HEIGHT AND MASS IN MALE AND FEMALE *G. INSCULPTA* (P=0.04).

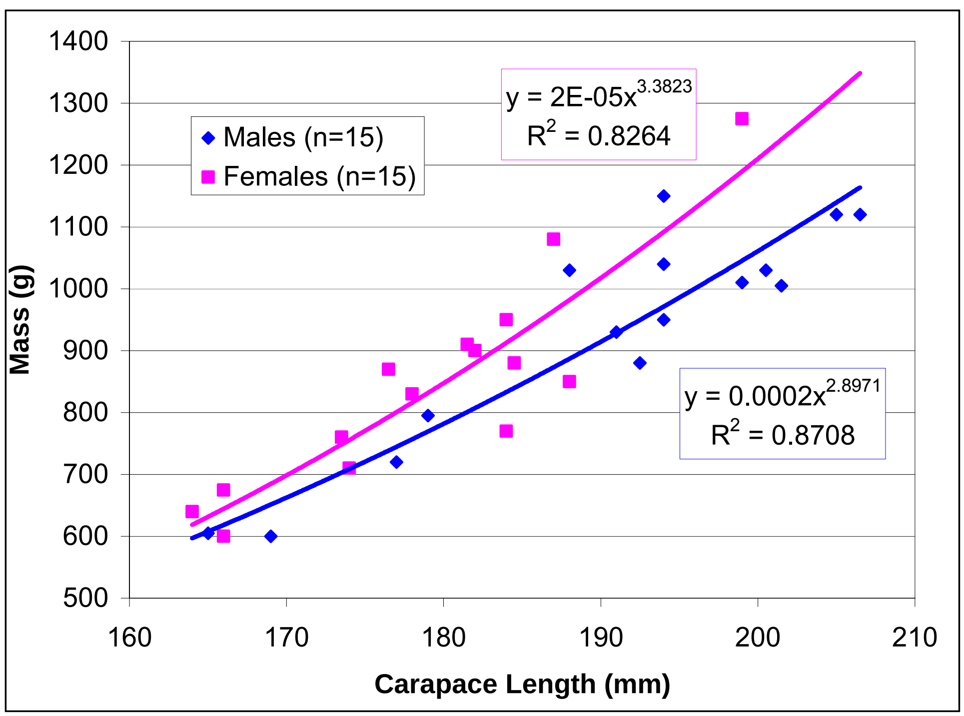

FIGURE 4.24. THE RELATIONSHIP BETWEEN CARAPACE LENGTH VERSUS MASS IN MALE AND FEMALE *G. INSCULPTA* (P=0.53).

DISCUSSION

Spotted Turtles:

Sexual maturity is reached in *C. guttata* when they attain a CL of approximately 80 mm (Ernst et al. 1994). There were twice as many male *C. guttata* per female captured in this study (2:1 sex ratio). Due to the fact that 76.1% of the turtles were captured by trap, sex ratios may have been biased. Sampling bias, such as technique for collection, behavioral differences between sexes, and determination of size at maturity, can influence the sex ratios (Gibbons and Lovich 1990). Males are more likely to enter aquatic traps than females, while females are more likely to be captured terrestrially during spring and early summer (Gibbons and Lovich 1990). This will be discussed further in the next chapter on capture information and trapping success. In Massachusetts, there were 0.57 male *C. guttata* per female, which was not significantly different from a 1:1 ratio (Graham 1995). There was not a significant difference in the ratio of males to females in South Carolina (Litzgus and Mousseau 2004).

Table 4.6 is a comparison of mean morphometrics by region. Other morphometric studies measured mid-line lengths (Graham 1995, Litzgus and Brooks 1998, Haxton and Berrill 1999, Litzgus and Mousseau 2004), so direct comparison with this study cannot be made without converting the data into similar forms, which has not yet been done. Mid-line measurements would be smaller than maximum length measurements that were used in this study, but general comparisons can be made. The mean CL and PL of Massachusetts turtles (Graham 1995) were larger than mean CL of West Virginia turtles. Mean mass

TABLE 4.6 Comparison of mean morphometric measurements of Spotted Turtles by region.

		West Virginia (Breisch 2006)		Massachusetts (Graham 1995)		South Carolina (Litzgus and Mousseau 2004)		Ontario (Litzgus and Brooks 1998)		Ontario (Haxton and Berrill 1999)	
		Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Mass (g)	mean	164.3	157.3			168	190				
	SD (±)	31.8	38.8			0.29	2.2				
	range	108 - 210	107 - 198								
Carapace Length (mm)	mean	102.6	99.2	113.3	110.2	105.2	103.8	116.3	115	121.5	121.4
	SD (±)	8.1	8.1	1.3	2	1.6	1	5.7	5.2	4.3	22.9
	range	86.7 – 112.9	90.2 – 109.8	105.1–123	79-126						
Dorsal-Ventral Height (mm)	mean	36.6	38.2			32.1	37.5				
	SD (±)	2.7	3.3			0.2	0.2				
	range	33.4 – 41.4	33.8 – 41.5								
Plastron Length (mm)	mean	88.1	89.6	96.4	101.5	86.8	91.2	94.9	101.1		
	SD (±)	5.7	7.9	1.2	2	1.5	1.1	4.8	4.9		
	range	77.7 – 96.1	79.7 - 99	89.3–104.8	72.0-115.8						

and CL of South Carolina turtles were larger than West Virginia turtles (Litzgus and Mousseau 2004). Mean DVH was smaller in South Carolina turtles than ones from West Virginia (Litzgus and Mousseau 2004). In South Carolina, mean male PL was smaller and mean female PL was larger than West Virginia turtles of the same sex (Litzgus and Mousseau 2004).

Both male and female Spotted Turtles have been found to have larger mean carapace lengths near the northern limits of their range (Litzgus and Brooks 1998, Haxton and Berrill 1999) (Table 4.6). In Ontario, the smallest *C. guttata* captured was a yearling with a CL of 27.8 mm and the largest had a CL of 142.5 mm (Haxton and Berrill 1999). The smallest turtle in this study was one-year old with 44 mm CL. Ontario Spotted Turtles had larger CL than this study, whose largest CL was 112.9 mm.

Another possible explanation for why the mean carapace lengths at my study are smaller than others is the high percentage of juveniles I found (43%). In Ontario, only 9% of Spotted Turtles found were juveniles (Litzgus and Brooks 1998). Massachusetts had 18% subadults (Graham 1995). South Carolina turtles were 14% juveniles (Litzgus and Mousseau 2004).

Wood Turtles:

There was no significant difference in the ratio between male and female *G. insculpta* in this study (1:1). This result is similar to the findings in New Hampshire (Tuttle and Carroll 1997), Pennsylvania (Ernst 2001), West Virginia (Niederberger and Seidel 1999), and Quebec (Walde et al. 2003), where there was also no significant difference reported.

Several studies have reported populations with a high percentage of juvenile Wood Turtles, similar to this one (36%). Another Wood Turtle population in West Virginia had 46% juveniles (Niederberger and Seidel 1999). In New Jersey, juveniles represented 66% of the population (Farrell and Graham 1991). A population in New Hampshire had 44% juveniles (Tuttle and Carroll 1997). Walde et al. (2003) had 31.4% juveniles in Quebec. In some studies, juveniles were observed less frequently. Juveniles were 23.9% of the population in Pennsylvania (Ernst 2001). In another study in Quebec, 18% of the Wood Turtle captures were juveniles and none were found younger than 5 years of age (Daigle 1997). Ontario juveniles consisted of 12% of captures (Brooks et al. 1992). In a Wisconsin study, only 1 juvenile was captured (Ross et al. 1991). No nests were found during my study, but juveniles as young as 1-year old were found, so some recruitment was taking place.

In this study males were significantly larger than females in carapace length, but there was no significant difference between the other morphometric measurements. Males had significantly larger carapace lengths than females in New Jersey (Harding and Bloomer 1979 (from Lovich et al. 1990), Farrell and Graham 1991), New Hampshire (Tuttle and Carroll 1997), Michigan (Harding and Bloomer 1979 (from Lovich et al. 1990)), Ontario (Brooks et al. 1992), and Quebec (Walde et al. 2003). Similar to my study, there was no significant difference in mass between the sexes in New Hampshire (Tuttle and Carroll 1997). However, other studies have reported a difference in mass between the sexes (Brooks et al. 1992, Walde et al. 2003). In several studies, differences in plastron lengths were not significant (Lovich et al. 1990, Farrell and Graham 1991, Brooks et al. 1992, Walde et al. 2003). Brooks et al. (1992) also found a significant difference between carapace widths, which was not significant in my study.

The largest male in my study was slightly larger than found in New Jersey and 22 mm smaller than the largest found in Michigan. The largest female in this West Virginia study was larger than in New Jersey and smaller than Michigan. The largest male in this study was 206.5 mm in carapace length and largest female was 199 mm in carapace length. In New Jersey the largest male was 206 mm and largest female was 188 mm (Harding and Bloomer 1979). In Michigan the largest male was 228 mm and largest female was 218 mm (Harding and Bloomer 1979).

CHAPTER 5
Capture Information and Trapping Success

INTRODUCTION

Trapping has been an effective means to capture Spotted Turtles in Massachusetts (Graham 1995, Milam and Melvin 2001), Ohio (Lewis and Faulhaber 1999) and New York (per. obs).

One objective of this study was to evaluate capture rates of a population of Spotted Turtles and Wood Turtles in West Virginia using hand capture and live trapping techniques. Another objective was to determine trapping success of capturing these turtles.

RESULTS

Twenty-one Spotted Turtles and 50 Wood Turtles were captured between 19 March 2001 and 2 April 2003. Of these turtles, 8 Spotted Turtles and 6 Wood Turtles were radio tracked.

Spotted Turtles:

Twenty-one Spotted Turtles were captured 260 times. Captures included 17 times by hand, radio tracked 189 times, and trapped 54 times. Males were captured 147 times, females 83 times and juveniles 30 times. Without radio tracking, males were caught 33 times, females 8 times, and juveniles 30 times (n=71) (Table 5.1).

TABLE 5.1. SPOTTED TURTLE HAND AND TRAP CAPTURE DATA.
DATES OF FIRST AND LAST CAPTURE, NUMBER OF DAYS BETWEEN FIRST AND LAST CAPTURE, AND TOTAL NUMBER OF DAYS CAPTURED. TOTAL, AVERAGE, MINIMUM, MAXIMUM, DATES, AND # BY SEX ARE LISTED. * MEANS TURTLE WAS RADIO TRACKED.

Turtle ID #	Sex	Date of 1st Capture	Date of Last Capture	# Days from 1st to Last Capture	# Days Captured
Cg01*	Male	05/20/01	7/11/2001	52	8
Cg02*	Female	05/22/01	5/22/2001	0	1
Cg03	Juvenile	05/22/01	3/29/2002	311	5
Cg04*	Female	05/22/01	3/31/2003	678	4
Cg05*	Female	05/23/01	5/25/2001	2	2
Cg06	Juvenile	05/23/01	4/1/2002	313	11
Cg07*	Male	05/30/01	3/30/2003	669	8
Cg08	Juvenile	05/31/01	5/31/2001	0	1
Cg09*	Male	06/16/01	3/30/2002	287	2
Cg10*	Male	06/17/01	8/14/2001	61	8
Cg11	Juvenile	06/25/01	8/15/2001	51	3
Cg12	Juvenile	07/09/01	7/9/2001	0	1
Cg13	Juvenile	07/09/01	8/18/2001	40	3
Cg14	Juvenile	07/11/01	3/30/2002	259	3
Cg15	Juvenile	08/13/01	8/17/2001	4	2
Cg16*	Male	07/09/01	8/14/2001	36	2
Cg17	Male	03/07/02	3/7/2002	0	1
Cg18	Juvenile	03/29/02	3/29/2002	0	1
Cg19	Female	03/30/02	3/30/2002	0	1
Cg20	Male	03/30/02	3/31/2002	1	2
Cg21	Male	04/01/03	4/1/2003	0	1
Cumulative Total Captures					**71**
Average # Days Captured					**3.4**
Minimum # Captures / Turtle					**1**
Maximum #Captures / Turtle					**11**
First Date Any Turtle Captured					**5/20/2001**
Last Date Any Turtle Captured					**4/1/2003**
Male - # Captures					**33**
Female - # Captures					**8**
Juvenile - # Captures					**30**

TABLE 5.2 RADIO-TRACKED SPOTTED TURTLE CAPTURE DATA.
NUMBER OF DAYS EACH RADIOTRACKED TURTLE WAS CAPTURED OVERALL AND BY RADIOTRACKING ONLY. TOTAL, AVERAGE, MINIMUM, MAXIMUM, DATES, AND NUMBER OF CAPTURES BY SEX ARE LISTED.

Turtle ID #	Sex	# Days Captured	Date of 1st Radio	Date of Last Radio	# Days 1st to Last Radio	# Days Radio Only
Cg01	Male	26	5/24/2001	7/10/2001	46	18
Cg02	Female	15	5/25/2001	6/17/2001	22	14
Cg04	Female	27	5/25/2001	7/9/2001	44	23
Cg05	Female	40	5/27/2001	3/30/2002	303	38
Cg07	Male	40	6/5/2001	3/30/2002	295	32
Cg09	Male	25	6/23/2001	3/8/2002	255	22
Cg10	Male	29	6/21/2001	4/4/02	283	21
Cg16	Male	23	7/9/2001	4/4/02	265	21

	All Captures		Radio Only Caps
Cumulative Total Captures	225		189
Average # Days Captured	28.1		23.6
Minimum # Captures / Turtle	15		14
Maximum #Captures / Turtle	40		38
First Date Any Turtle Captured	5/20/2001		5/24/2001
Last Date Any Turtle Captured	3/31/2003		4/4/2002

The maximum number of times a turtle was only hand and/or trap captured was 11, with an average number of 3.4 captures per turtle. The 8 radio tracked Spotted Turtles were captured an average of 28.1 times with the range of 15 to 40 captures per turtle (Table 5.2).

Using all 3 capture methods (hand, trap and radio track), June had the highest overall capture rate (n=85, 32.7%) (Figure 5.1). The lowest captures rates were in October and December with 5 captures (19%) which were all radio tracked. This data is biased because the most intensive searching for turtles took place during May through August 2001. June had the highest number of captures for both males (n=40) and females (n=38) (Figure 5.2). Males were located 28 times in July, 17 times in August and 16 times in September and March. Second highest capture rate in females was 18 in May. Highest capture months for juveniles were June and July (n=7 each).

When radio telemetry is taken out, March and June had the highest percent of hand or trap captures (n=15, 21.2%) (Figure 5.3). April had the lowest amount of hand or trap captures (n=4, 5.6%), but it also had fewer search days. In March, more *C. guttata* were captured by hand than trapped (Figure 5.4). In April through August they were more often trapped than hand captured, with the highest trapping numbers in June (n=15) and July (n=13). No *C. guttata* were hand captured in June.

Males and juveniles were caught every month from March through August. Females were caught March, May, and August. The earliest date in the spring *C. guttata* was captured without radio telemetry was 7 March and the

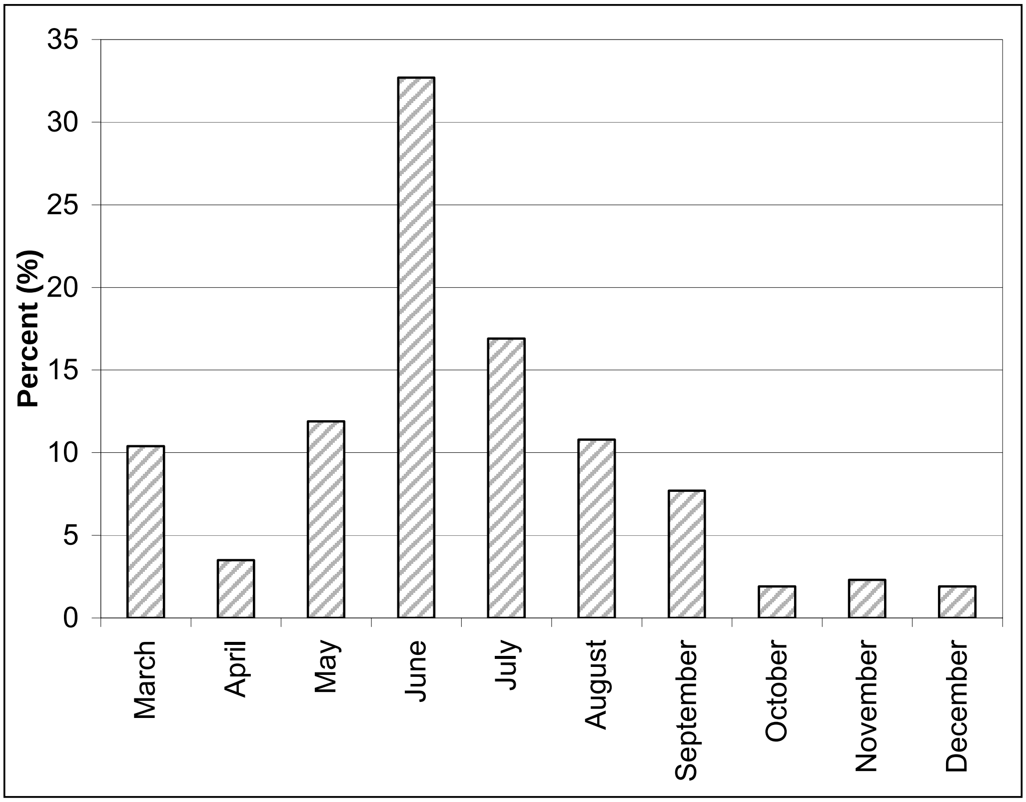

FIGURE 5.1. PERCENT CAPTURE OF SPOTTED TURTLES BY MONTH.

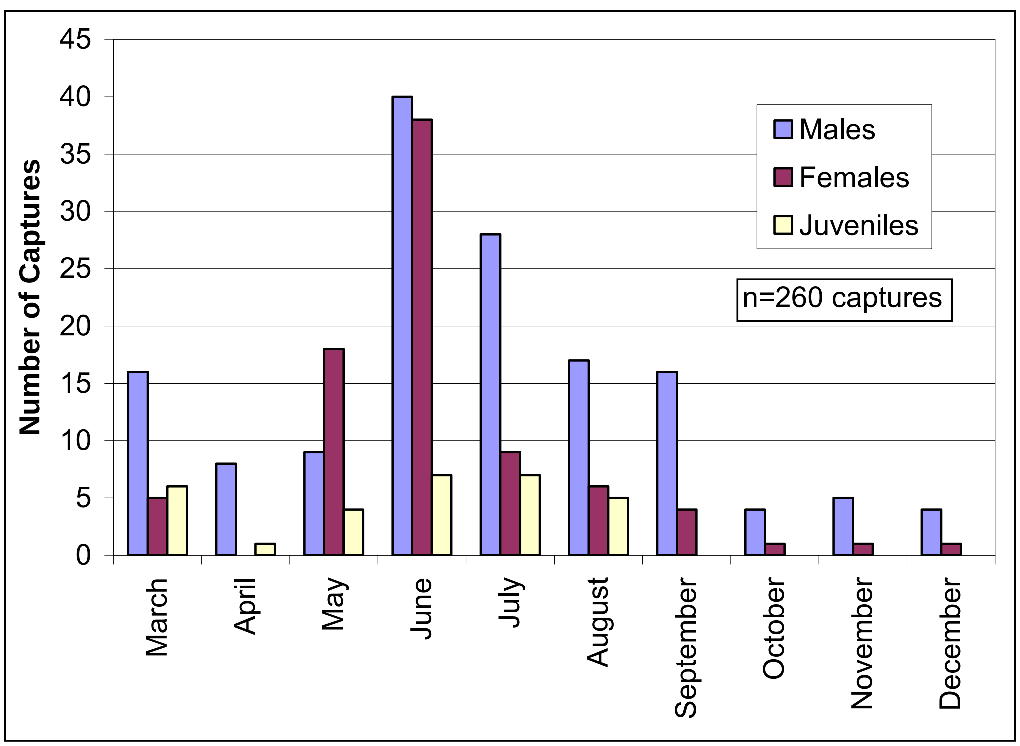

FIGURE 5.2. MALE, FEMALE, AND JUVENILE SPOTTED TURTLE CAPTURED PER MONTH.

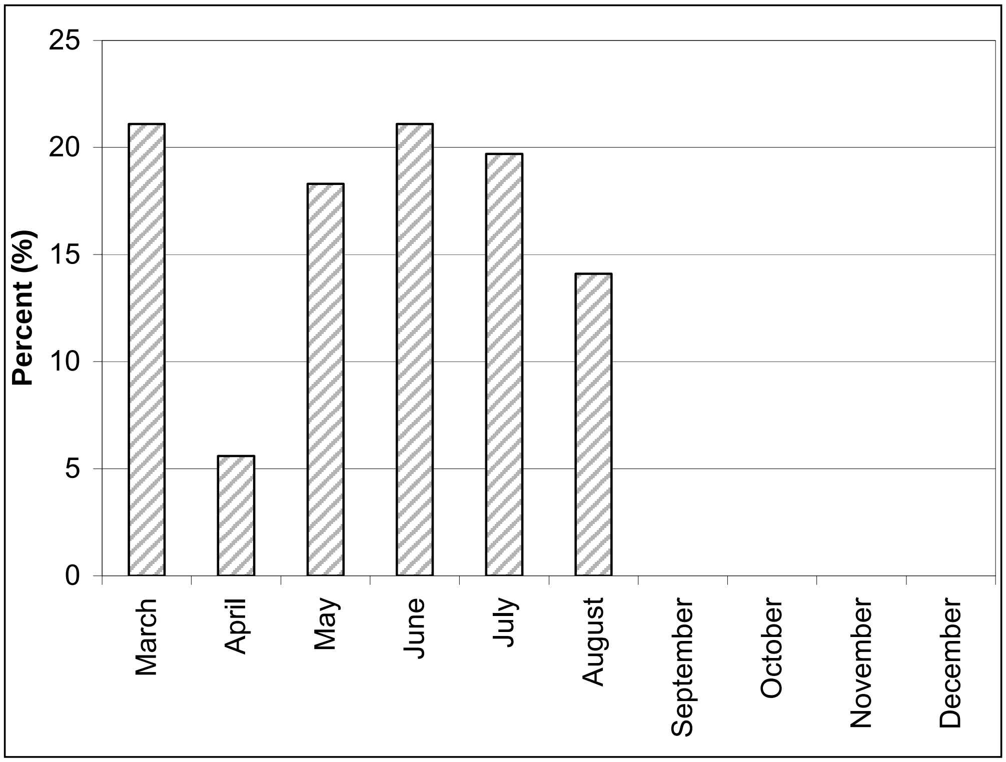

FIGURE 5.3 PERCENT OF HAND/TRAPPED SPOTTED TURTLES BY MONTH

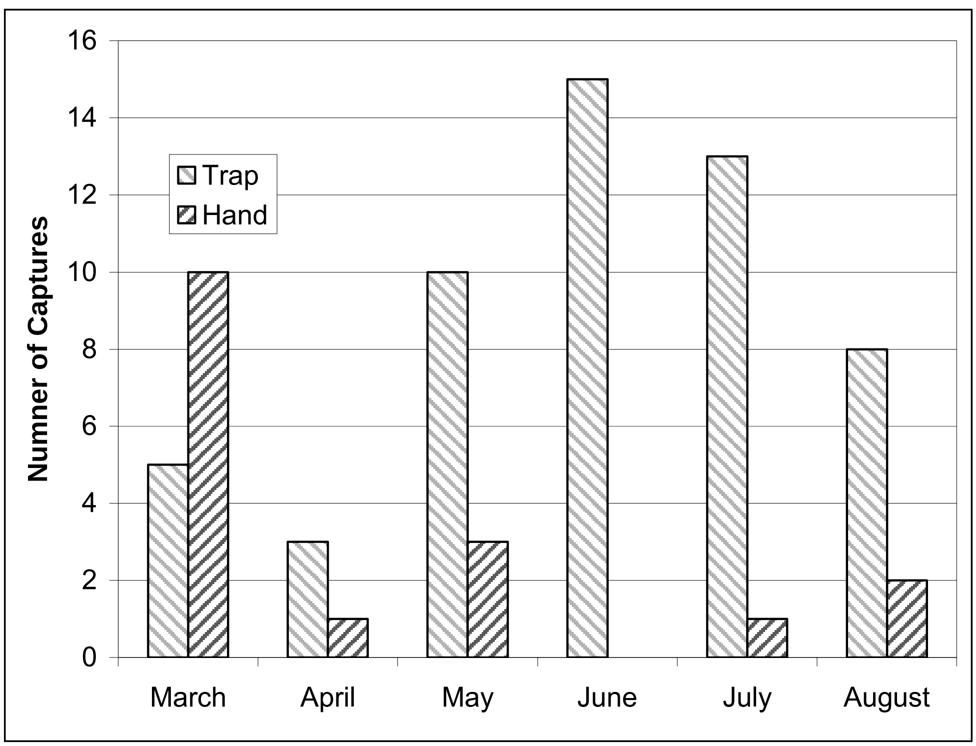

FIGURE 5.4. NUMBER OF HAND AND TRAP CAPTURE OF SPOTTED TURTLE BY MONTH.

latest date was 18 August. Males were trapped or hand captured the most in June (n=8) (Figure 5.5). May was the most productive month for females with 4 captures. Juveniles were captured most frequently in June and July with 4 captures each month (Figure 5.5).

The maximum number of *C. guttata* captured in a day was 5 (2 trapped and 3 by hand) which occurred on 30 March 2002. The maximum number of times turtles were trapped in a day were 4, which occurred on 22 May, 9 July, 11 July, and 15 August 2001. The maximum hand capture was 3 in one day which happened on 29 and 30 March 2002.

Seven Spotted Turtles were captured by both the hand and trap methods. Eleven were only captured in traps. For 3, the only method that captured them was by hand. All 3 hand captured turtles were displaying different behaviors: 1 was stationary and basking, 1 was swimming, and 1 was buried in the muck.

Trapping was more effective than hand capture for all sexes. Traps caught 76.1% (n = 54) while hand capture caught 23.9% (n = 17). Males were caught in traps 75.8% of the time (n = 25), compared to 24.2% of the time that they were hand captured (n = 8). Females were captured in traps 62.5% of the time (5 times), compared to 37.5% (3 times) that they were hand captured. Juveniles were captured in traps 24 times (80%) and hand captured 6 times (20%).

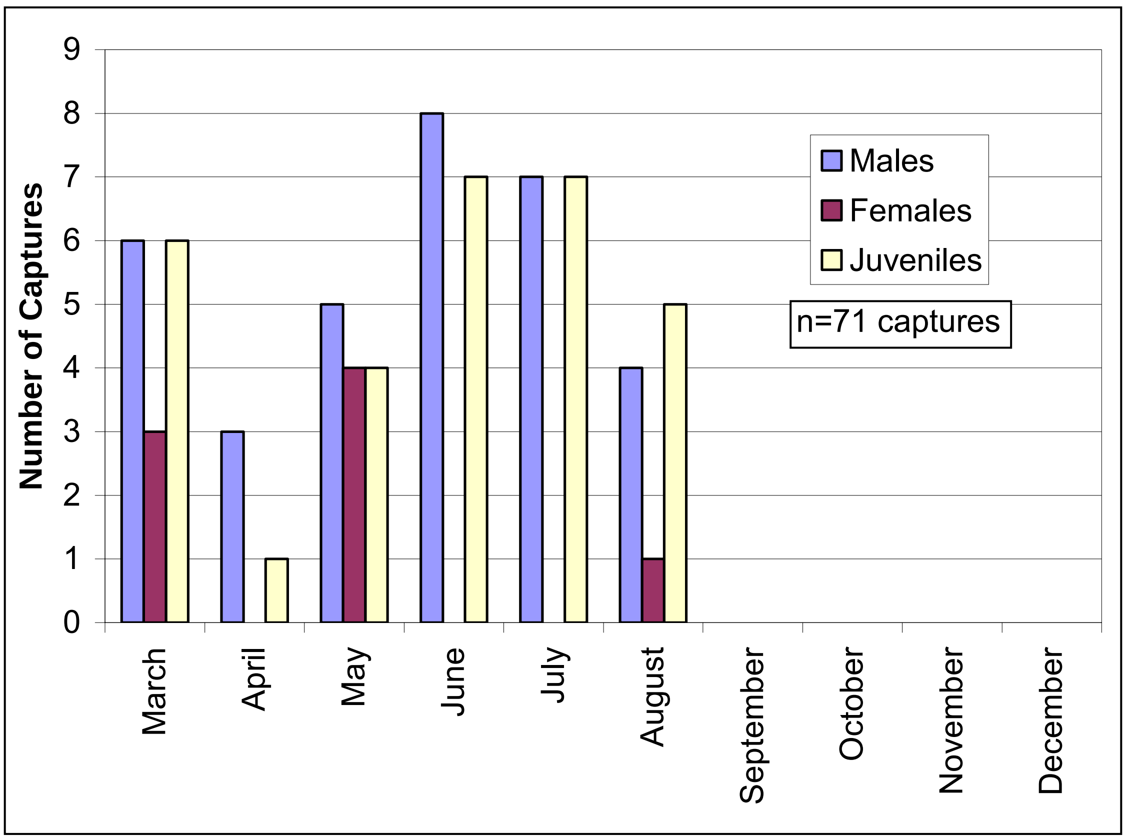

FIGURE 5.5. NUMBER OF CAPTURES PER MONTH THAT MALE, FEMALE, AND JUVENILE SPOTTED TURTLES WERE HAND OR TRAP CAPTURED.

Trapping Success:

Total trap nights for this study was 609 (Table 5.3). There were 380 trap nights in the Spotted Turtle wetland (east, north, west, and woods), 75 trap nights in the vernal area, 47 trap nights in the backwater channel, and 23 trap nights in the stream (Table 5.3). Spotted Turtles were trapped 54 times (11.3 trap nights per turtle). Trap nights were 323 for baited box trap, 255 trap nights using the unbaited funnel trap, and 23 trap nights using the hoop trap (Table 5.3). Of the Spotted Turtles, 94.4% that were trapped were captured in baited box traps (51 captures, 6.3 trap nights per turtle). Small unbaited funnel traps caught turtles 3 times (5.6%, 85 trap nights per turtle). No *C. guttata* were captured in hoop traps.

Baited box traps were set in the artificial fish ponds for 63 trap nights (forested ponds n = 39; unforested ponds n = 24). One turtle over wintered in 1 of these man-made ponds (see next chapter). No turtles were trapped in these ponds. Hoop traps were used for 13 trap nights in the stream (Table 5.3). One juvenile Wood Turtle was captured in a hoop trap on 18 August 2001.

Capture rates for Spotted Turtles in only locations they had been observed was 10 trap nights per turtle with 554 total trap nights (Table 5.4). Unforested artificial ponds and the stream were excluded no *C. guttata* were observed using those areas. Baited box traps in these areas had 5.9 trap nights per capture (n = 299 trap nights) and funnel traps had 85 trap nights per turtle (n=255 trap nights).

TABLE 5.3. SPOTTED TURTLE TRAPPING SUCCESS BY ALL TRAP TYPES AND LOCATIONS.

Location	**Box Trap**			**Funnel Trap**			**Hoop Trap**			**Total Trap**		
	# Trap Nights	**# Cap Turtles**	**#TN/ Cap**	**# Trap Nights**	**# Cap Turtles**	**#TN/ Cap**	**# Trap Nights**	**# Cap Turtles**	**#TN/ Cap**	**# Trap Nights**	**# Cap Turtles**	**#TN/ Cap**
Backwater Channel	15	0	0	32	0	0	0	0	0	47	0	0
Artificial Ponds, forested	39	0	0	0	0	0	0	0	0	39	0	0
Artificial Ponds, unforested	24	0	0	0	0	0	0	0	0	24	0	0
Old Stream Channel	15	0	0	0	0	0	0	0	0	15	0	0
Sphagnum	0	0	0	6	0	0	0	0	0	6	0	0
Main Wetland, East	66	14	4.7	22	0	0	0	0	0	88	14	6.3
Main Wetland, North	60	24	2.5	47	2	23.5	0	0	0	107	26	4.1
Main Wetland, West	45	7	6.4	30	1	30	0	0	0	75	8	9.4
Main Wetland, Woods	28	5	5.6	74	0	0	0	0	0	110	5	22.0
Stream	0	0	0	0	0	0	23	0	0	23	0	0
Vernal Area, wet	31	1	31.0	44	0	0	0	0	0	75	1	75.0
Total # Trap nights	**323**	**51**	**6.3**	**255**	**3**	**85**	**23**	**0**	**0**	**609**	**54**	**11.3**

TABLE 5.4. SPOTTED TURTLE TRAPPING SUCCESS OF BAITED AND UNBAITED BOX TRAPS BY KNOWN LOCATIONS OBSERVED.

Location	Baited Box Trap			Funnel Trap			Total Trap		
	# Trap Nights	# Cap Turtles	#TN/ Cap	# Trap Nights	# Cap Turtles	#TN/ Cap	# Trap Nights	# Cap Turtles	#TN/ Cap
Backwater Channel	15	0	0	32	0	0	47	0	0
Artificial, forested	39	0	0	0	0	0	39	0	0
Old Stream Channel	15	0	0	0	0	0	15	0	0
Sphagnum	0	0	0	6	0	0	6	0	0
Main Wetland, East	66	14	4.7	22	0	0	88	14	6
Main Wetland, North	60	24	2.5	47	2	23.5	107	26	4
Main Wetland, West	45	7	6.4	30	1	30	75	8	9
Main Wetland, Woods	28	5	5.6	74	0	0	102	5	20
Vernal Area, wet	31	1	31.0	44	0	0	75	1	75
Total	**299**	**51**	**5.9**	**255**	**3**	**85**	**554**	**54**	**10**

TABLE 5.5. TRAP CAPTURE RATES OF SPOTTED TURTLES BY KNOWN LOCATIONS CAPTURED.

Location	Box Trap			Funnel Trap			Total Trap		
	# Trap Nights	# Cap Turtles	#TN/ Cap	# Trap Nights	# Cap Turtles	#TN/ Cap	# Trap Nights	# Cap Turtles	#TN/ Cap
Main Wetland, East	66	14	4.7	22	0	0	88	14	6.3
Main Wetland, North	60	24	2.5	47	2	23.5	107	26	4.1
Main Wetland, West	45	7	6.4	30	1	30	75	8	9.4
Main Wetland, Woods	28	5	5.6	74	0	0	102	5	20.4
Vernal Area, wet	31	1	31.0	44	0	0	75	1	75.0
Total # Trap nights	**230**	**51**	**4.5**	**217**	**3**	**72.3**	**447**	**54**	**8.3**

Spotted Turtles were trapped in the main wetland and the vernal area (Tables 5.5). When just these locations are examined, the number of trap nights per turtle was 8.3 with 447 trap nights. There were 230 trap nights for baited box traps and 217 trap nights for unbaited funnel traps. The average number of trap nights per capture for box traps was 4.5. Unbaited funnel traps had 72.3 trap nights per capture. The most efficient area for capturing Spotted Turtles using both trap types was the north side of the wetland with 4.1 trap nights per capture (107 trap nights, 26 captures). The east side was 6.3 trap nights per capture, the west side was 9.4 trap nights per capture, and the woods area was 20.4 trap nights per capture. The least productive was the vernal area, which averaged 75 trap nights per capture (Table 5.5).

The east side of the main wetland had the highest number of trap nights with baited box traps (n = 66). Fourteen *C. guttata* were captured there, which averaged 4.7 trap nights per turtle (Tables 5.5). The highest capture rate using baited box traps was on the north side of the wetland which averaged 2.5 trap nights per capture (n=24 captures). The channel towards the woods had a capture rate of 5.6 trap nights per capture and the west side of the wetland had 6.4 trap nights per capture. Only 1 *C. guttata* was captured in the vernal area; the capture rate was 31 trap nights per capture.

Only 3 captures of *C. guttata* were made using the unbaited funnel trap. Two were on the north side of the wetland (23.5 trap nights per capture) and 1 was on the west side of the wetland (30 trap nights per turtle).

A juvenile (Cg#06) was trapped the most times with 11 captures. Most times a male was trapped was 8 (Cg#10) and most times a female was trapped was 2 (Cg#04). Cg#06 and Cg#10 were captured the most often (4 times each) with other turtles in the same trap. On 9 occasions there were multiple trap captures in a single trap. Most number of captures in a single trap was 3 males on 14 August 2001 and 8 other multiple turtle captures had 2 turtles in the trap. Six of these were a male and a juvenile together, caught in June and July 2001. Two days in a row, 24 and 25 June 2001, the same male (Cg#10) and juvenile (Cg#06) were caught together but they were in different traps each day. Once a female (Cg#05) and a juvenile (Cg#06) were caught on 23 May 2001 and once a female (Cg#19) and a male (Cg#20) were caught on 30 March 2002.

Amphibians trapped with *C. guttata* were *Bufo americanus*, *Hyla versicolor*, *Rana clamitans melanota*, and *Notophthalmus v. viridescens*. One *Chrysemys picta* was caught with 1 *C. guttata* on 11 July 2001 at the northwest end of the main wetland. On 16 June 2001, a *Chelydra serpentina* was trapped with a *C. guttata* in the vernal area.

Wood Turtles:

Fifty Wood Turtles were captured a total of 230 times. Eighty-five of those times were by hand, once by trap and 144 times by radio tracking (Table 5.6). Without radio tracking, males were captured 28 times, females 30 times, and juveniles 28 times. The earliest date in the spring a *G. insculpta* was found was 8 March 2002, which was active on the stream bottom (there were no field days in January and February). The latest date in the year *G. insculpta* was found was 26 December 2001, active on the stream bottom. The earliest date any Wood Turtles were found terrestrially was 9 March. The individual was basking. Latest date of the year that they were found on land was 20 October. Temperature recorded from data loggers indicated that the earliest emergence date for the radio tracked turtles was 15 March and latest basking date was 30 November (see chapter 7).

The maximum number of times a turtle was captured by hand or trap was 6, with the average number of 1.7 captures per turtle. Forty-three were hand captured only and 1 juvenile was only caught by trap. The average number of times a radio tracked turtle was captured was 25.5 with a range of 8 to 39 captures per turtle (Table 5.7). The average number of times radio tracked turtles were only located by radio tracking, (excluding captures where they were found by hand) was 24 with a range of captures from 7 to 37 per turtle (Table 5.7). Radio tracked males were caught 19 times, 17 by radio telemetry. Radio tracked females were caught 134 times, 127 of them by radio telemetry.

TABLE 5.6. WOOD TURTLE HAND AND TRAP CAPTURE DATA.
DATES OF FIRST AND LAST CAPTURE, NUMBER OF DAYS BETWEEN FIRST AND LAST CAPTURE, AND TOTAL NUMBER OF DAYS CAPTURED. TOTAL, AVERAGE, MINIMUM, MAXIMUM, DATES, AND NUMBER BY SEX ARE LISTED. * MEANS TURTLE WAS ALSO RADIOTRACKED.

Turtle ID #	Sex	Date of 1st Capture	Date of Last Capture	# Days from 1st to Last Capture	# Days Captured
Gi01	Male	3/19/2001	4/2/2003	744	3
Gi02	Male	3/19/2001	3/19/2001	0	1
Gi03*	Female	3/19/2001	5/25/2001	67	2
Gi04	Female	3/19/2001	3/19/2001	0	1
Gi05	Female	3/19/2001	4/2/2002	379	4
Gi06	Female	3/19/2001	12/26/2001	282	3
Gi07	Male	3/19/2001	3/8/2002	354	3
Gi08*	Female	5/23/2001	5/23/2001	0	1
Gi09	Juvenile	5/23/2001	4/1/2003	678	6
Gi10	Juvenile	5/27/2001	5/27/2001	0	1
Gi11	Juvenile	5/27/2001	5/27/2001	0	1
Gi12*	Female	6/5/2001	4/1/2003	665	3
Gi13*	Female	6/14/2001	6/14/2001	0	1
Gi14	Juvenile	6/15/2001	4/1/2003	655	2
Gi15	Juvenile	8/18/2001	8/18/2001	0	1
Gi16	Male	9/14/2001	10/14/2002	395	3
Gi17*	Male	10/20/2001	10/20/2001	0	1
Gi18*	Male	10/20/2001	10/20/2001	0	1
Gi19	Male	11/16/2001	3/31/2003	500	3
Gi20	Female	11/16/2001	10/14/2002	332	4
Gi21	Male	11/16/2001	11/16/2001	0	1
Gi22	Juvenile	12/26/2001	4/2/2002	97	3
Gi23	Female	12/26/2001	12/26/2001	0	1
Gi24	Male	3/8/2002	10/14/2002	220	3
Gi25	Female	3/9/2002	3/9/2002	0	1
Gi26	Juvenile	3/9/2002	3/9/2002	0	1
Gi27	Juvenile	3/9/2002	3/9/2002	0	1
Gi28	Juvenile	3/9/2002	4/2/2002	24	2
Gi29	Juvenile	3/9/2002	3/9/2002	0	1

TABLE 5.6. WOOD TURTLE HAND AND TRAP CAPTURE DATA CONTINUED.

Turtle ID #	Sex	Date of 1st Capture	Date of Last Capture	# Days from 1st to Last Capture	# Days Captured
Gi30	Male	3/9/2002	3/31/2002	22	2
Gi31	Female	3/9/2002	3/31/2002	22	2
Gi32	Female	3/9/2002	3/9/2002	0	1
Gi33	Female	3/9/2002	3/9/2002	0	1
Gi34	Male	3/30/2002	3/30/2002	0	1
Gi35	Female	3/30/2002	3/31/2003	366	3
Gi36	Juvenile	3/30/2002	3/31/2002	1	2
Gi37	Male	4/2/2002	4/2/2002	0	1
Gi38	Female	4/2/2002	4/2/2002	0	1
Gi39	Juvenile	4/2/2002	4/2/2002	0	1
Gi40	Juvenile	4/2/2002	4/2/2002	0	1
Gi41	Juvenile	4/2/2002	4/2/2002	0	1
Gi42	Juvenile	6/1/2002	6/1/2002	0	1
Gi43	Male	6/1/2002	6/1/2002	0	1
Gi44	Female	6/1/2002	6/1/2002	0	1
Gi45	Male	6/1/2002	6/1/2002	0	1
Gi46	Male	3/31/2003	4/1/2003	1	2
Gi47	Juvenile	3/31/2003	3/31/2003	0	1
Gi48	Male	3/31/2003	3/31/2003	0	1
Gi49	Juvenile	4/1/2003	4/1/2003	0	1
Gi50	Juvenile	4/2/2003	4/2/2003	0	1
Cumulative Total Captures					86
Average # Captures / Turtle					1.7
Minimum # Captures / Turtle					1
Maximum #Captures / Turtle					6
First Date Any Turtle Captured					3/19/2001
Last Date Any Turtle Captured					4/2/2003
Male - # Captures					28
Female - # Captures					30
Juvenile - # Captures					28

TABLE 5.7. RADIO TRACKED WOOD TURTLE CAPTURE DATA.
NUMBER OF DAYS EACH RADIOTRACKED TURTLE WAS CAPTURED OVERALL AND BY RADIOTRACKING ONLY. TOTAL, AVERAGE, MINIMUM, MAXIMUM, DATES, AND NUMBER OF CAPTURES BY SEX ARE LISTED.

Turtle ID #	Sex	# Days Captured	Date of 1st Radio	Date of Last Radio	# Days 1st to Last Radio	# Days Radio Only
Gi03	Female	39	05/28/01	07/02/02	400	37
Gi08	Female	37	05/25/01	07/02/02	403	36
Gi12	Female	38	06/07/01	07/02/02	390	35
Gi13	Female	20	06/16/01	07/02/02	381	19
Gi17	Male	11	11/16/01	10/13/02	331	10
Gi18	Male	8	11/16/01	10/14/02	332	7

	All Captures		Radio Only Caps
Cumulative Total Captures	153		144
Average # Days Captured	25.5		24
Minimum # Captures / Turtle	8		7
Maximum #Captures / Turtle	39		37
First Date Any Turtle Captured	03/19/01		05/25/01
Last Date Any Turtle Captured	04/01/03		10/14/02

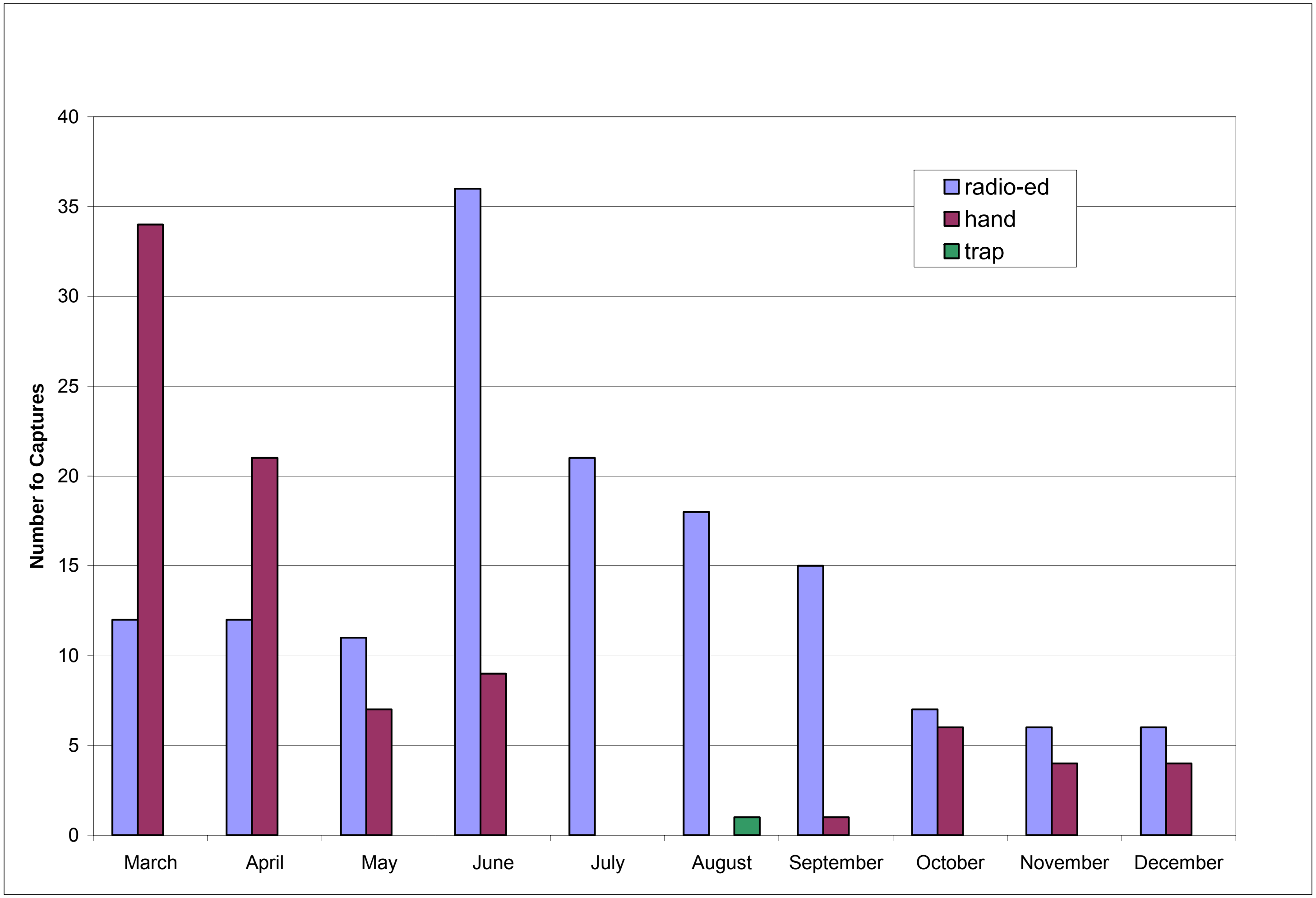

FIGURE 5.6. FREQUENCY OF WOOD TURTLES CAPTURED BY MONTH AND METHOD.

The most captures using all 3 methods (hand, trap, radio track) were in March. The lowest number of captures was in July. Turtles were radio tracked the most during June (n=36) (Figure 5.6). Most hand captures were in March (n=34) and April (n=21). No turtles were hand captured in August.

A juvenile was captured in a hoop trap on 18 August 2001. This was the only time that this individual was caught. The trap was located on the downstream side of the old beaver dam used by Gi#08 as a hibernaculum. Water temperature was 16°C.

Males were captured in March, April, June, and September through December (Figure 5.7). Females were captured March through June and October through December. Juveniles were captured March through June, August and December. Most captures of males and females were in March (males = 12, females = 14). Juveniles were most frequently encountered in April (n = 11) and March (n = 8) (Figure 5.7).

Wood Turtles were captured most often in the stream (n = 127, 55%). They were found on the stream bank out of the water 11 times (5% of captures). On land, they were observed 34% of the time or 79 captures. Wood Turtles were located 9 times (4% of captures) in the main Spotted Turtle wetland. On four occasions it is unknown if they were in the water or on land.

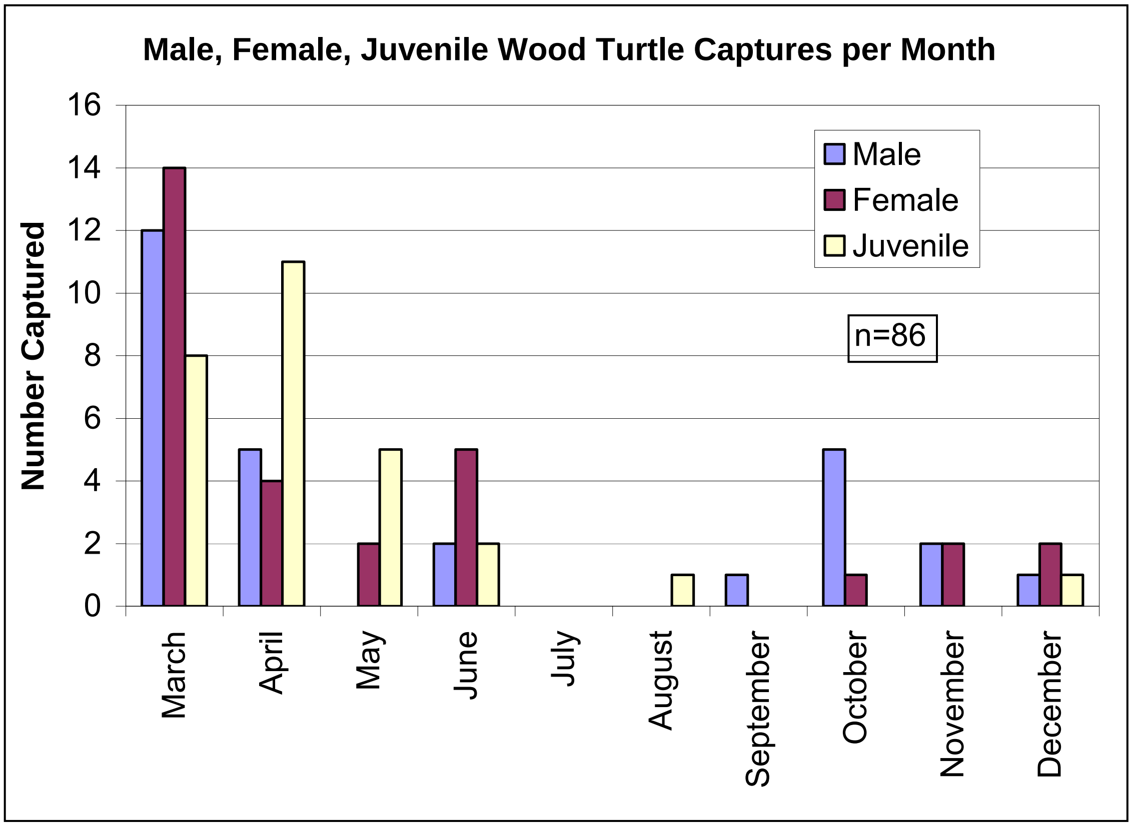

FIGURE 5.7. MALE, FEMALE, AND JUVENILE WOOD TURTLES CAPTURED PER MONTH.

Other Turtles Captured:

Several other species of turtles were captured during the course of this study. One hundred ten Painted Turtles were marked during the study (93 captured in the artificial ponds). Thirteen Snapping Turtles were trapped and one live and one dead Stinkpot were found on the shore of the large pond. Five *Terrapene c. carolina* were encountered.

DISCUSSION

Spotted Turtles:

Hand captures and live-trapping were important in this study in order to catch the maximum number of turtles. Eleven of the turtles I captured were only caught by trapping and 3 were only captured by hand. If only one of those methods had been used, more turtles would have been missed. Sampling bias, such as technique for collection, behavioral differences between the sexes, and determination of size at maturity, can influence the sex ratios (Gibbons and Lovich 1990). Males are more likely to enter aquatic traps than females, while females are more likely to be captured terrestrially during spring and early summer (Gibbons and Lovich 1990). Since 76.1% of captures were by trap in my study, this might help explain why twice as many males were captured than females.

Spotted Turtles in Massachusetts were captured most frequently from late March through mid-May (Milam and Melvin 2001). Pennsylvania turtles were captured most frequently in the spring (Ernst 1976). Number of trap nights per capture was more efficient in my study (10 trap nights per capture) than in a

Massachusetts study that has 138.3 trap nights per capture (Graham 1995). In this study, 76.1 of the *C. guttata* were caught in traps and 23.9% were captured by hand. This rate is higher than other studies in Massachusetts that had trap capture rates of 55.2% (Graham 1995) and 20% and 60% (Milam and Melvin 2001). Similar to my study, Graham (1995) found baited trapping to be more efficient and uniform than hand capture. Other studies also used canned sardines in oil to bait the traps (Graham 1995). Effectiveness of hand capture decreases as vegetation cover and amount of time checking traps increases (Graham 1995). Haxton and Berrill (2001) observed a decrease in observability of Spotted Turtles as seasons progress.

Wood Turtles:

Earliest and latest terrestrial activity of Wood Turtles I observed or as indicated by the data loggers were 9 March and 30 November, respectively. Niederberger and Seidel's (1999) West Virginia Wood Turtles were submerged from October through January. The latest a Wood Turtle was observed out of the water was 23 October and earliest emergence was early March (Niederberger and Seidel 1999). In southeastern Pennsylvania, Wood Turtles had a maximum activity period of 263 days and were active all months except December through February (Ernst 2001). In that population, earliest terrestrial activity was 11 March and latest was 28 November (Ernst 2001). In central Pennsylvania, Wood Turtles were inactive from late October or November until late March or early April (Kaufmann 1992). Latest a New Hampshire *G. insculpta* was reported basking was 11 November on the bank of the stream (Tuttle 1996). Harding and Bloomer (1979) found that due to longer winters, Wood Turtles in northern Michigan entered hibernation earlier and emerged in the spring later than a more southern population from New Jersey. From mid-May through early October, New Jersey Wood Turtles were terrestrial (Farrell and Graham 1991).

My study was similar to others that found that hand capture was most successful for finding Wood Turtles during the fall and spring months when the turtles were found within or by the banks of the stream (Farrell and Graham 1991, Daigle 1997, Niederberger and Seidel 1999). In a West Virginia study, 7% of Wood Turtle captures from May through September were in the water (Niederberger and Seidel 1999).

During the summer months, only females were found in my study. Other studies also observed females more frequently than males during summer months (Niederberger and Seidel 1999).

New Jersey Wood Turtles had all but one of the same species of turtle using their habitat as they did in my study. In New Jersey, Painted turtles, snapping turtles, box turtles, Spotted Turtles and Bog Turtles used the same area (Harding and Bloomer 1979). No Bog Turtles were observed in my study but Stinkpots were found which were not in New Jersey. Only painted and snapping turtles were observed utilizing the same area as Wood Turtles in Michigan (Harding and Bloomer 1979).

CHAPTER 6

Home Range, Seasonal Movements and Habitat Use

INTRODUCTION

The objective of this study was to determine the home range and movement patterns of a population of Spotted and Wood Turtles in West Virginia using radio telemetry techniques. Characteristics of the habitats these turtles used were described.

RESULTS

SPOTTED TURTLES

Twenty-one Spotted Turtles were captured 260 times during this study. Combining locations for all *C. guttata,* the overall activity area was 3.1 ha using minimum convex polygon (MCP) (Figure 6.1). Greatest straight line distance within this polygon was 416 m. Two main activity centers were in the main wetland and vernal area, which were about 80 m apart (Figure 6.1). North side of the main wetland had the most number of captures (n = 57) (Figure 6.2). Vernal area had the second highest number of captures (n = 50). Lowest number of captures were in main pond, artificial ponds, and stream (n = 2 each).

Population density was 6.8 turtles/ha for their entire activity area of 3.1 ha. When the area of Cg#16 was excluded due to his long over-wintering foray, the main activity area was 1.07 ha. Using this area, the population density of Spotted Turtles was 19.6 turtles/ha.

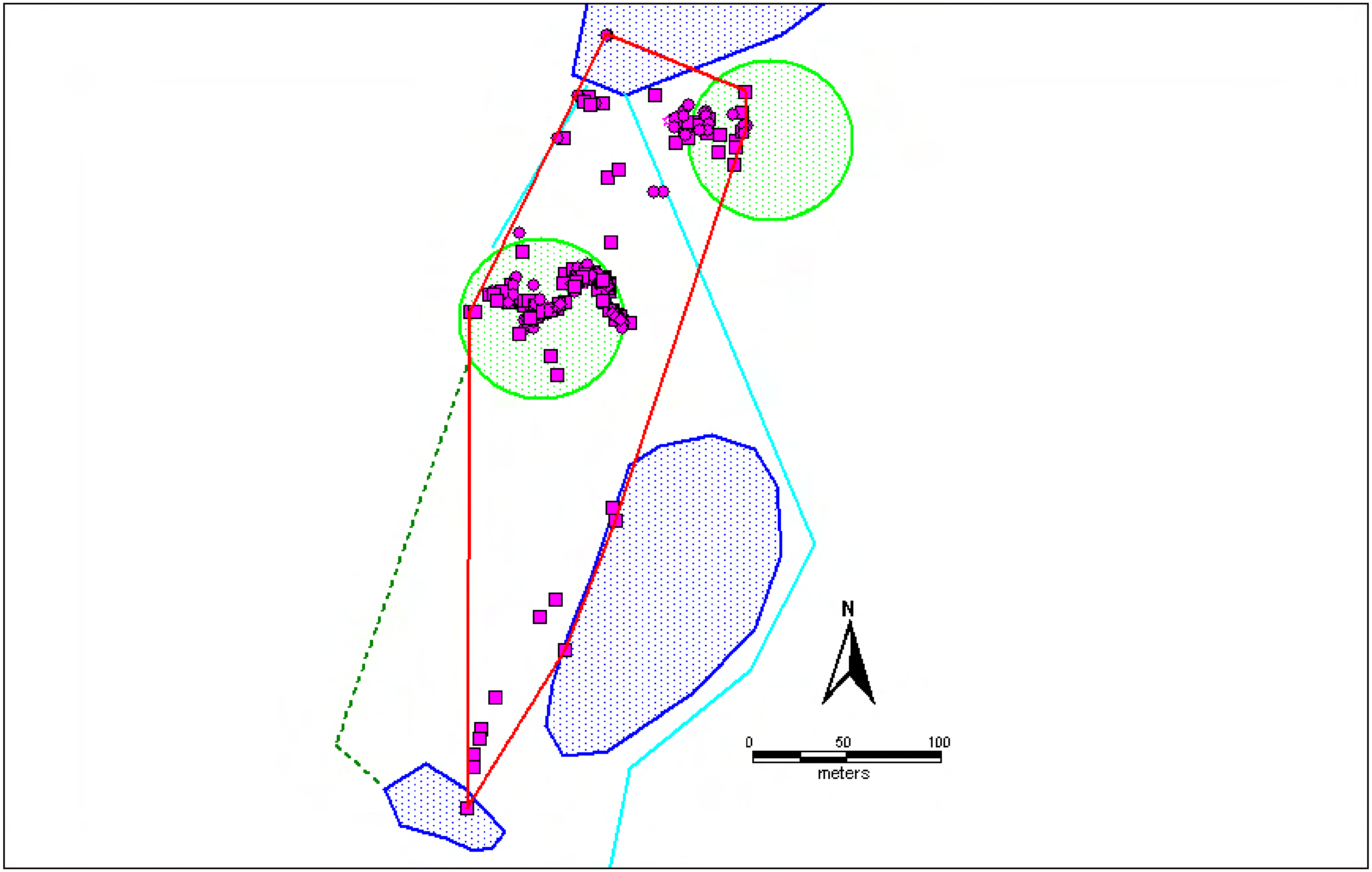

FIGURE 6.1. LOCATIONS OF ALL *C. GUTTATA* CAPTURED AND MINIMUM CONVEX POLYGON.

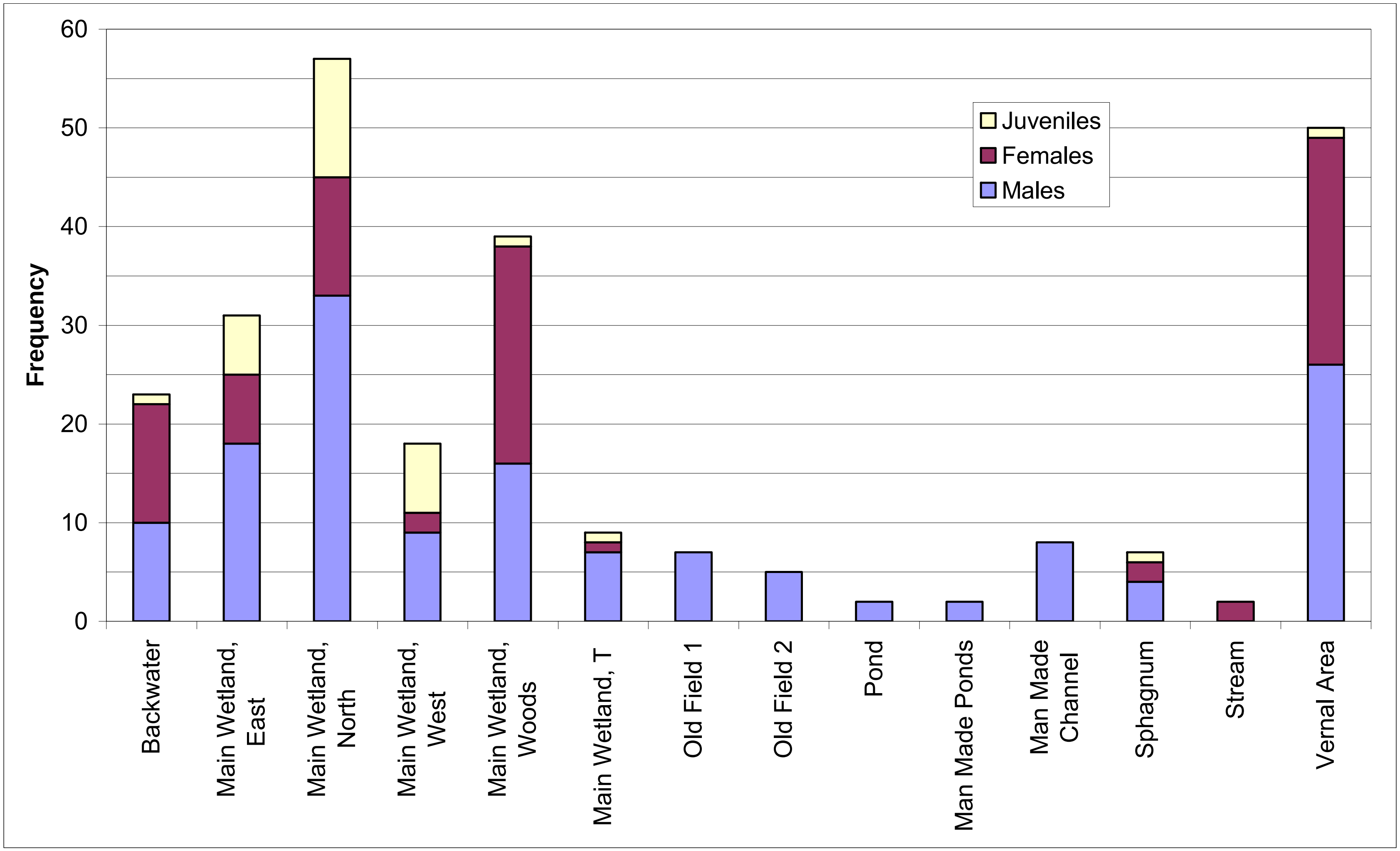

FIGURE 6.2. MALE, FEMALE AND JUVENILE SPOTTED TURTLE BY APPROXIMATE LOCATION.

Males were located most often in the north side of the wetland (n = 33) and vernal area (n = 26) (Figure 6.2). They were observed 18 times on the east side of the wetland, 9 times on the west side, and 16 times in the channel towards the woods. They were also observed 7 times in the intersection with the woods and wetland area, woodland sphagnum area 4 times, and 10 times in the backwater channel. Other observations were also made in the old fields, main pond, and artificial pond areas. Two males used the main wetland and the vernal area so they had to have crossed the stream in order to move between the two areas, although none were observed in the stream.

Females were located most frequently in the vernal area (n = 23) and the channel towards the woods part of the wetland (n = 22) (Figure 6.2). They were observed 12 times in the north side of the wetland and the backwater channel. Other observations were in the east and west sides of the wetland, intersection of the woods and wetland and *Sphagnum* area. A female was captured twice in the stream which separated the main wetland from the vernal area and she was observed using both of those areas. No females were observed using the ponds or old field areas.

Nine juveniles were captured 30 times. Juveniles were most frequently found on the north side of the wetland (n = 12 times) (Figure 6.2, 6.3). They were found 7 times on the west side and 6 times on the east side. Juveniles were observed once each in the backwater channel, woods channel, intersection, and *Sphagnum* areas. Only 1 juvenile was found near the vernal area.

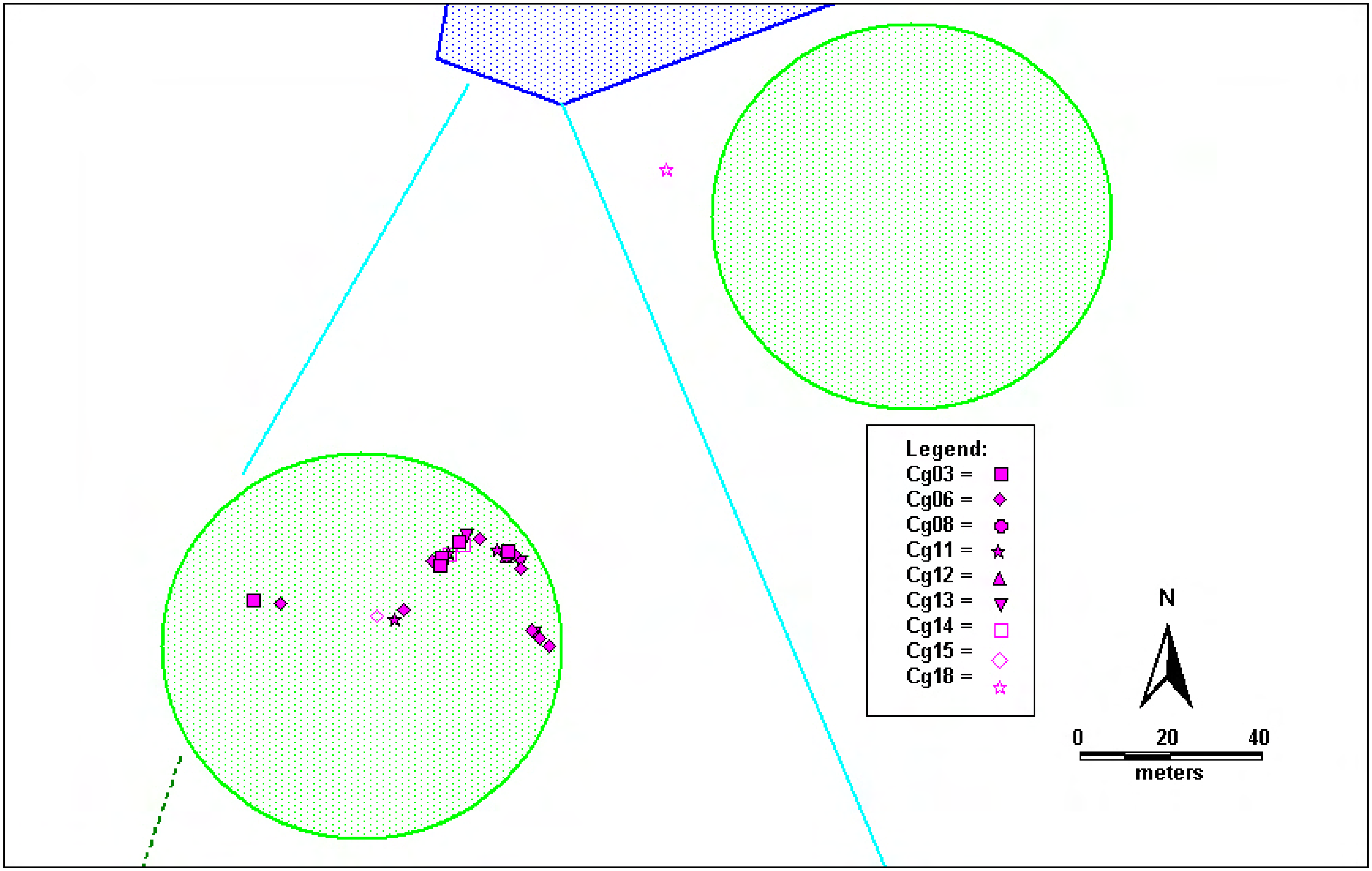

FIGURE 6.3. ALL JUVENILE SPOTTED TURTLE LOCATIONS.

The most frequently caught juvenile *C. guttata* was Cg#06 who was captured 11 times between 23 May 2001 and 1 April 2002. A MCP drawn for this turtle showed he had an observed home range of 0.07 ha. The longest daily movement for this turtle was 27 m from 25 to 26 June 2001, when it moved from the northeast end of the main wetland to the southwest side. Other daily movements for this turtle were 18 m, 0 m, and 11 m. Greatest straight line distance between the furthest 2 points this turtle was located was 60 m.

Radio-Telemetry

Eight *C. guttata* (5 males, 3 females) were radio tracked for this study.

Radio tracked males were observed 143 times. On average, males were most frequently found dry or with slightly damp shells, out of the water, in tussocks or dry vegetation (n = 55, 38.5% of captures). Males were submerged in water 24.5% of the time (n = 35 captures) or partially submerged in water 11.9% of the time (n = 17). They were found in mud on 12 occasions (8.4% of captures). For 15.4% of the observations (n = 22), radio tracked males were caught in traps set in water. On 2 occasions the microhabitat was not recorded.

Females were radio located 82 times. On average, females were also most frequently captured with dry or slightly damp shells (n = 34, 41.5% of captures). They were found completely submerged in water 20.7% of the time (n = 17) and partially submerged in the water 15.9% of the time (n = 13). Females were located in mud 12 times (14.6%). Radio tracked females were caught in traps 4 times (4.9%). In two cases (2.4%) it is unknown what in condition the turtle was captured.

Most of the time, Spotted Turtles were found in the main wetland (n = 122, 54.2% of captures). This was true for both males (n = 79, 55.2%) and females (n = 43, 52.4%). To more closely examine how the turtles used that area, it was divided in east, north, west, woods and intersection sections (see Study Area). In the main wetland, most *C. guttata* were captured on the north side (n = 40, 17.8% of all captures). Captures in the woods area were second most frequently observed (n = 38, 16.9%). East side had 25 captures (11.1%), west side had 11 captures (4.9%), and the t-intersection area had 8 captures (3.6%). Of all of the radio captures, 49 (21.8%) were in the vernal area. There were 22 captures in the backwater channel (9.8%). Spotted Turtles were caught 6 times in the *Sphagnum* area (2.7%). Old Field 1 (OF1; the north field) had 8 captures (3.6%) and Old Field 2 (OF2; south field) had 4 captures (1.8%). They were caught twice each in the stream, main pond, and artificial ponds (0.9% each). Spotted Turtles were caught 8 times (3.6%) in an old channel that runs between the OF1 and the man-made ponds.

Males were most frequently found in the north side of the wetland (n = 29, 20.3%) and females were most commonly found in the vernal area (n = 23, 28%). Males were captured in the vernal area 26 times, but it was only 18.2% of their total captures (second most frequent location). Males were caught in the east side of the wetland 18 times (12.6%), woods area of the main wetland 16 times (11.2%), backwater channel 12 times (14.6%), west side 9 times (6.3%), and intersection area 7 times (4.9%). Males were caught in OF1 8 times (5.6%) and OF2 4 times (2.8%). Old channel between OF2 and man-made ponds had 8 captures (5.6%). Main pond and man-made ponds each had 2 captures (1.4% each). Males were caught in the *Sphagnum* area 4 times (2.8%). No males were ever observed in the stream, although they had to cross it to move between the main wetland and the vernal area.

After the vernal area, woods area was the next frequent area that females were found (n = 22, 26.8%). Use of backwater channel was observed 12 times (14.6%). Females spent 13.4% of their time in north side of main wetland (n = 11), 8.5% of time on east side (n = 7), 2.4% of time on west side (n = 2) and 1.2% of time in intersection area (n = 1). Females were caught twice each in the *Sphagnum* area and stream (2.4%). No females were captured in any of the ponds or fields.

A short summary of each radio tracked turtles' movements and habitat locations in which they were found is given below.

Cg#01:

Male Cg#01 was first captured on 20 May 2001. He was observed 26 times before his transmitter signal was lost on 11 July 2001 (Figure 6.4). Using MCP, total area of this turtle's activity was 0.4 ha. His main activity took place in the main wetland along the water channel that arced around the wetland. North side of main wetland was the most frequent location of his capture (n = 8). He was captured an equal number of times on the west side and backwater channels (n = 6 each). He was also observed on the east side (n =2), and woods

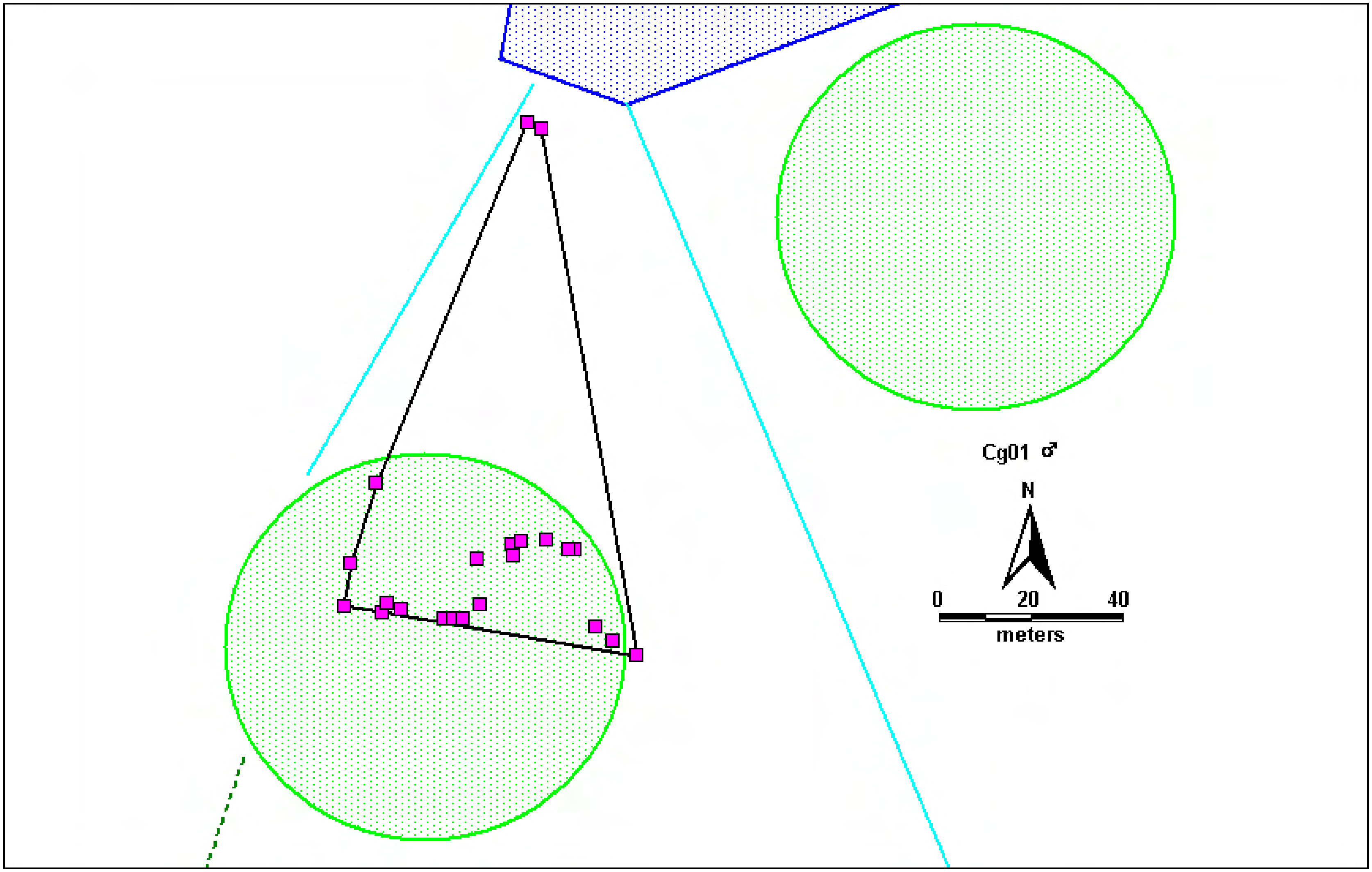

FIGURE 6.4. CG#01 LOCATIONS AND MINIMUM CONVEX POLYGON.

channel (n = 4). No over-wintering data is known due to transmitter failure.

From 14 through 16 June he moved 86 m through the backwater channel to its northern end. He stayed there 16 June and by 17 June he had moved 92 m back to the main wetland. This was his longest movement in 1 day during the course of the study. Other day to day observations of straight line distance between his locations were 30 m, 24 m, 24 m, 2.5 m, 0 m, 39 m, 8 m, 15 m, 11 m, 22 m, 34 m, 2 m (mean = 27.8 m) . Greatest straight line distance between the 2 farthest points within this turtle's home range was 120 m.

Cg#01 was most frequently found submerged or partially submerged (n = 9 each). He was trapped 6 times. Only once was he captured in a dry setting and once he was captured in mud.

Cg#02:

Female Cg#02 was captured 15 times between 22 May and 17 June 2001 (Figure 6.5). The transmitter signal failed after the last date and the turtle was never relocated. Her home range (MCP) was 0.3 ha. She was originally captured on the east side of the main wetland. End of May through June, she moved within the main wetland. She was most frequently captured in the woods channel (n = 7). She was also observed in the backwater area (n = 3), east side of main (n = 2), north side of main (n = 2), and west side of main (n = 1). There is no over-wintering data for this turtle due to her transmitter failing.

Her longest daily movement observed was between 14 and 15 June 2001, when she moved a straight line distance of 93 m from the woods channel to the

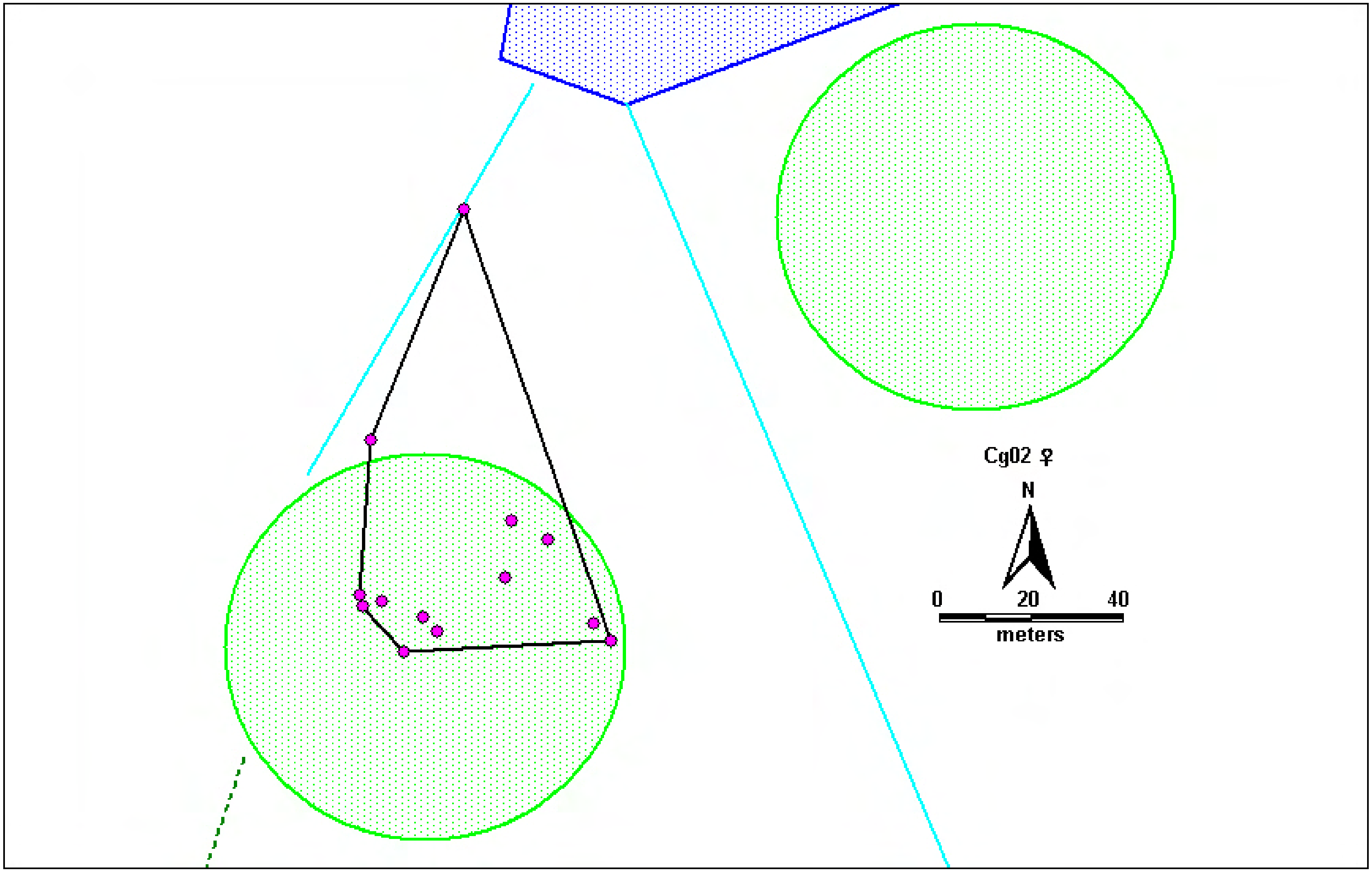

FIGURE 6.5. CG#02 LOCATIONS AND MINIMUM CONVEX POLYGON.

north end of the backwater channel. She stayed in that area on 16 June and on 17 June she had moved 55 m south towards the main wetland in the backwater channel. That was the last time she was located. Straight line distance of other daily movements was 10 m, 3 m, 38 m, 29 m, and 19 m (mean = 32.0 m). Greatest straight line distance between the 2 farthest points within this turtle's home range was 100 m.

She was caught 5 times submerged, 2 times partially submerged, 4 times in mud, 3 times dry and once in a trap.

Cg#04:

Female Cg#04 was captured 27 times from 22 May 2001 through 31 March 2003 (Figure 6.6). Her signal was lost on 15 August 2001 and she was not observed again until 30 and 31 March 2003, when she was hand captured in a location that was very near where she over-wintered. MCP home range was 0.15 ha. Most of her captures were in the north and woods sections of the main wetland (n = 8 each). She was captured an equal number of times in the backwater and east channels (n = 4 each). She was also observed in the intersection (n = 1) and *Sphagnum* (n = 2) areas. She was never caught in the west end of the main wetland, although she had to pass through that area to move to the locations in which she was found. This turtle's transmitter also failed so no over-wintering data are available.

Her longest daily movement observed was 137 m straight line distance from the north end of the backwater area south to woods channel from 24 to 25 June 2001. She had moved 138 m from the woods channel to the north end of

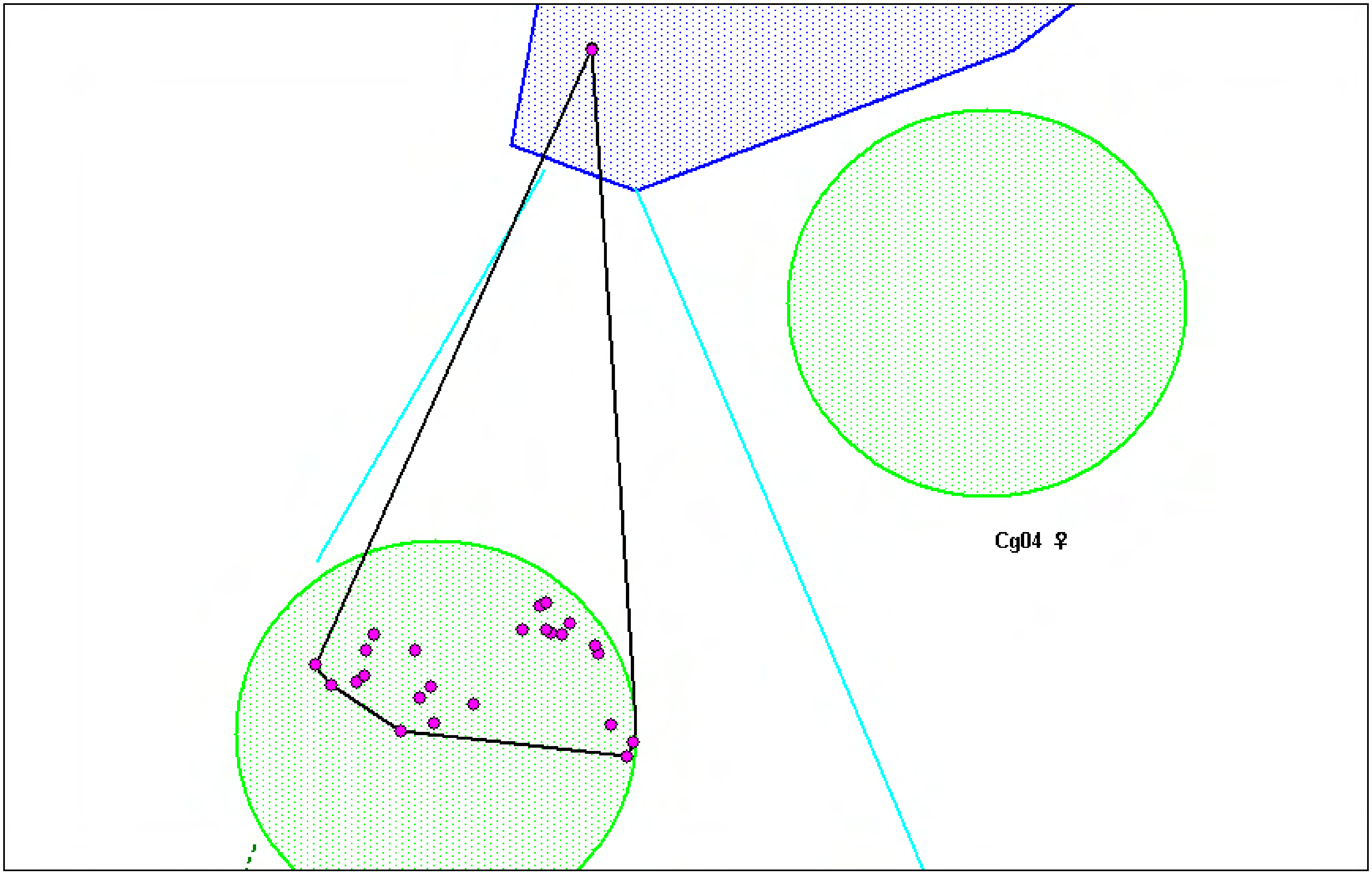

FIGURE 6.6. CG#04 LOCATIONS AND MINIMUM CONVEX POLYGON.

backwater channel between 18 and 23 June 2001. Her other daily movements were 42 m, 18 m, 5.5 m, 52 m, 31 m, 44 m , 10 m, 10 m, 26 m, 22 m, 0 m, 15 m, 0 m (mean = 29.5 m). Greatest straight line distance between the 2 farthest points within this turtle's home range was 156 m.

She was caught an equal number of times in a dry setting and submerged (n = 7 each). She was caught 5 times partially submerged, 4 times in mud, and twice each in a trap and unknown.

Cg#05:

Female Cg#05 was observed 40 times (Figure 6.7). She was observed from 23 May 2001 through 30 March 2002. Home range was 0.82 ha using MCP. Most of her captures were in the vernal area (n = 23). She was also observed in the woods channel (n = 7), backwater (n = 5), stream (n = 2), and north, east and west ends of main wetland (n = 1 each). She over-wintered at the north end of the backwater channel near the main pond area. She was observed moving west from the vernal area in September and October 2001. On 15 November 2001, she was in the north end of the backwater channel. When she was located again on 26 December 2001, she was in a runway deep inside a tussock bank. It is assumed this is the location she over-wintered. She was relocated in this same spot on 8 March 2002, 40 cm inside the runway entrance facing out and responsive.

Her longest daily movement was on 14 to 15 June 2001 when she moved 37 m north from the stream to the vernal area. Other day to day observations of

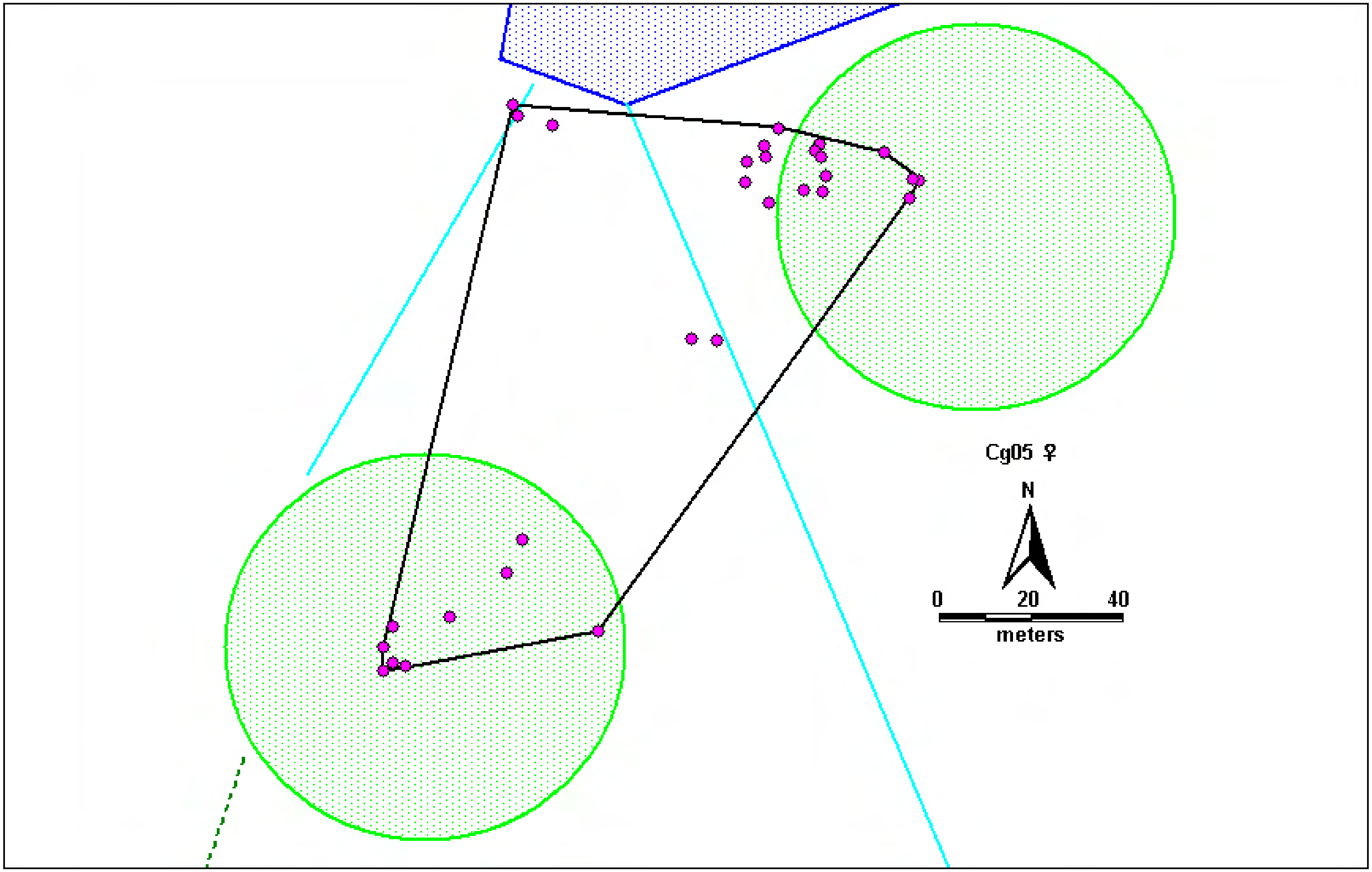

FIGURE 6.7. CG#05 LOCATIONS AND MINIMUM CONVEX POLYGON.

straight line distance between her locations were 3 m, 0 m, 5 m, 32 m, 8 m, 7 m, 30 m, 14 m, 2 m, 0 m, 1.5 m, 4 m, 0 m, 0 m, and 14 m (mean = 9.8 m). Greatest straight line distance between the 2 farthest points within this turtle's home range was 160 m.

This turtle was most frequently caught in a dry setting (n = 24). She was caught 6 times partially submerged and 5 times submerged. She was observed in mud on 4 occasions and trapped once.

Cg#07:

Male Cg#07 was observed on 40 occasions between 30 May 2001 and 30 March 2003 (Figure 6.8). Using MCP, his home range was 0.71 ha. This turtle was most frequently observed on the east side of main wetland (n = 13). He was observed on the north side (n = 9), west side (n = 1), woods channel (n = 2) and backwater area (n = 5). Cg#07 was also seen in OF1 (old field north of main wetland) (n = 7), main pond (N = 1), and vernal area (n = 3). It is unclear where this turtle over-wintered because he was caught in different locations each time he was tracked in the winter. He was in the main wetland in September 2001, moved to the vernal area in October, found in the backwater channel in November, the t-intersection area by the woods channel in December and in the central part of the main wetland in March 2002. His temperature data logger also fluctuated throughout the winter months much more than those on other turtles, which indicated he was more active over winter (see Chapter 7).

His longest daily movement was on 16 to 17 June 2001 when he moved 92 m straight line distance from north main wetland to north end of backwater

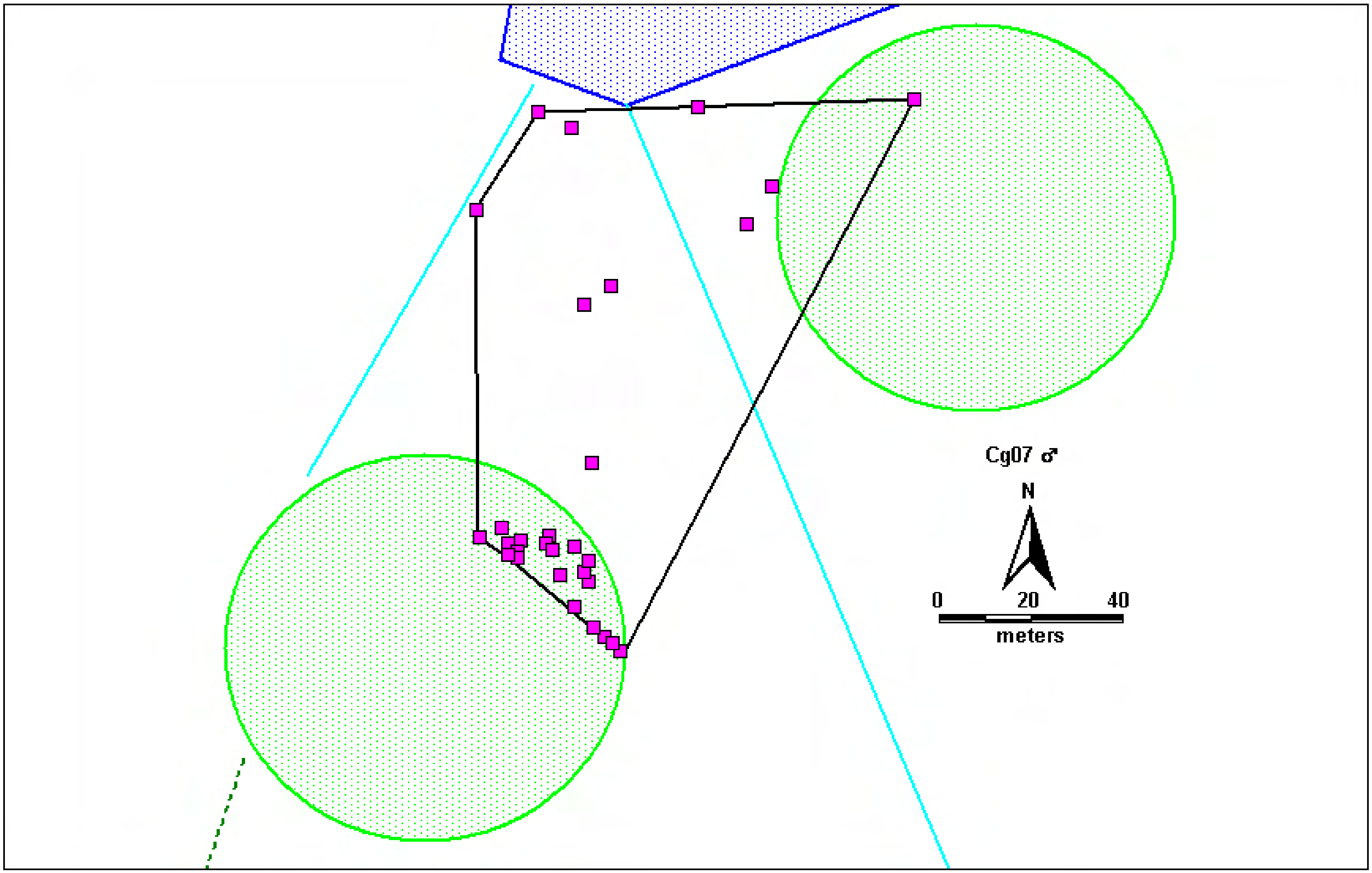

FIGURE 6.8. CG#07 LOCATIONS AND MINIMUM CONVEX POLYGON.

area. Other daily movements were 31 m, 38 m, 25m, 18 m, 22 m, 4 m, 13 m, 8 m, 0 m, 16 m, 4 m, 2.5 m, 0 m, 0 m, and 27 m (mean = 18.8 m). Greatest straight line distance between the 2 farthest points within this turtle's home range was 138 m.

Cg#07 was most frequently captured in a dry setting (n = 18). He was captured 9 times completely submerged in water and 5 times each partially submerged or in a trap. He was caught once in mud and twice was not recorded.

Cg#09:

Cg#09 was a male captured 25 times between 16 June 2001 and 30 March 2002 (Figure 6.9). Overall home range was 0.25 ha MCP. The last observation was made on 30 March 2002 after his transmitter had been removed. When the last movements were taken out of the calculation, his activity center throughout the period he was radio tracked was 0.06 ha, all located in the vernal area. He was captured 23 times in the vernal area, and once each on the north and west sides of the main wetland. He was observed hibernating deep in the mud under a rotting fallen log in the vernal area from 15 November 2001 through 9 March 2002. *Clemmys guttata* nests were found 2 consecutive years in the moss on top of this log (see Chapter 9).

Longest daily movement for this turtle was 18 m, from 17 to 18 August 2001, when he moved west in the vernal area. He was only observed 2 days in a row on 6 occasions. Other daily movements recorded for him were 0 m, 11 m, 5 m, 12 m, and 11 m (mean = 9.5 m). He had a large movement between 9 March and 29 March 2002, when he moved 100 m from the vernal area to main

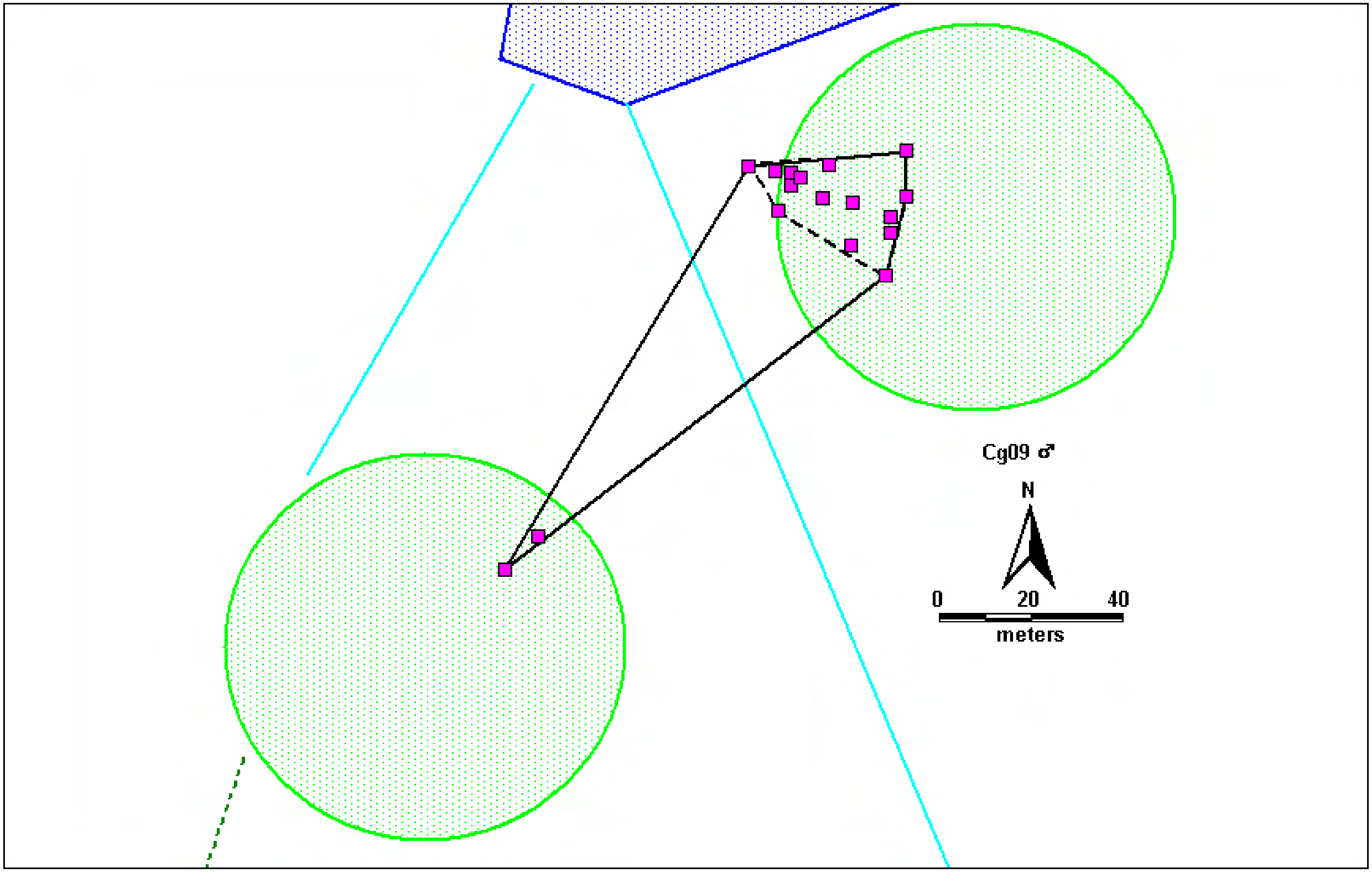

FIGURE 6.9. CG#09 LOCATIONS AND MINIMUM CONVEX POLYGON.

wetland. Greatest straight line distance between the 2 farthest points within this turtle's home range was 128 m.

This turtle was most frequently captured in a dry setting (n = 16). He was caught 5 times in mud. He was submerged twice and partially submerged and trapped once each.

Cg#10:

Male Cg#10 was observed 29 times from 17 June 2001 through 4 April 2002 (Figure 6.10). Home range was 0.12 ha using MCP. Most captures were in the north end of main wetland (n = 9). He was observed in the wood channel (n = 6), t-intersection (n = 7), and *Sphagnum* areas (n = 2). He was also seen on the east side (n = 3) and west side (n = 1) of main wetland. Once he was located in the old field north of main. Cg#10 over-wintered in the t-intersection area, where he was found from 20 October 2001 through 8 March 2002. He was found 35 cm deep in the water on top of the mud bottom, hidden in *Sparganium*.

From 9 to 10 July 2001, he moved 28 m from the east side to the northwest side of the main wetland. This was his longest daily movement. Other daily movements were 13 m, 25 m, 0 m, 5 m, 0 m, 0 m, 2 m, and 13 m (mean = 9.6 m). Greatest straight line distance between the 2 farthest points within this turtle's home range was 77 m.

He was caught an equal amount of times dry and in a trap (n=8 each). He was caught 7 times submerged, once partially submerged, and 5 times in mud.

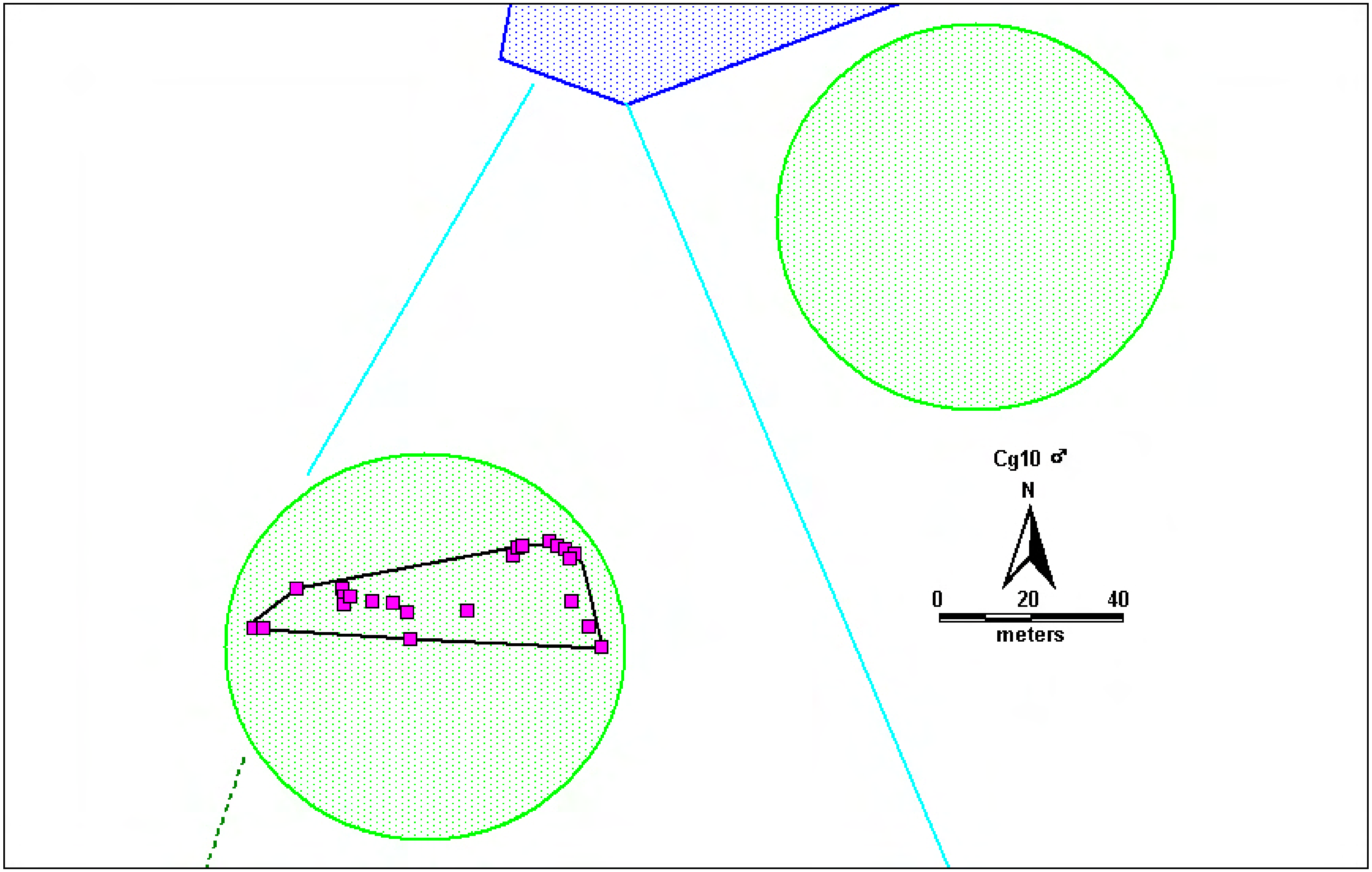

FIGURE 6.10. CG#10 LOCATIONS AND MINIMUM CONVEX POLYGON.

Cg#16:

Male Cg#16 was observed 23 times, from 9 July 2001 through 19 October 2002 (Figure 6.11). Total area of this turtle's activity was 1.41 ha using MCP. On 4 occasions, 13–16 September 2001, he was observed in old field 2, south of the main wetland, prior to his movement to the hibernacula. Most captures for this turtle were in the channel between man-made ponds and main wetland, where he was captured 9 times as he moved to and from his hibernacula. He was located in this channel on 19 October though 16 November 2001. This turtle over-wintered in a forested man-made pond, where he was observed on 26 December 2001 and again on 8 March 2002. He was observed moving back towards the main wetland between 28 March and 4 April 2002, which is when his transmitter was removed. Other locations he was located were north end main wetland (n = 2), woods channel (n = 4), and *Sphagnum* area (n = 2).

This turtle's longest daily movement was when he moved 82 m from the man-made ponds channel toward the main wetland after he emerged from hibernation in the spring. This occurred between 30 and 31 March 2002. Other daily movements recorded were 0 m, 28 m, 4.5 m, 10 m, 0 m, 0 m, 20 m, 33 m, 24 m, 12 m, and 58 m (mean = 22.6 m). Greatest straight line distance between the 2 farthest points within this turtle's home range was 288 m.

Cg#16 was most frequently captured in a dry setting (n = 12). He was caught 8 times submerged, once partially submerged and twice in a wet trap.

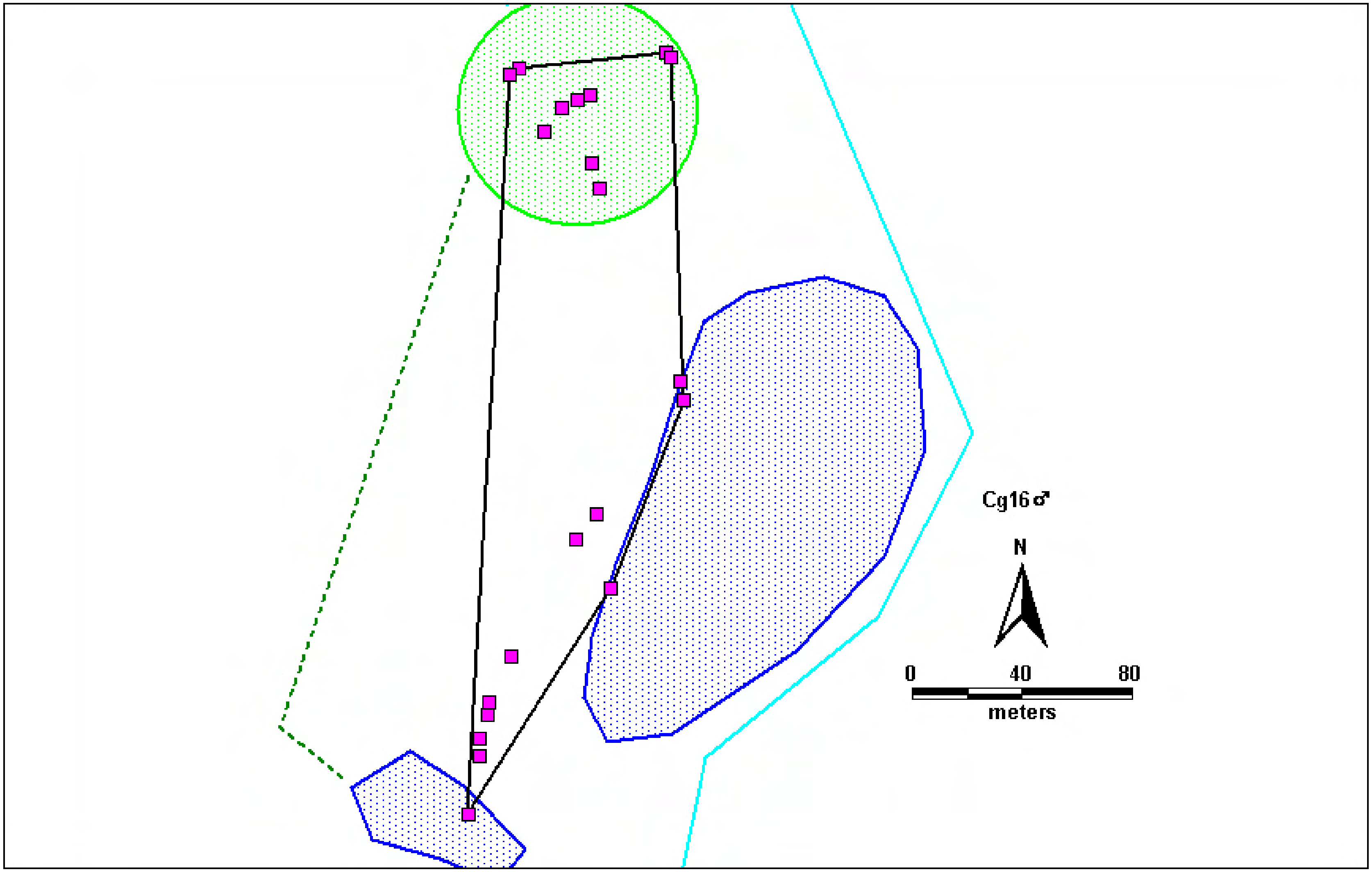

FIGURE 6.11. CG#16 LOCATIONS AND MINIMUM CONVEX POLYGON.

Combined:

Home range for all *C. guttata* combined ranged from .25-1.41 ha (n = 8, mean = 0.52 ± 0.41 ha). When male Cg#16 was removed from the equation because of his long distance over-wintering travel, mean home range was 0.39 ± 0.27 ha.

All *C. guttata* home ranges were overlaid to show the overlap of ranges between the turtles (Figure 6.12). All but one of the turtle (Cg#16) used generally the same area. Cg#16 traveled to the man-made pond, which extended the overall size of the Spotted Turtle activity area. A closer view of *C. guttata* home ranges better illustrates the home range overlap (Figure 6.13). The total area of all home ranges combined was 2.37 ha. Combining all turtle home ranges, the amount of area 2 or more Spotted Turtles overlapped was 0.94 ha (Figure 6.14). This was 39.7% of the overall activity area.

Total area used by males was 2.28 ha. Amount of overlap for 2 or more males was 0.50 ha, which was 21.9% overlap of the entire area they inhabited (Figure 6.15). When Cg#16 was removed from the calculation, the total area in which males were found was 0.95 ha. Area of overlap was 0.48 ha, which was 50.5% overlap.

Females used a total area of 0.99 ha. Overlap for 2 or more females was 0.50 ha, or 50.5% of total female activity area (Figure 6.16).

Males overlapped females 0.9 ha, which was 29.0% of the overall 2.37 ha home range males and females used (Figure 6.17). When Cg#16 was removed, the area of males and female home ranges combined was 1.07 ha.

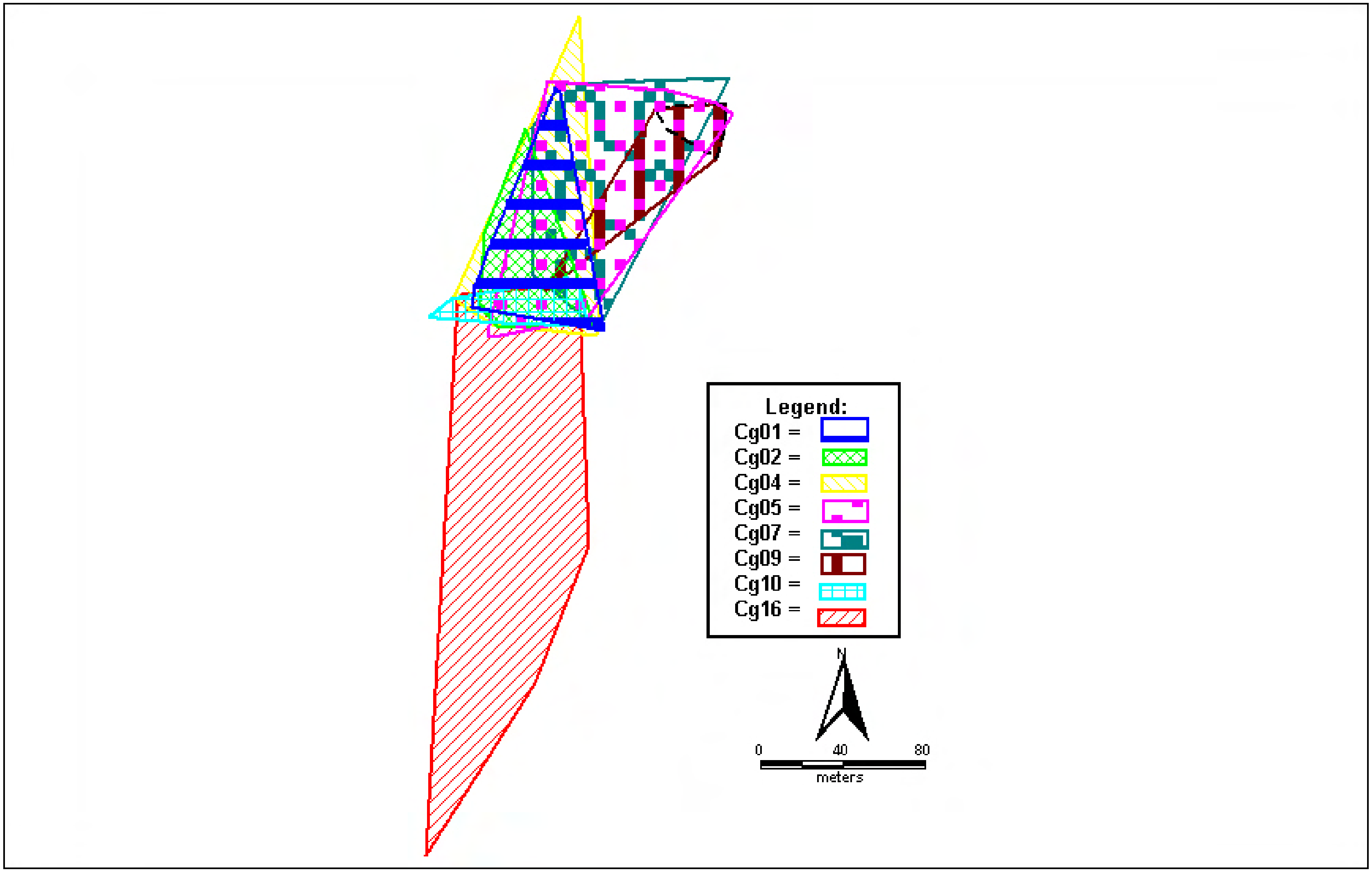

FIGURE 6.12. ALL SPOTTED TURTLE HOME RANGES.

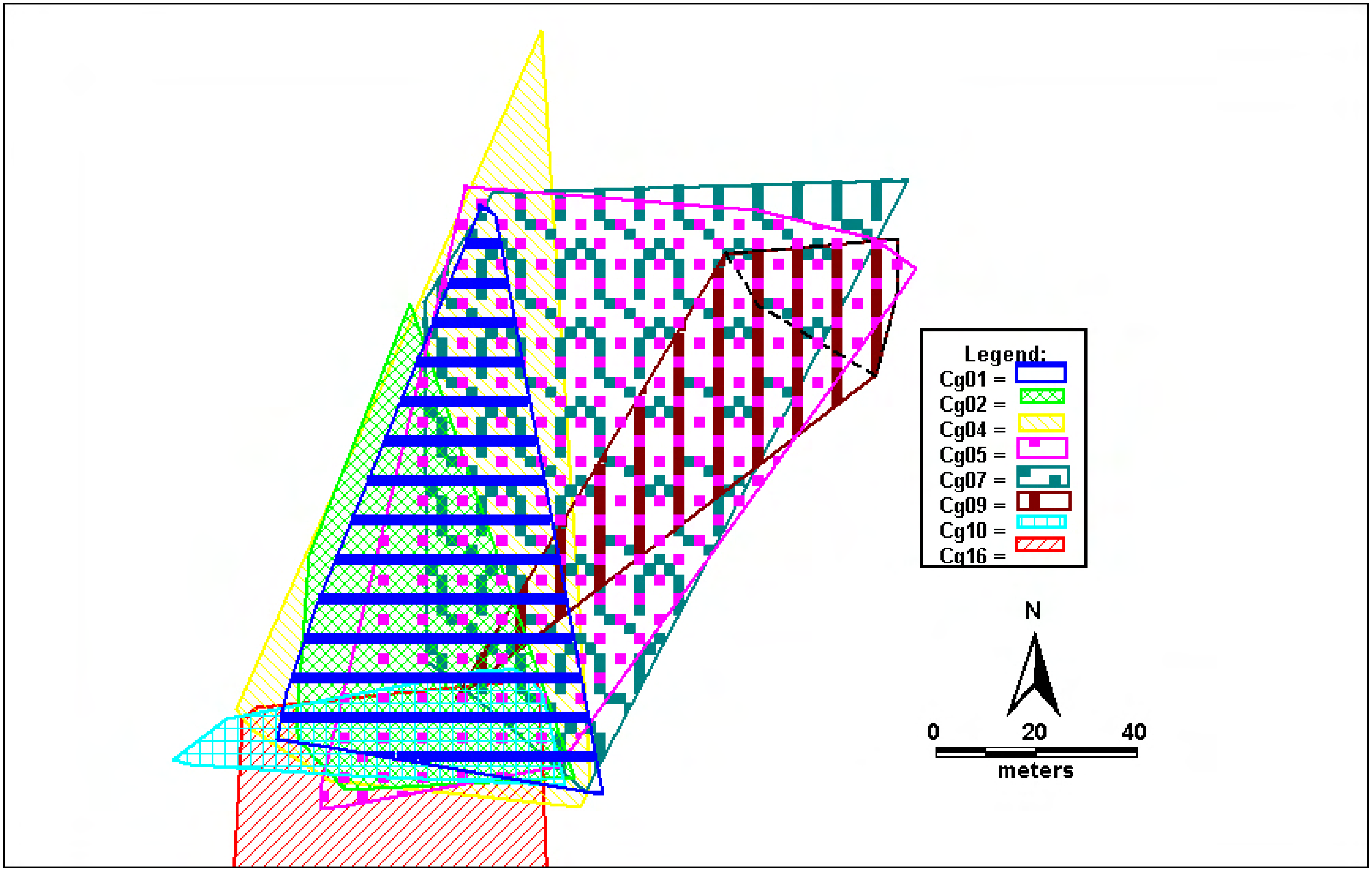

FIGURE 6.13. CLOSE-UP OF ALL SPOTTED TURTLE HOME RANGES WITHOUT ALL OF CG#16.

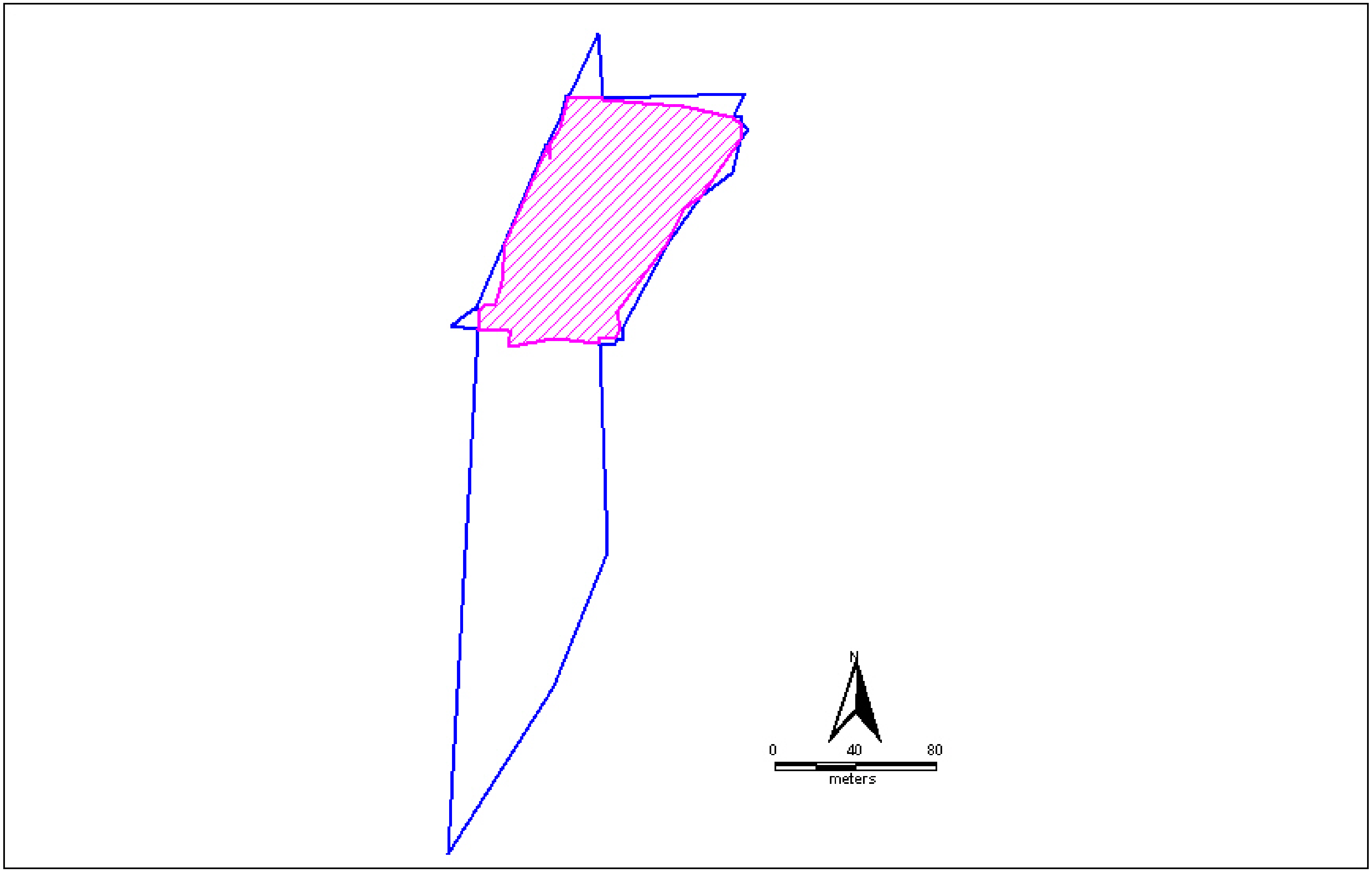

FIGURE 6.14. OVERLAP AREA OF ALL SPOTTED TURTLE HOME RANGES.

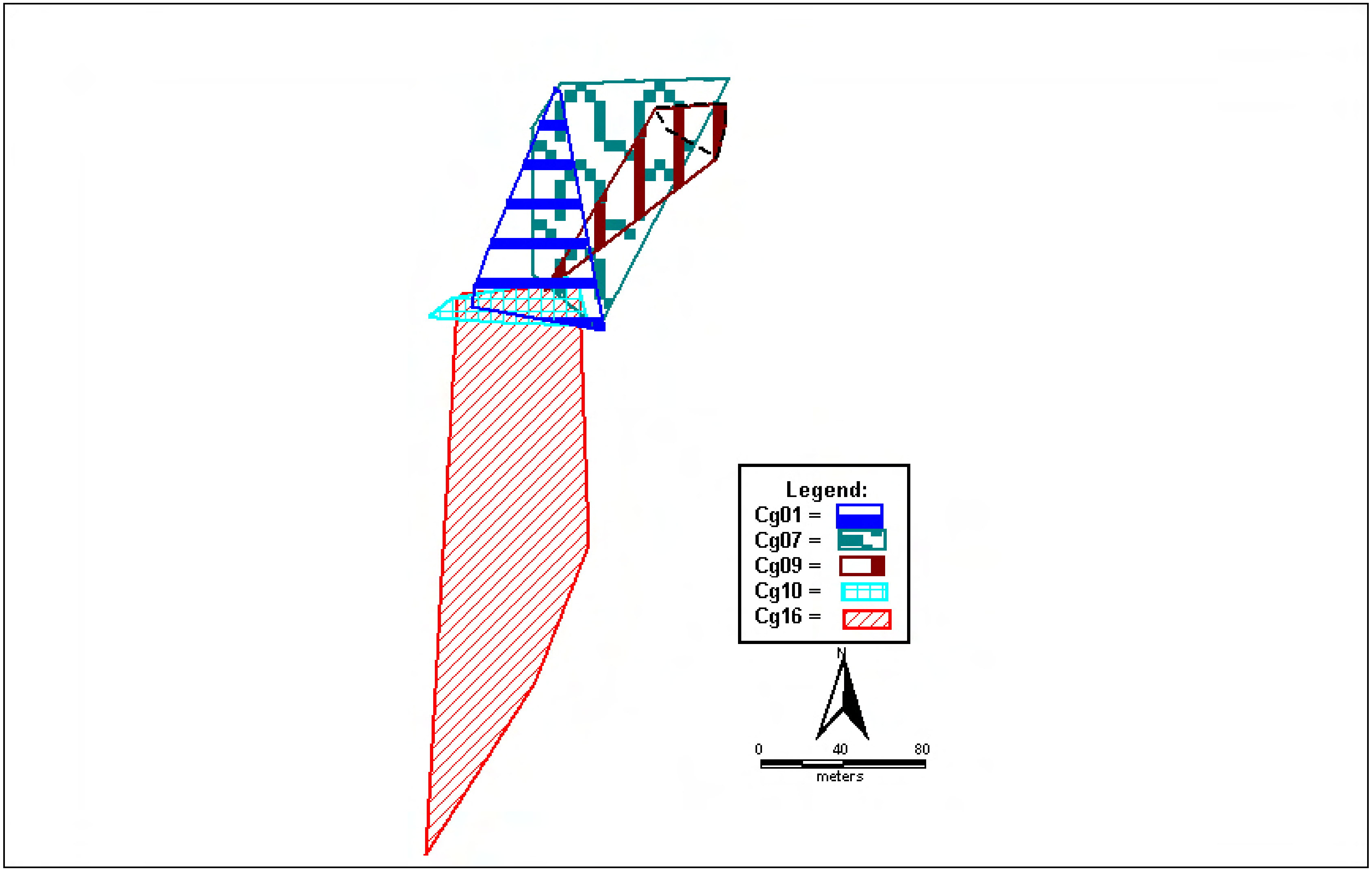

FIGURE 6.15. MALE SPOTTED TURTLE HOME RANGES.

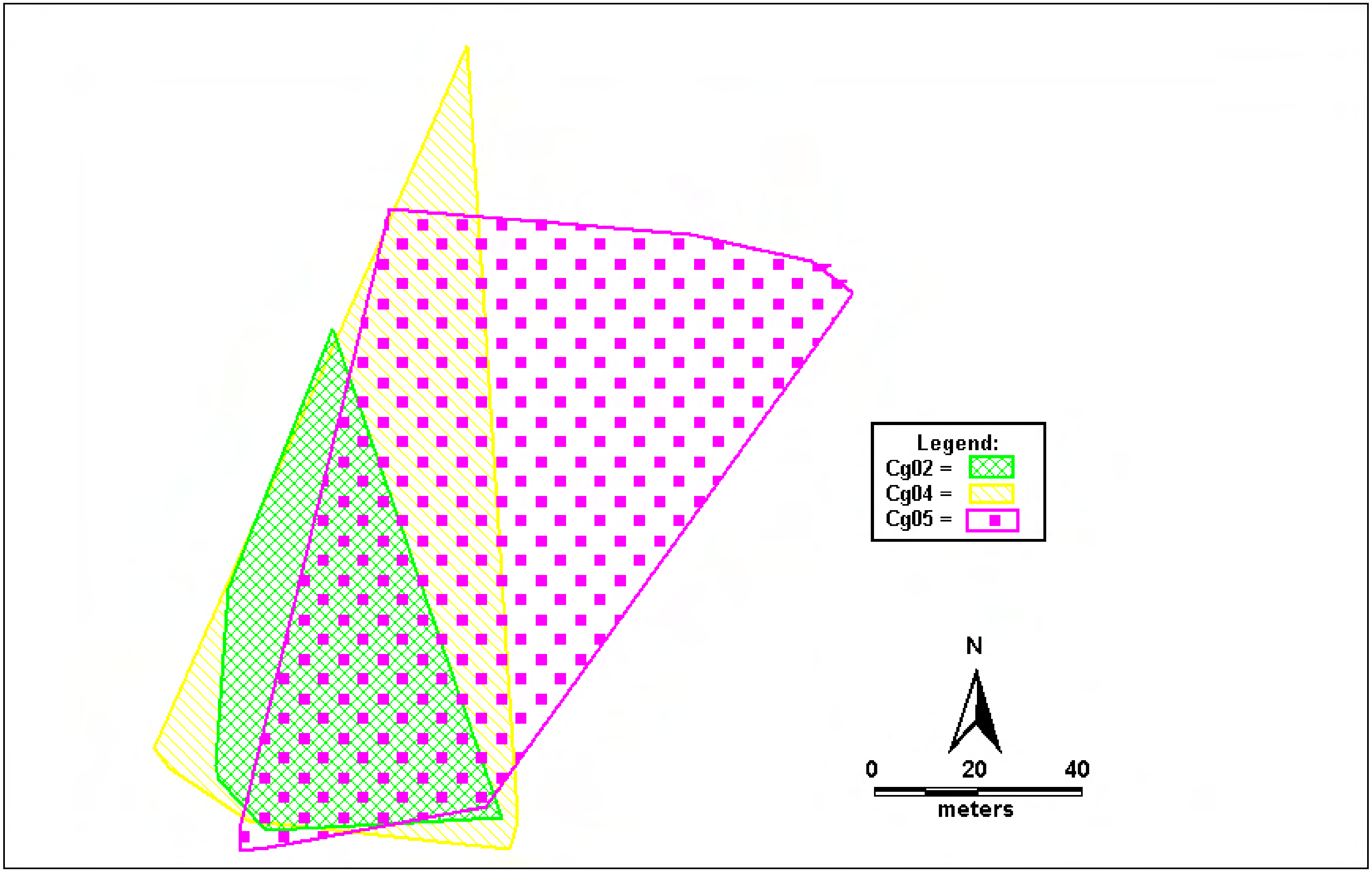

FIGURE 6.16. FEMALE SPOTTED TURTLE HOME RANGES.

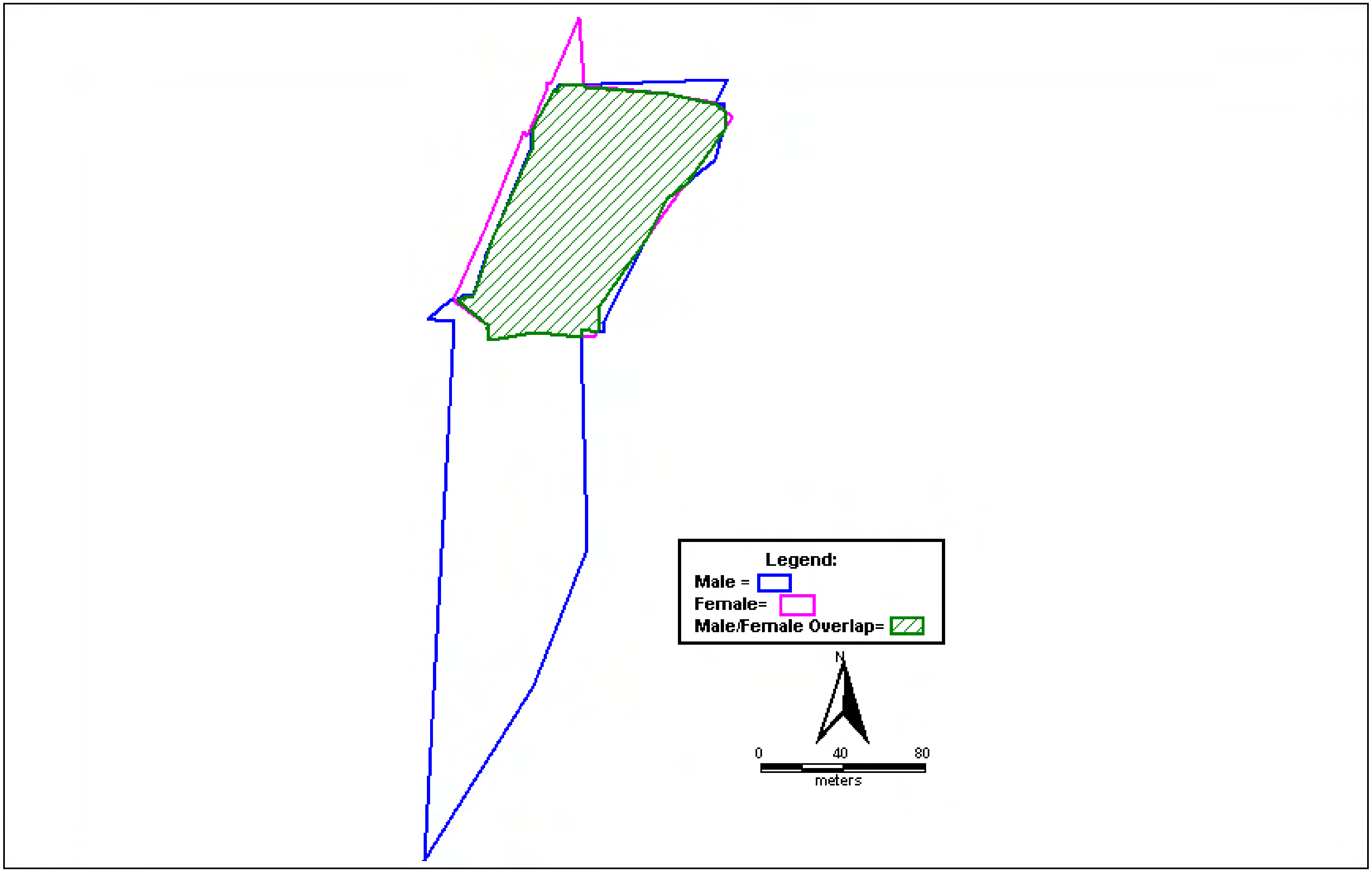

FIGURE 6.17. OVERLAP AREA OF MALE AND FEMALE SPOTTED TURTLE HOME RANGES.

Males and females overlapped 0.87 ha (81.3%).

The greatest straight line distance between the 2 farthest points in the Spotted Turtle home ranges was 288 m by male Cg#16. The greatest straight line distance for a female was 160 m. The average greatest distance was 145.9 ± 63.7 m (range 77-288 m). All turtles moved 100 m or more, except 1 male who moved 77 m. Farthest a turtle moved in 24 hours was by a female who moved 137 m. Ninety-two m was the longest daily male movement, which was done by 2 males. Mean distance for daily movement was 72.4 ± 40.8 m.

All 5 Spotted Turtles that were captured before 1 June 2001 had their longest movements in a 24-hour period in June. Four of the 5 had their longest movement in a day between 14 and 17 June 2001, while 1 male's longest daily movement was 24-25 June 2001. The 3 remaining males were not captured until 16 June, 17 June, and 9 July 2001 and their longest movements in 24 hours were from 17-18 August 2001, 9-10 July 2001, and 30-31 March 2002, respectively.

WOOD TURTLES:

Wood Turtles were captured 230 times during this study. Combining locations for all *G. insculpta,* the overall activity area was 69.05 ha using MCP (Figure 6.18). Greatest straight line distance between any 2 turtles was 2600 m. However, following the stream, the distance was 3,325 m (this was the length of the survey area).

Population density of Wood Turtles for the entire activity area was 0.7 turtles/ha. This is a very conservative estimate because much of this area was

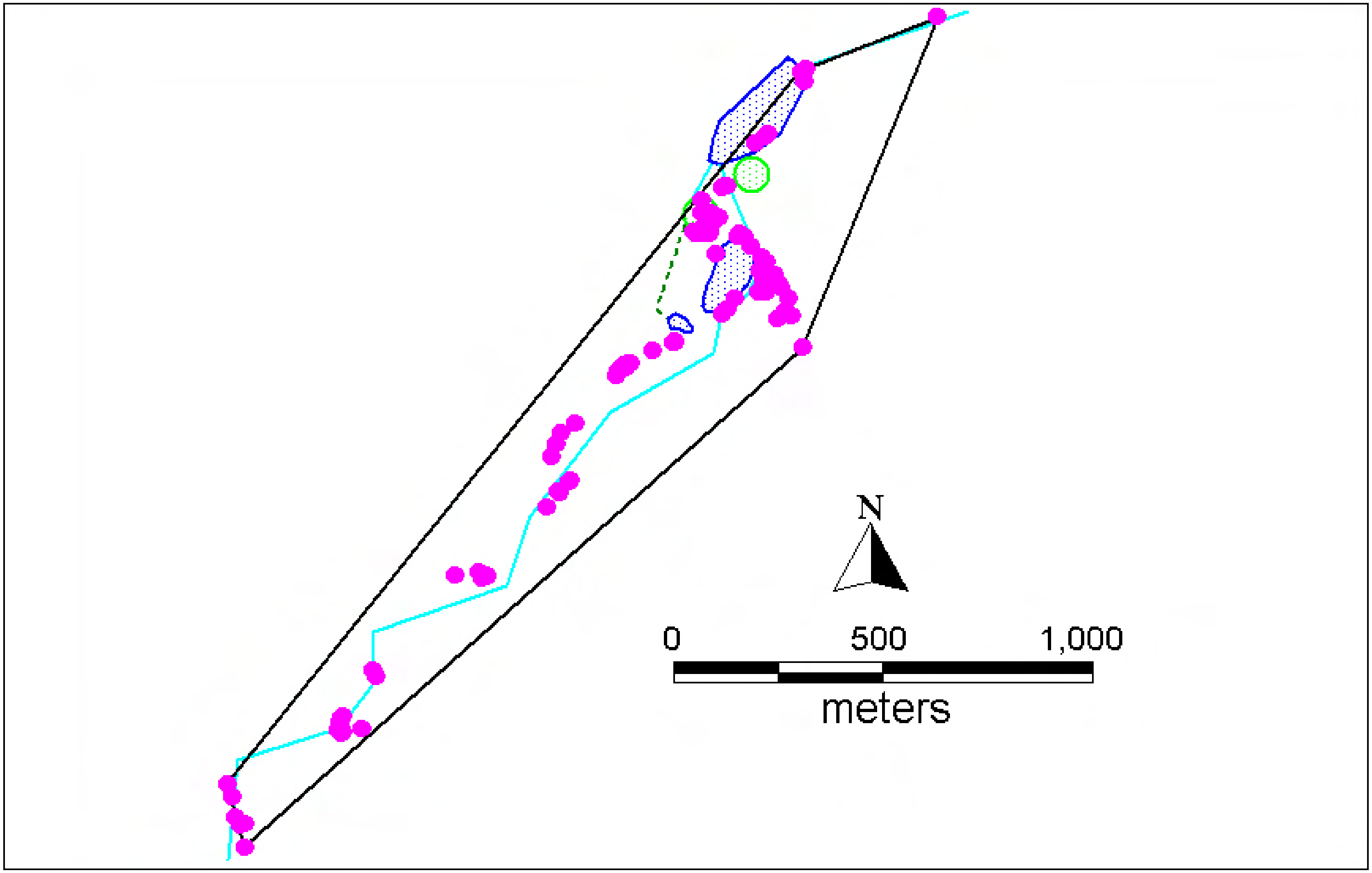

FIGURE 6.18. ALL WOOD TURTLE LOCATIONS AND MINIMUM CONVEX POLYGON.

not incorporated into the MCP due to the shape of the stream stretch. Since most Wood Turtles were found in or near the stream, density was also estimated by km of stream stretch (3.325 km for the study area). There were 15 Wood Turtles/km of stream.

Glyptemys insculpta that were not radio tracked were most frequently found in the stream (n = 63, 81.3% of captures). They were observed on land 9 times (11.7%). They were found 4 times (5.2%) basking on the stream bank, and once (1.3%) in the main Spotted Turtle wetland. Figure 6.19 depicts the location of all Wood Turtles hand-captured and radio tracked.

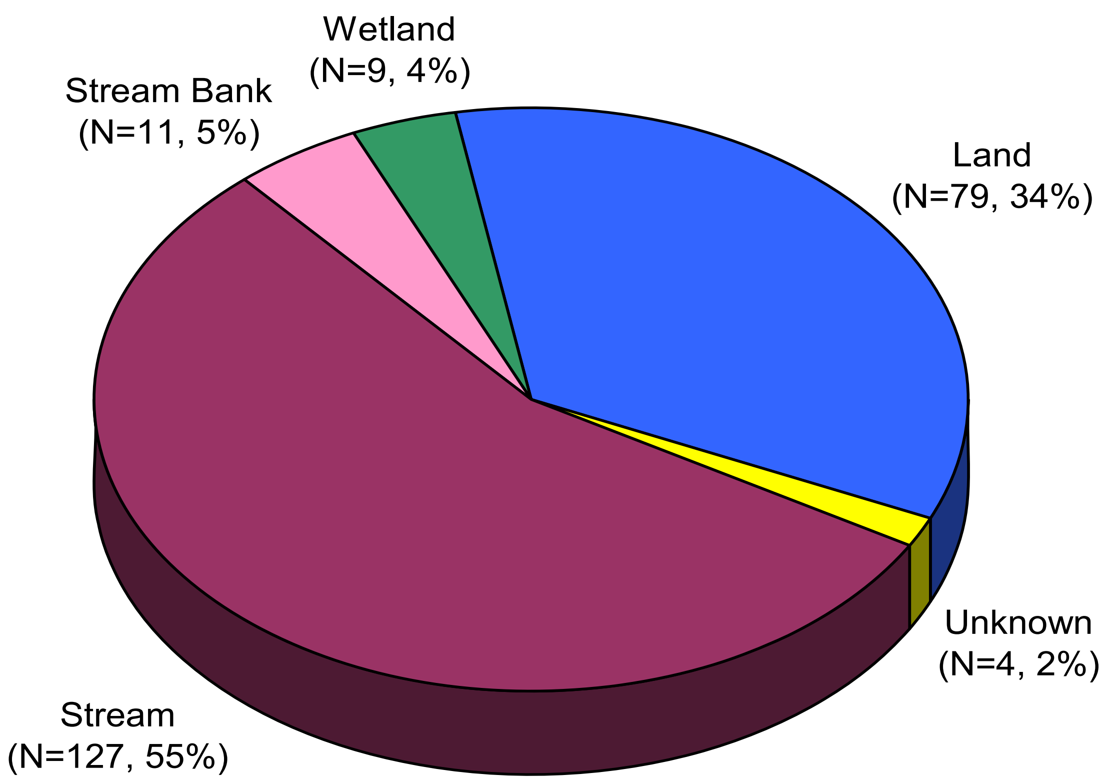

FIGURE 6.19. LOCATIONS OF WOOD TURTLES.

Communal Hibernation:

There were 9 hibernacula approximately 100 to 600 m apart along the stream stretch that *G. insculpta* occupied (Figure 6.20). The hibernacula consisted of cut backs under stream banks, log jams, and tree roots.

The most Wood Turtles found throughout the course of the study in a single hibernaculum was 13 (Hibernacula I). This hibernaculum was found through radio-tracking male Gi#18. On 9 March 2002, he was radio tracked to a mass of Sycamore roots, which were probed for turtles. Eight additional unmarked turtles were pulled out of the hibernaculum at that time, but Gi#18 was in too deep and could not be reached. One turtle had 1 annulus, 3 had 2 annuli, and 5 were adults (including the radio tracked male). Two of those turtles were recaptured at the hibernaculum on 31 March 2002. When the site was revisited on 2 April 2002, 3 unmarked turtles were discovered (1 female, 2 juveniles). Another unmarked juvenile was captured there on 1 April 2003. The sex ratio of the turtles found in that location was 7 juveniles, 2 males, and 4 females.

Second largest communal hibernaculum had 7 turtles (Hibernaculum H). A pool just downstream to this hibernaculum had 3 additional turtles in it, for a total of 10 turtles using this area. Three were the most found at one time, which occurred on 16 November 2001 and 9 March 2002. Radio tracked female Gi#13 was found in that area 6 times, and once up on the bank above within 5 m of the stream.

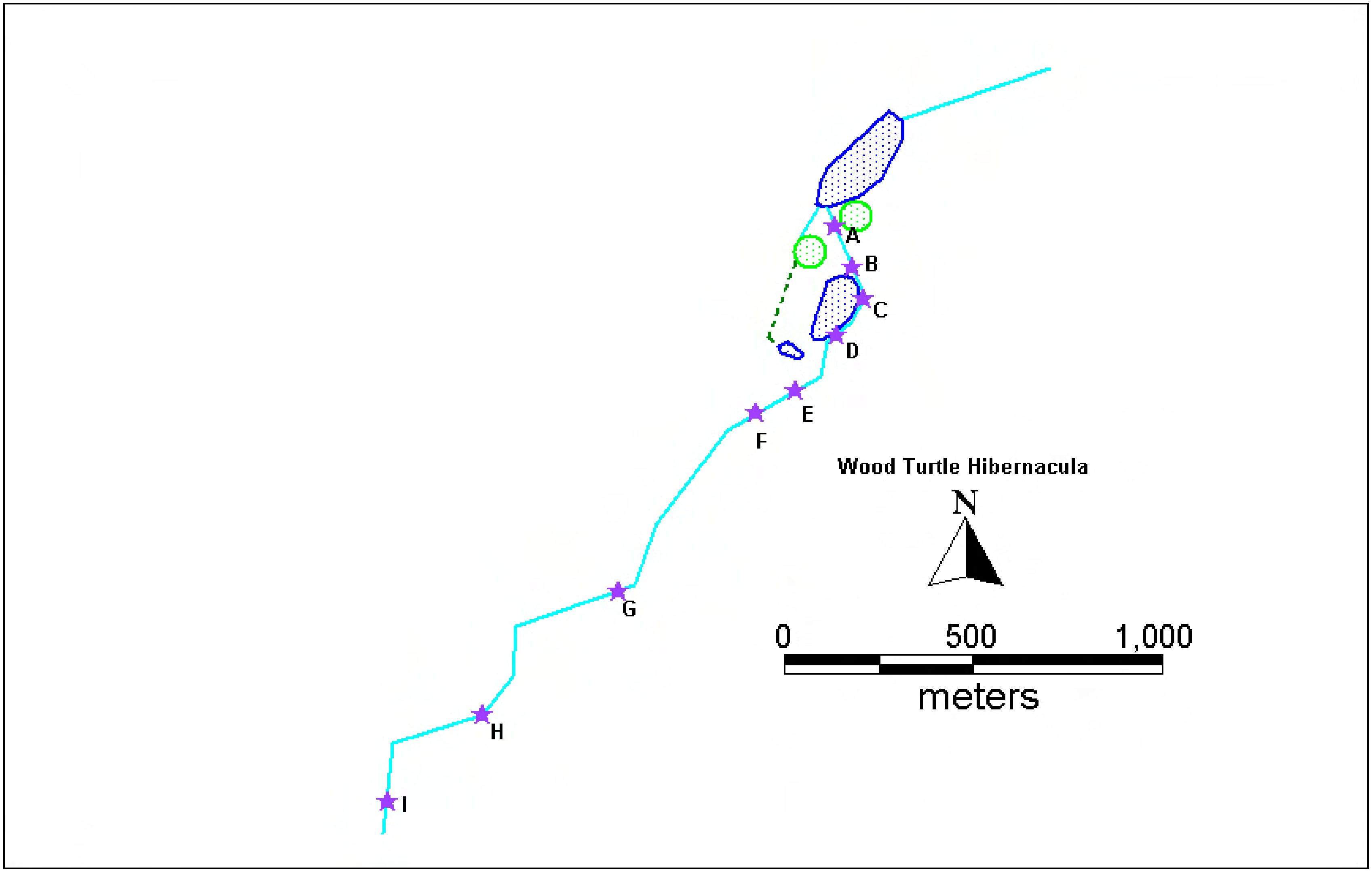

FIGURE 6.20. MAP OF WOOD TURTLE HIBERNACULA.

The most times one turtle was hand-captured at the hibernaculum or nearby pool was 4 (Gi#21). Four turtles were captured there once, 3 turtles were captured twice, and 1 turtle was captured 3 times. The sex ratio in this hibernaculum was 2 juveniles, 3 males and 5 females. Unfortunately, flood waters destroyed this hibernaculum and none were found there in winter 2002-2003. Other hibernacula contained 1 to 4 *G. insculpta.*

Radio-Telemetry

Six *G. insculpta* (2 males, 4 females) were radio tracked. Radio tracked males were observed 19 times. Females were radio-located 134 times. Females were radio tracked year round, although most observations took place from May through August 2001. Males were not found until October 2001, so summer movement and habitat use is not known for them.

Females were found most frequently on land (n=64, 47.8% of captures). They were observed 52 times in the stream (38.8%). They were found 8 times (6%) in the main Spotted Turtle wetland, 6 times basking on the stream bank (4.5%), and 4 times the locations were unknown (3%) because of radio-telemetry problems or we couldn't negotiate the area due to thick vegetation.

Gi#03:

Female Gi#03 was observed 39 times from 19 March 2001 through 2 July 2002 (Figure 6.21). Total activity area was 0.93 ha and the greatest straight line distance between the 2 farthest points this turtles was located was 307 m.

Longest straight line distance she was found from the stream was 205 m.

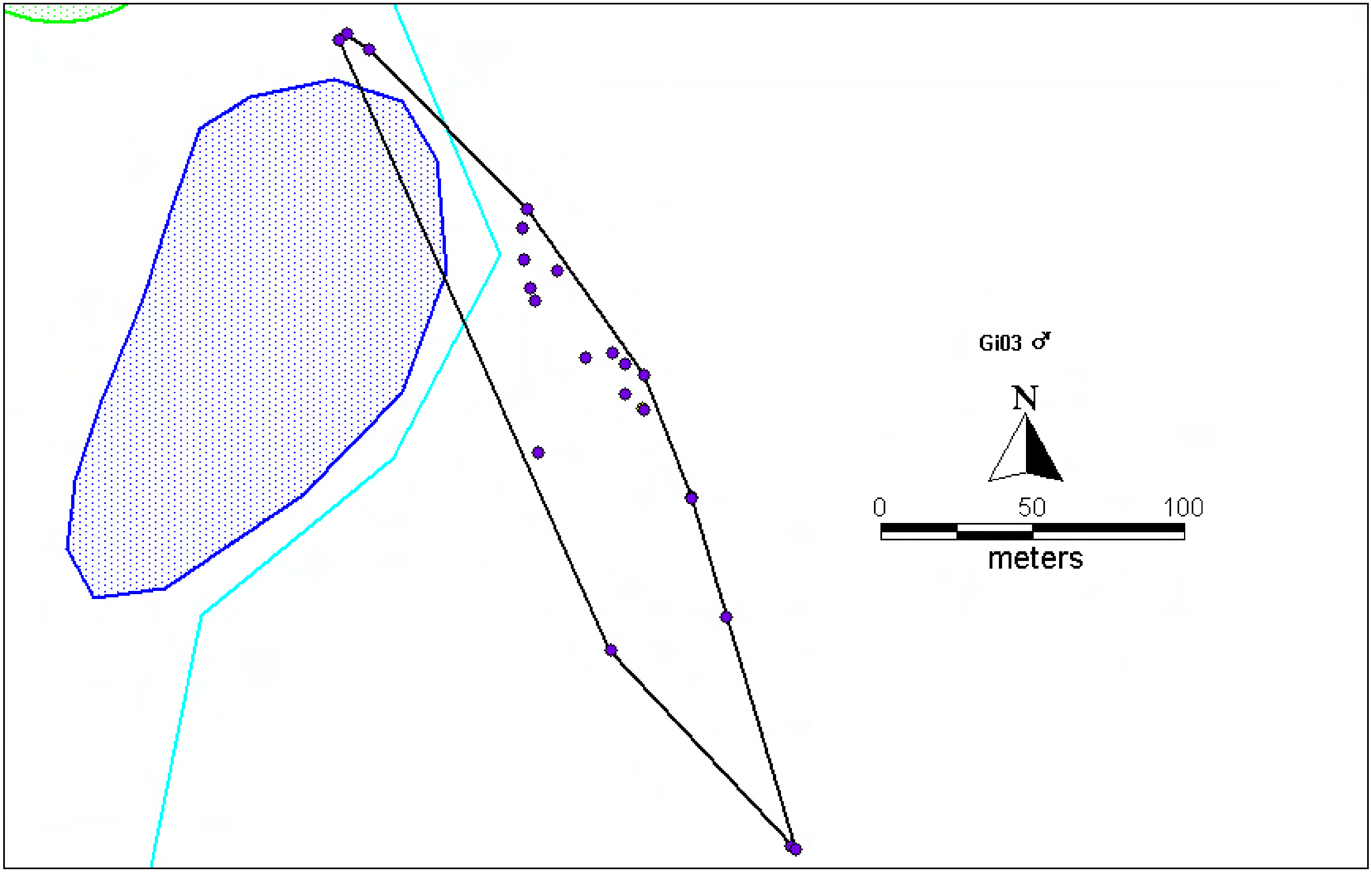

FIGURE 6.21. GI#03 LOCATIONS AND MINIMUM CONVEX POLYGON.

Path she chose to move to and from that location was 230 m straight line from the stream. Earliest date in the spring she was found out of the stream was 19 March 2001 when she was found basking on the stream bank with a muddy carapace that was drying. Latest date she was observed on land in the fall was 16 September 2001, when she appeared to be heading back toward the stream which was 60 m away.

Gi#08:

Female Gi#08 was captured 37 times between 23 May 2001 and 2 July 2002 (Figure 6.22). Home range was 0.20 ha (MCP). Greatest straight line distance between the 2 farthest points this turtles was located was 81 m.

Longest straight line distance she was found from the stream was 38 m. Earliest date in the spring she was found out of the stream was 2 April 2002 when she was found basking on top of the dam she used for her hibernaculum. Latest date she was observed on land in the fall was 16 September 2001. She had been in that location for 3 straight days.

Gi#12:

Female Gi#12 was observed 38 times from 5 June 2001 through 1 April 2003 (Figure 6.23). MCP home range was 3.13 ha. Greatest straight line distance between the 2 farthest points this turtles was located was 473 m.

Longest straight line distance she was found from the stream was 78 m. Earliest date in the spring she was found out of the stream was 1 June 2002 and she was still in the stream as of 4 April 2002. She was not originally located until 5 June 2001 and the site was not visited n May 2002.

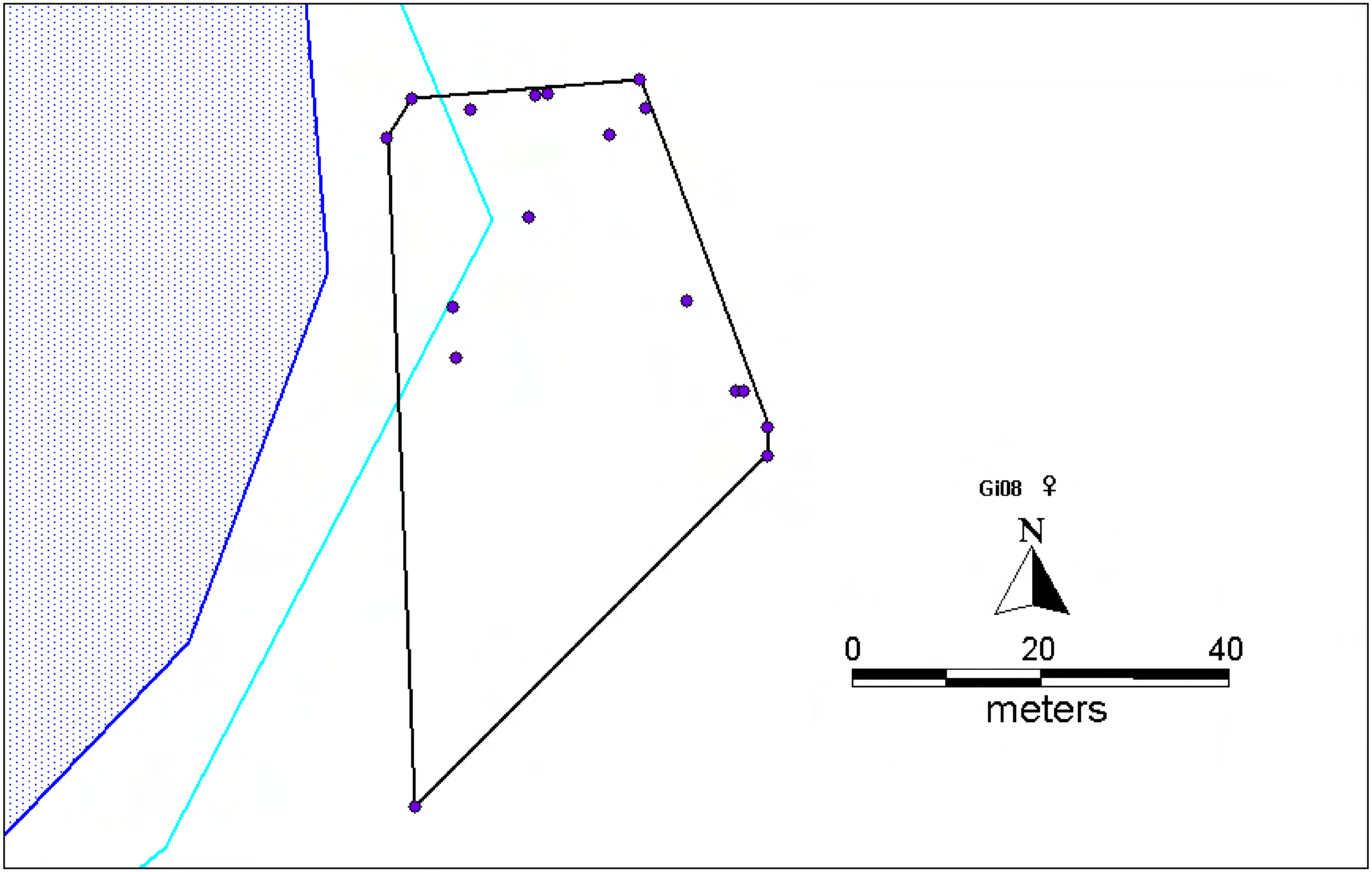

FIGURE 6.22. GI#08 LOCATIONS AND MINIMUM CONVEX POLYGON.

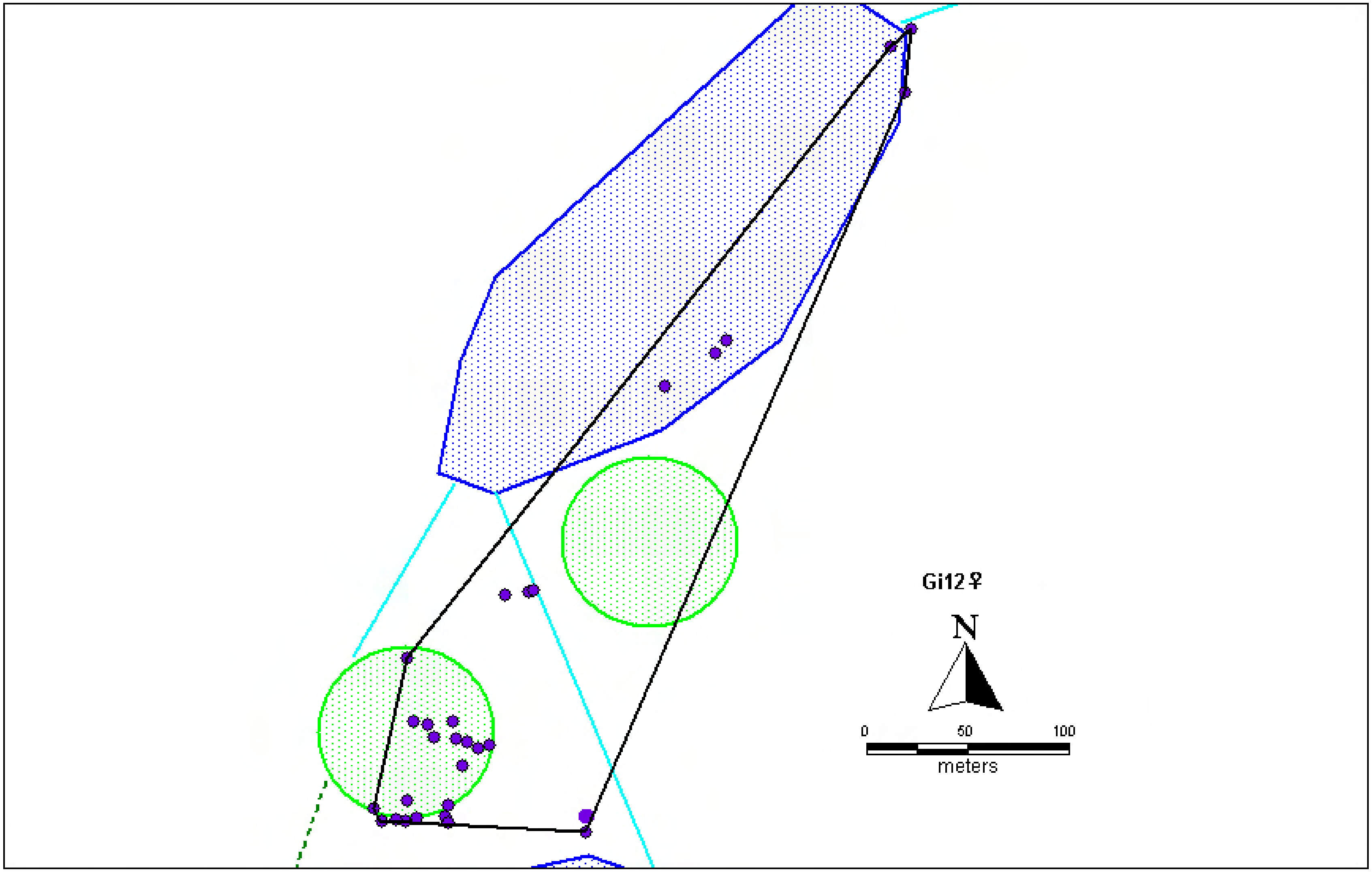

FIGURE 6.23. GI#12 LOCATIONS AND MINIMUM CONVEX POLYGON.

Gi#13:

Female Gi#13 was observed 20 times from 5 June 2001 through 1 April 2003 (Figure 6.24). Her home range (MCP) was 18.41 ha. Greatest straight line distance between the 2 farthest points this turtles was located was 2,220 m. She moved onto private land on 29 June 2001, and I was unable to track her until she moved back upstream in August. Although unable to pinpoint her, she moved at least another 200 m straight line distance north of the end of the study area.

Longest straight line distance she was found from the stream was 75 m. Earliest date in the spring she was found out of the stream was 31 March 2002 when she was 5 m from the stream up on the bank hidden under fallen leaves. Latest date in the fall she was on land was 19 August 2001.

Gi#17:

Male Gi#17 was located 11 times between 20 October 2001 and 13 October 2002 (Figure 6.25). His home range was 1.24 ha (MCP). Greatest straight line distance between the 2 farthest points this turtles was located was 486 m.

Longest straight line distance he was found from the stream was 40 m. Earliest date in the spring he was found out of the stream was 1 June 2002. He had been found in the stream 31 May 2002. Latest date in the fall he was observed on land was 13 October 2002 when he was found on the stream bank.

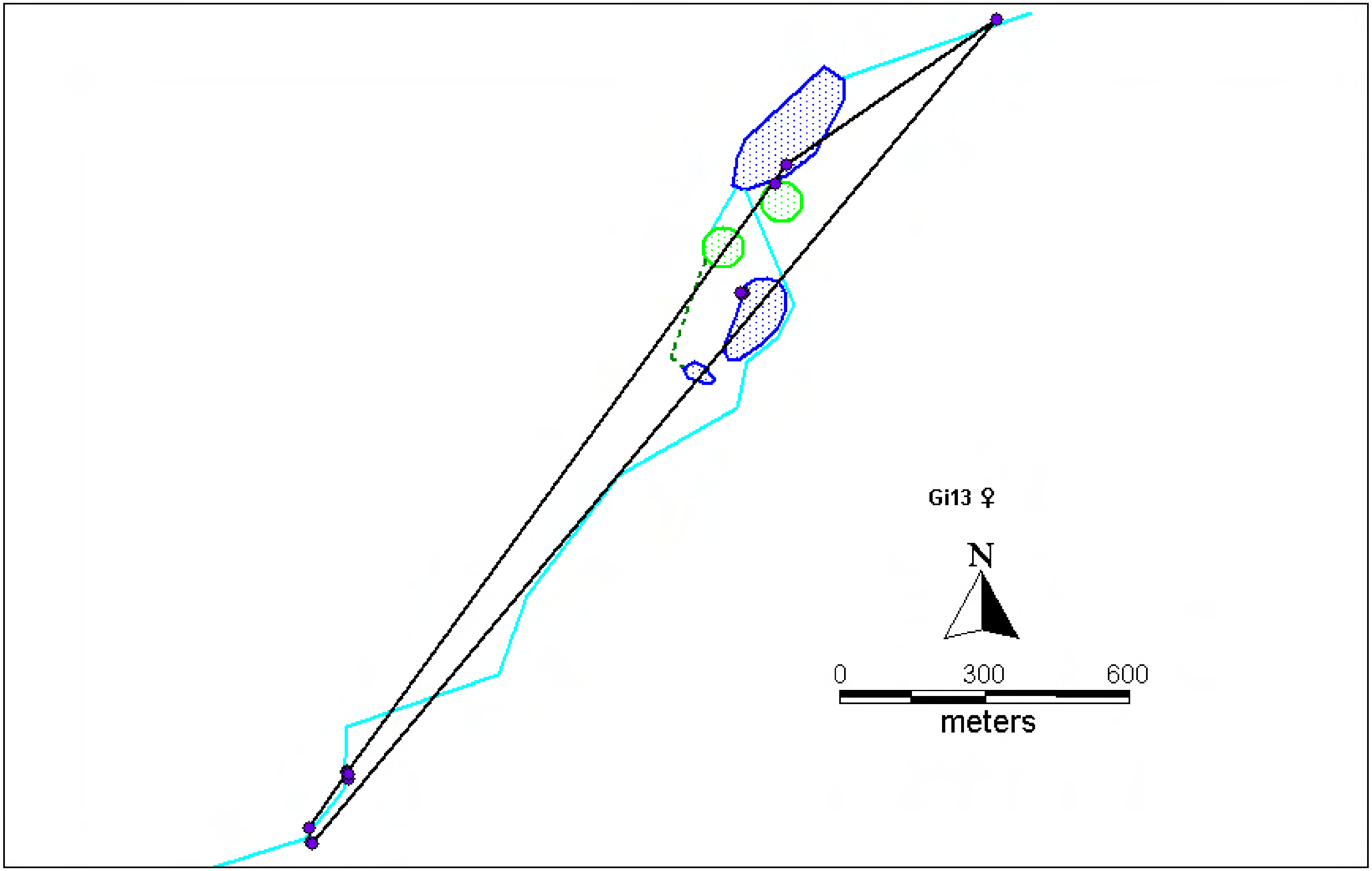

FIGURE 6.24. GI#13 LOCATIONS AND MINIMUM CONVEX POLYGON.

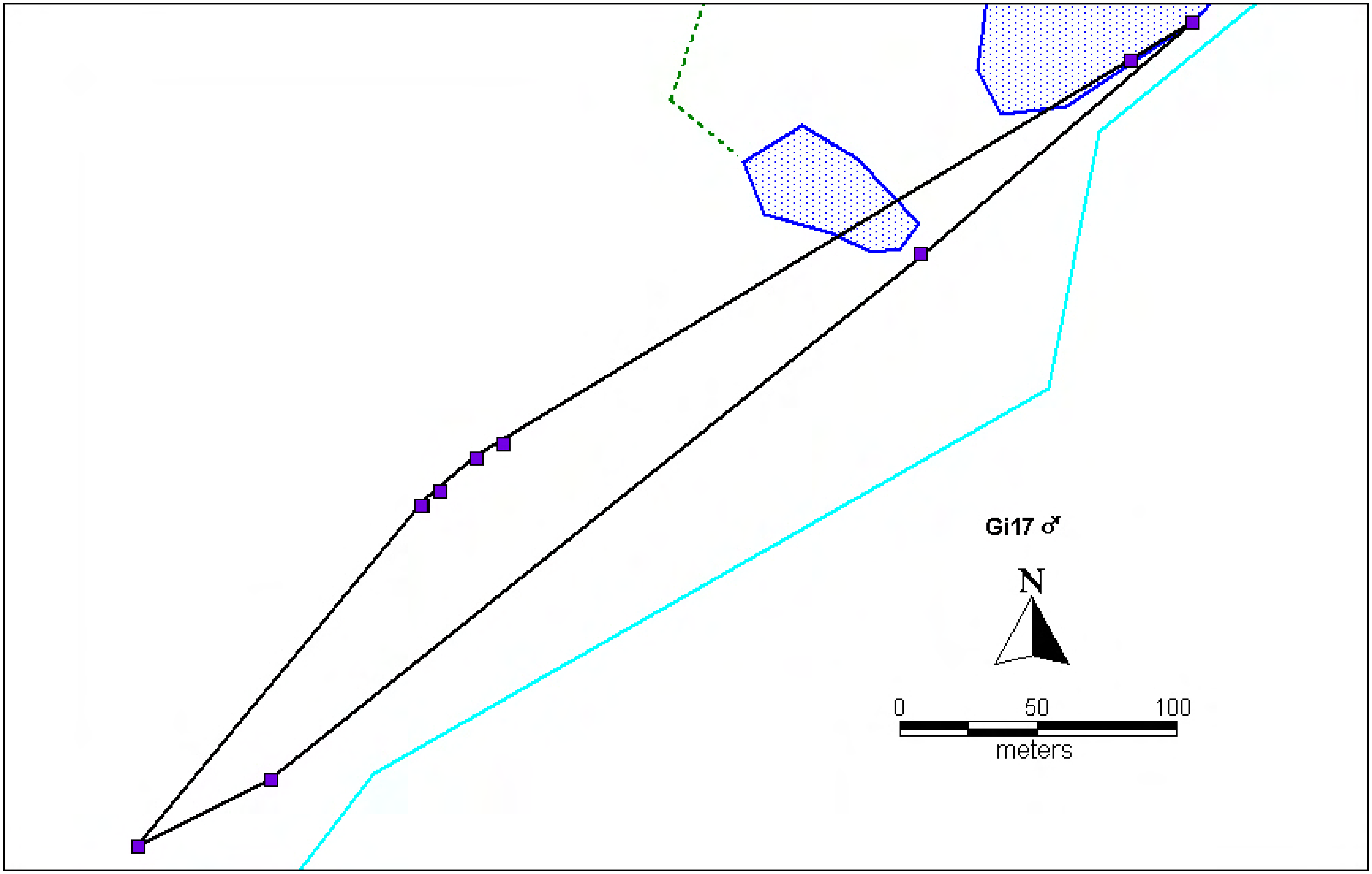

FIGURE 6.25. GI#17 LOCATIONS AND MINIMUM CONVEX POLYGON.

Gi#18:

Male Gi#18 was observed 8 times from 20 October 2001 through 14 October 2002 (Figure 6.26). MCP home range was 2.96 ha. Greatest straight line distance between the 2 farthest points this turtles was located was 392 m.

Longest straight line distance he was found from the stream was 53 m. Earliest date in the spring he was found on land was 2 April 2002 when he was 14 m from the stream under a thin layer of leaves. Latest date in the fall he was observed on land was 14 October 2002 when he was 45 m from the stream.

Combined:

Home ranges for all *G. insculpta* averaged 4.48 ± 6.92 ha (n = 6, range 0.20 - 18.41 ha). When the female who traveled the greatest distance was removed from the equation, mean home range was 1.69 ± 1.29 ha (n = 5, range 0.20 - 3.13 ha). Males, who were not radio tracked as frequently as the females, had home ranges 1.24 and 2.96 ha. Female home ranges were 0.20, 0.93, 3.13, and 18.41 ha.

Home ranges were overlaid to show the overlap of ranges between turtles (Figure 6.27). Overall area of the combined home ranges was 23.73 ha. Combining all Wood Turtle home ranges, the amount of area 2 or more turtles overlapped was 3.17 ha (Figure 6.28). This was 13.4% of the overall Wood Turtle activity area.

Total area used by males was 4.2 ha and there was no overlap in their ranges. Females used a total area of 20.4 ha. Overlap for 2 or more females was 2.28 ha, or 11.2%, of total female activity area (Figure 6.29). Males

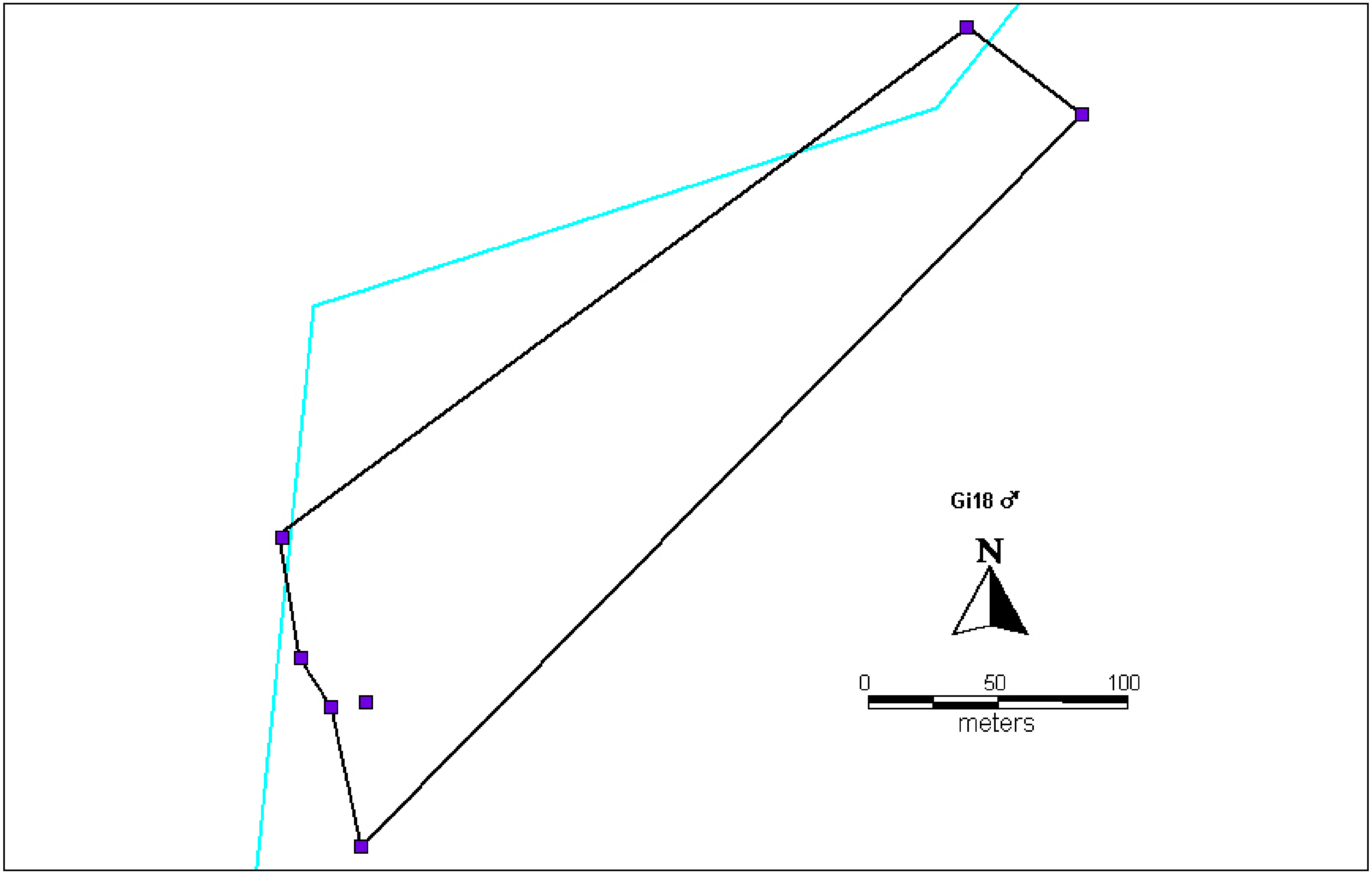

FIGURE 6.26. GI#18 LOCATIONS AND MINIMUM CONVEX POLYGON.

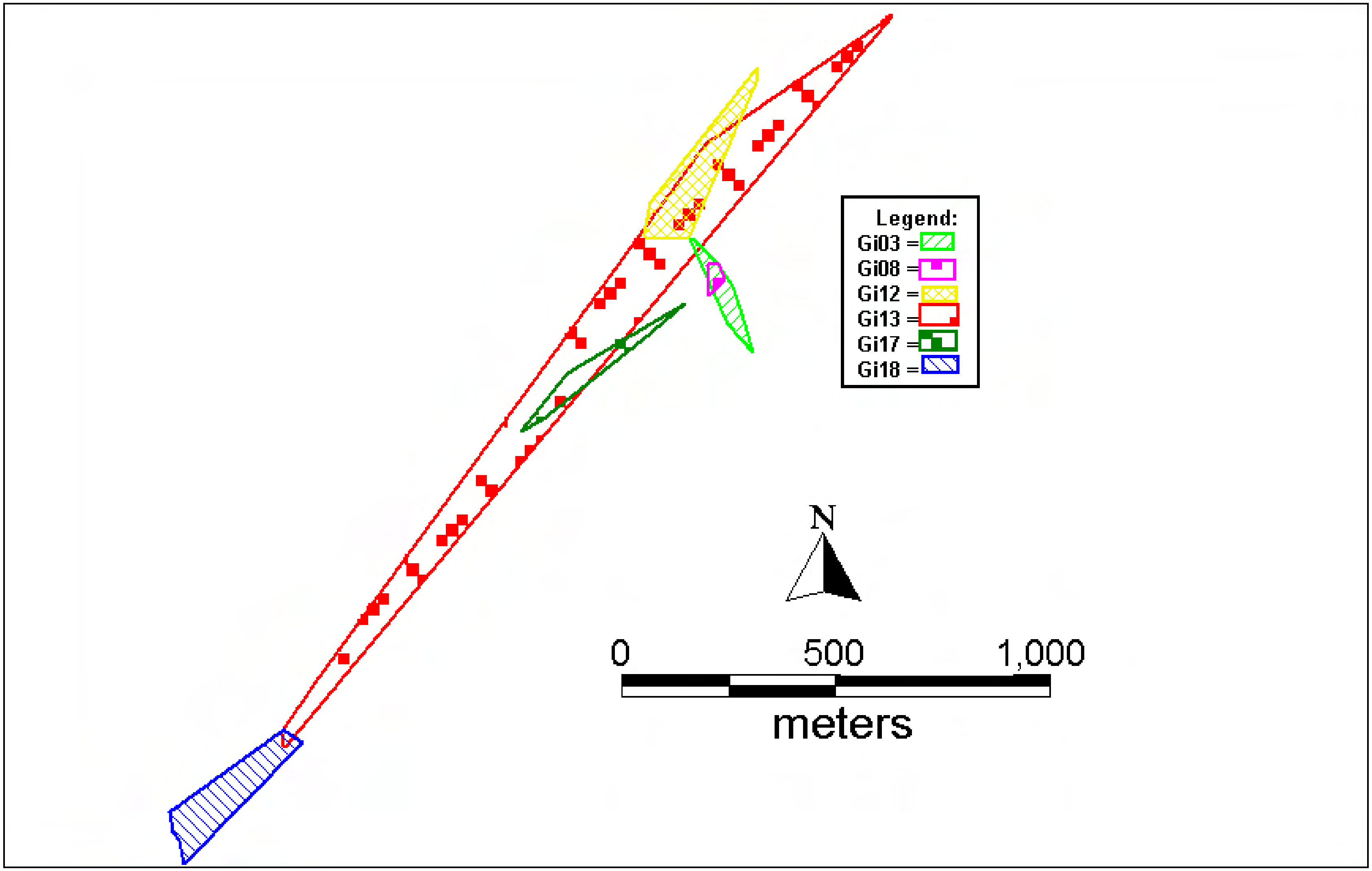

FIGURE 6.27. ALL WOOD TURTLE HOME RANGES COMBINED.

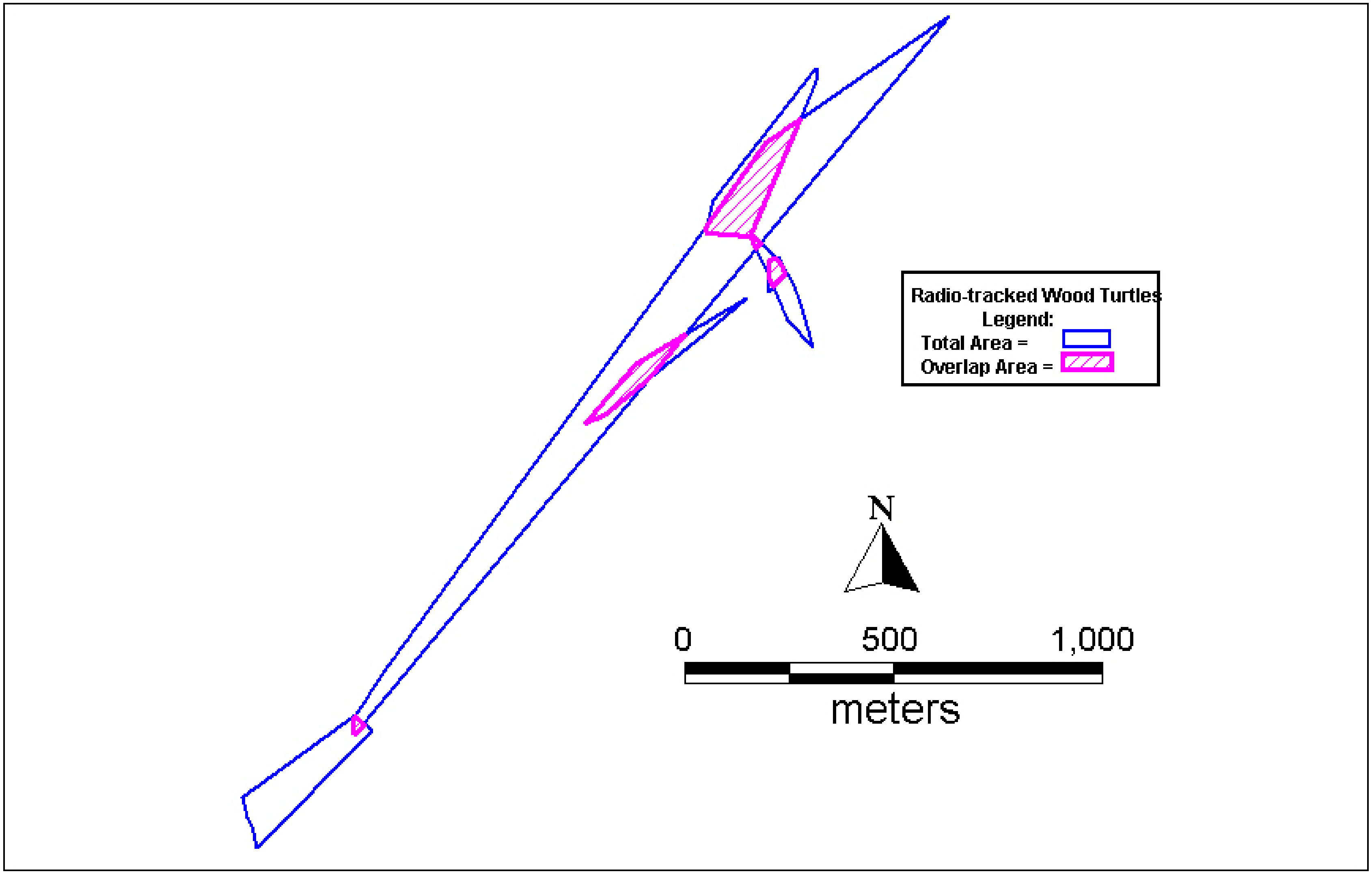

FIGURE 6.28. OVERLAP OF WOOD TURTLE RANGES.

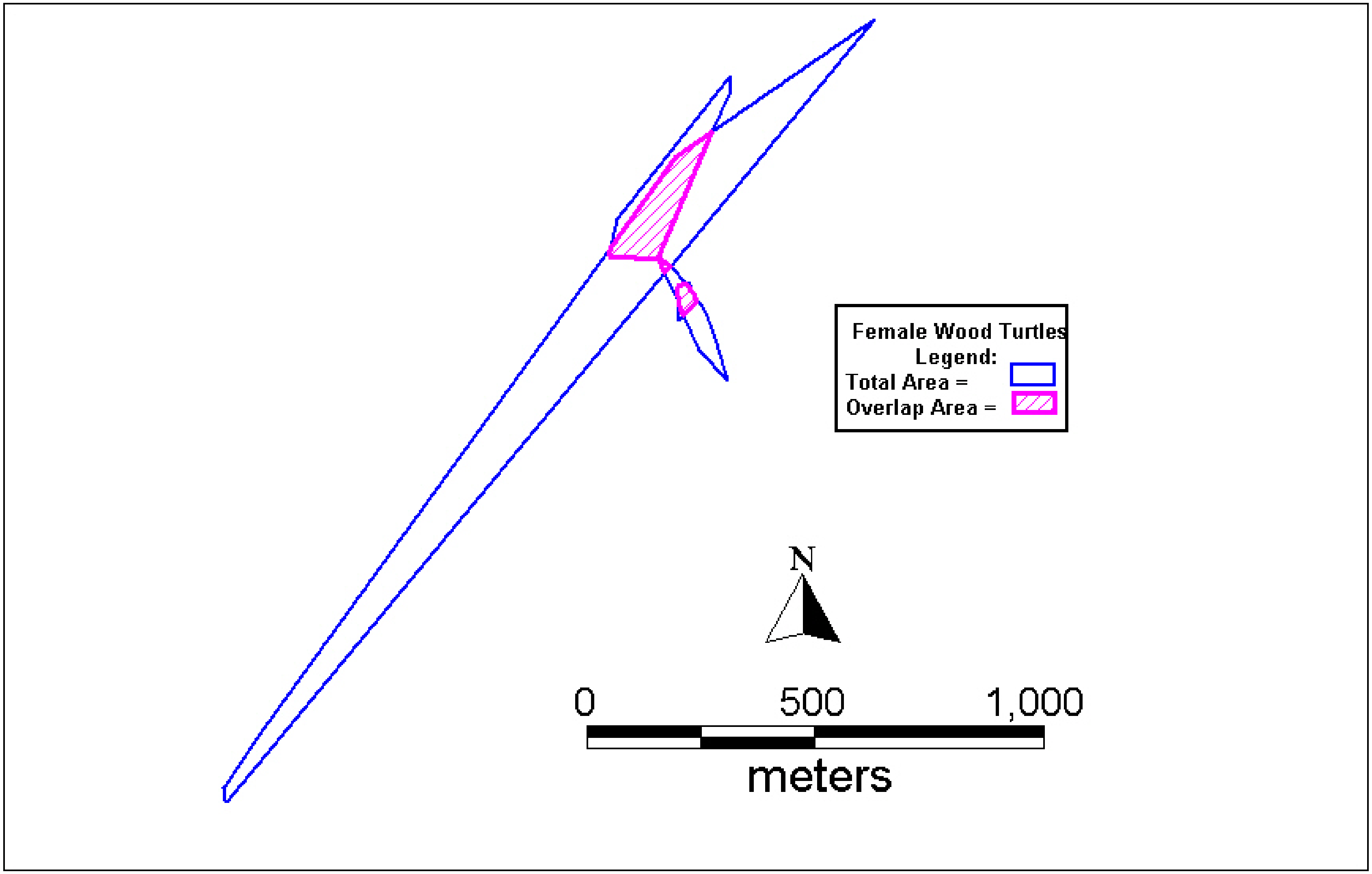

FIGURE 6.29. OVERLAP OF FEMALE WOOD TURTLE HOME RANGES.

overlapped females 0.89 ha, which was 3.8% overlap of the overall 23.73 ha radio tracked *G. insculpta* used.

Of all of the radio-tracked turtles, the greatest straight line distance moved between the 2 farthest recaptures was more than 2,220 m by Gi#13, although it is unconfirmed exactly how far that turtles moved, possibly 200 m more. The short distance between a turtle's 2 farthest recaptures was 81 m by female Gi#08. The rest of the Wood Turtles (2 males, 2 females) moved from 307 to 486 m between their farthest recaptures.

Females generally moved their greatest distances in 1 day in mid-June 2001. Three of the 4 females radio tracked had their longest movement in 24 hours between 15-17June 2001. Gi#03's longest daily movement was 13-14 September 2001 when she was heading back towards the stream for the winter. Although, she moved 80 m between 12-14 June 2001 and from 16-17 June she moved 23 m.

Farthest any of the Wood Turtles were found from the stream was 205 m by female Gi#03. This occurred from 18 to 19 August 2001. The 3 other females were found a maximum of 75-81 m from the stream. Males were not radioed in summer months, so their greatest distance from the stream is uncertain. The farthest males were observed from the stream was 40 and 45 m.

Spotted and Wood Turtle Overlap:

Four Wood Turtles (2 females, 2 juveniles) were observed in the main Spotted Turtle wetland and fields for at least 1 capture.

One radio tracked female spent much of her activity season in or adjacent to the main wetland. Shortly after her transmitter was applied, female Gi#12 moved into the Spotted Turtle wetland (7 June 2001). From 12 -21 June she had a journey to the north end of the main pond, and on 23 June 2001 she was back in the tussocks in the main wetland. She remained in this wet meadow until 23 July 2001 when she moved south to the very northern end of Old Field 2 (see study area) which was drier. In this location she was found frequently under roses, grapes, *Rubus,* stinging nettle and/or tearthumb. She remained in this vicinity at least until 16 September 2001. On 20 October she was found in the stream near Hibernaculum B (Figure 6.20). From 16 November 2001 through 1 April 2002, she was captured in or near Hibernaculum A, where she over-wintered. On 1 June 2002, she was recaptured under roses in the border between the northwest end of OF2 and the woods, where she was damp and had been feeding on a worm. Her last capture was 2 July 2002, where she was found in the middle of the tussock field of the main wetland.

Radio tracked female Gi#13 was not found in the main wetland area, but she was observed using the same old channel that Cg#16 used to get to his over-wintering man-made pond. This channel has standing water in it for part of the year, but is fairly dry and the water is not flowing. However, from aerial photos, it appears that this could have originally been a section of the stream channel for the stream before water was diverted for the man made ponds. This is a possible explanation for why female Gi#13 followed the stream channel for much of her journey, yet was on land for this portion of her trip. She was found in this channel from 17 to 19 August 2001.

Two juveniles were observed in the main wetland. Juvenile Gi#10 was captured 3 (out of 6) times in the channel towards the woods area of the main wetland. On 23 May 2001, this turtle was basking fully exposed on the wetland edge. On 30 May 2001, it was submerged in muddy water with just its marginals showing. It was recaptured in the same location the next day (31 May). This turtle was found on basking top of and in the water adjacent to Hibernaculum A on 2 and 4 April 2002, respectively. The 6th and last time this turtle was seen was on 1 April 2003. It had moved upstream and was found near Hibernaculum E (Figure 6.20). The second juvenile (Gi#11) was found completely submerged yet visible in the main wetland on 27 May 2001.

Overall home range of all of Wood Turtles radio tracked in this study (23.73 ha) was 10 times larger than overall area of Spotted Turtle home ranges (2.37 ha). Mean Spotted Turtle home range (0.52 ha) 11.6% of the size of the mean Wood Turtle home range (4.48 ha) (Wood Turtle home range was 8.62 times larger). The amount of area Spotted Turtle home ranges overlapped Wood Turtle home ranges was 1.95 ha. This was 82.3% of the Spotted Turtle's home range and 8.2% of the Wood Turtle home range.

DISCUSSION

Spotted Turtles:

Mean home range of *C. guttata* in my study (0.52 ha) was similar to a study in Pennsylvania (Ernst 1970). There was no significant difference between male and female Spotted Turtles in Pennsylvania for mean minimum area home ranges, which were 0.53 ha for both (Ernst 1970). In that location the marsh the Spotted Turtles utilized was 5.26 ha (Ernst 1970). Total area of the main wetland and vernal area in my study was only 0.21 ha, although the Spotted Turtles were found in an area 2.37 ha. This was less than half the size of the marsh in Pennsylvania. Graham (1995) used the Fitch method to determine home range in Massachusetts and found males had a larger home range (0.79 and 0.89 ha) than females (0.56 ha). Ohio turtles had mean home range of 1.3 ha using minimum perimeter polygons and mean core activity area of 0.14 ha (Lewis and Faulhaber 1999). Core activity areas for females (0.08 ha) in Ohio were significantly larger than for males (0.04 ha), but there was no difference in minimum perimeter polygons for the sexes (Lewis and Faulhaber 1999). Ontario turtles had a much larger mean range, which was 3.7 ha (range 0.4 to 6.8 ha) and females had significantly larger home ranges than males (Haxton and Berrill 1999). Spotted Turtles in Massachusetts had mean home range of 3.5 ha, ranging from 0.2-53.1 ha (Milam and Melvin 2001). There was no significant difference between male and female home ranges, although females had a tendency for larger ranges (Milam and Melvin 2001).

Ernst (1970) found that home range of Spotted Turtles overlapped. My study had similar results.

The longest straight line distance between farthest recaptures for Spotted Turtles in Ohio was 712 m, although the turtle actually trekked 1.5 km (Lewis and Faulhaber 1999). Mean greatest straight line distance in that study was 322 m

(Lewis and Faulhaber 1999). Of the longest movements, females made 10 out of 11 of them (Lewis and Faulhaber 1999). Two males in South Carolina moved greatest straight line distance of more than 1000 m between the 2 farthest recaptures (Lovich et al. 1990). Turtles in my study did not move nearly as far, with the longest distance between 2 points being 288 m by male Cg#16.

In South Carolina, greatest distance traveled in 24 hours was 423 m (Lovich et al. 1990). This was much longer than the longest 24-hour movement exhibited in my study, which was 137 m by a female. The longest 24-hour movement by a male in my study was 92 m. Of movements traveled in a 24 hour period in South Carolina, 22% of them were greater than 100 m (Lovich et al. 1990). In Massachusetts, longest distance movement was 442 m in August by a male (Graham 1995).

Most of my Spotted Turtles did not move during the overwintering months. One turtle however, (Cg#07) moved around the habitat throughout the winter months. Haxton and Berrill (2001) had no movement over winter during their study, except for one event during a January thaw where one turtle moved but then remained inactive the rest of the winter.

Wood Turtles:

A large area of unused or unstudied land is included in the overall home range MCP, which gives a very low estimate to my Wood Turtle density. Since all of my Wood Turtles were found within or in close proximity to the stream, number of turtles per unit of stream length gave a better indication of Wood Turtle density. Density per km of stream for my population (15 turtles/km stream length) was much smaller than Niederberger and Seidel's West Virginia study (169 turtles/km river length) (1999). This outcome is expected since the river habitat they studied was much larger (>30 m wide) than the stream at my site (which averaged 5 m wide).

In Wisconsin, Wood Turtles had a mean home range of 0.25 ha for males (range 0.08-0.41) and 0.54 ha for females (range 0.27-0.91) (Ross et al. 1991). At a second site in Wisconsin females had home ranges of 2.2 ha and 0.6 ha (Ross et al. 1991). At my site males had 1.24 and 2.96 ha home ranges, which were larger than males from Wisconsin. Female home ranges in my study were from 0.2-18.41 ha. All but 1 of them (0.2 ha) were larger than home ranges at the first site in Wisconsin. The second Wisconsin site had a female with 2.2 ha home range, (Ross et al. 1991) which was well within the range of my turtles. Mean total home range of turtles in central Pennsylvania was 4.99 ha for males (range 2.76-6.36 ha) and 3.30 ha for females (range 2.88-4.08 ha) (Kaufmann 1995). New Hampshire Wood Turtles had larger home ranges than my study. Using MCP, males in New Hampshire ranged from 3.2-67.9 ha and females were 2.4-19.9 ha (Tuttle and Carroll 2003).

The greatest distance any turtle moved between recaptures in Quebec was 2,820 m (Daigle 1997). This was farther than the longest distance my turtles moved, which was 2,220 m. Almost half of the turtles in the Quebec study, which were hand-captured, had greatest movements of less than 200 m. All but 1 of my radio tracked Wood Turtles moved more than 300 m. In Pennsylvania, females had daily movements of up to 410 m and males moved a maximum of

358 m straight line distance (Ernst 2001). Females moved up to 1000 m during nesting season (Ernst 2001). Daily movements were usually less than 100 m (Ernst 2001).

Farthest any Pennsylvania Wood Turtle was located from a stream was 250 m (mean 15.7 m, range 0.5-250 m) (Ernst 2001). In New Hampshire, the farthest a female was located from the stream was 231 m (Tuttle and Carroll 2003). In my study, 205 m was the farthest any Wood Turtle was from the stream. This was done by a female who chose a path that was 230 m to return to the stream. No males were radio tracked during the summer so it is unknown how far they moved from the stream. However, Tuttle and Carroll (2003) observed that females moved farther from streams than males.

Due to my small sample size and the fact that my Wood Turtles were first captured in different sections of the study area, all home ranges only overlapped 13.4%. In Pennsylvania, Kaufmann (1995) found that on average males and females overlapped 22%, males overlapped each other 40%, and females overlapped each other 21%. In my study, males overlapped females 3.8%, males did not overlap each other at all, and females overlapped each other 11.2%. Male home ranges overlapped females in New Hampshire (Tuttle and Carroll 2003) and Quebec (Daigle 1997). Spotted Turtles in Massachusetts had a mean home range of 3.5 ha, ranging from 0.2-53.1 ha (Milam and Melvin 2001). Turtles of the same sex also overlapped each other in New Hampshire (Tuttle and Carroll 2003). Similar to what Kaufmann noted (1995), the range of my female that moved the farthest overlapped most of the other radio tracked turtles' ranges.

CHAPTER 7

Thermal Ecology of *Clemmys* and *Glyptemys* in West Virginia

INTRODUCTION

Turtles are ectothermic, so temperature and thermoregulation play important roles in their life history (Brattstrom and Collins 1972). They are heliotherms, which means they rely on basking in the sun to raise their temperature to increase metabolism (Brattstrom and Collins 1972). Basking raises the turtle's metabolism, and by adjusting their body temperature they increase their efficiency in foraging, digestion, and locomotion (Brattstrom and Collins 1972, Hutchison 1979). Spotted and Wood Turtles rely on both terrestrial and aquatic retreats to avoid extremes in heat and cold (Ernst 1982, Ernst 1986).

There have been studies that recorded body and external temperatures experienced by Spotted Turtles (Ernst 1982) and Wood Turtles (Ernst 1986). Studies have been published on the temperatures of Wood Turtles at the northern and southern limits of their range using data recorded by hand in the field. No research has been published that used data loggers to continuously monitor external temperatures of Wood Turtles. No previous studies have monitored Wood or Spotted Turtle thermal ecology in West Virginia.

Few studies have been published using data loggers to continuously monitor the thermal regime of turtles. This technique has been used on Blanding's Turtles (*Emydoidea blandingii*) in Minnesota (Sajwal and Lang 2000). Data loggers are being used to record Wood Turtle over-wintering temperatures in New Jersey (Breisch pers. comm.). Data loggers have been used to collect over-wintering data on 1 Spotted Turtle in Canada near the northern limit of their range (Litzgus et al. 1999) and to monitor a Spotted Turtle hibernaculum in Ohio (Lewis and Ritzenthaler 1997).

An objective of this study was to explore the range of temperatures in the thermal regime of Wood and Spotted Turtles in West Virginia. This temperature data represented the thermal ecology of a population of Wood Turtles near the southern limit of their range and of a population of Spotted Turtles located mid-range in their latitudinal distribution. The relationship between temperature and behavior was analyzed as well as the averages and extremes turtles endured. Comparisons were made between the temperatures of Spotted versus Wood Turtles. Another objective was to determine whether we could use data loggers as indicators to measure the frequency and duration of aquatic versus terrestrial habitat use by Wood Turtles. Since turtles could not be radio tracked everyday, analyzing temperature patterns of turtles could be a useful tool in determining their basking and aquatic periods. This would be very useful from fall through spring to determine late and early dates of emergence and measure periods of time they are aquatic during the summer.

RESULTS

Hourly temperature recordings were taken from 15 June 2001 through 12 October 2002 using temperature sensitive data loggers. Full months that data were recorded for the different data loggers can be seen in Table 7.1. Over-wintering temperatures were recorded for 4 Spotted Turtles. Data loggers recorded year round temperatures for 6 Wood Turtles. Data loggers were also used to record environmental temperatures. Two data loggers recorded temperatures in Spotted Turtle hibernacula, 2 in Wood Turtle hibernacula, 1 in the stream, and 4 recorded air temperatures in various locations (see Figure 3.6).

Although 19 data loggers were used in this study, data was partially lost from 4 and completely lost from 2. Male *C. guttata* #16's data logger did not record any over-wintering temperatures, despite being functional when launched. Summer data did not download properly from female *G. insculpta* #12, so temperatures from 12 June through 15 September were lost. The data logger affixed to female Gi#08 stopped functioning during March 2002. Over the course of the winter, a beaver chewed all the branches off of the tree above Gi#12's hibernaculum where an air temperature recording data logger was attached. The data logger attached to a branch in the actively used *G. insculpta* hibernaculum was washed away after a rain event. One data logger was stolen. Data was successfully downloaded from all of the other data loggers.

The average daily mean, maximum, minimum, and average daily difference in maximum / minimum temperatures of the Spotted Turtles, Wood Turtles and their environmental temperatures can be seen in Tables 7.1 - 7.4.

Environmental Temperatures:

The main wetland hibernaculum had slightly (1.2 – 2.2°C) higher average mean temperatures from December through March than the vernal pool wetland (Table 7.1). From December through March, the average daily mean temperatures for the vernal area hibernaculum ranged from 3.6 - 7.3°C. For the same months, the main wetland hibernaculum had average daily mean temperatures between 5.3 - 8.5°C. January was the coldest month with mean temperatures for both the main wetland and vernal hibernacula at 5.3°C and 3.6°C, respectively. Main wetland's lowest minimum temperature was in January (4.8°C), although the lowest recording for the vernal hibernaculum was in March (3.1°C) (Table 7.2). In that hibernaculum, January and February were very close to the March temperature, both at 3.2°C. January also had the lowest maximum temperatures for both hibernacula (main = 6.5°C, vernal = 5.3°C) (Table 7.3). The main hibernaculum temperatures were the steadiest in December and January (average 0.1°C daily change), although throughout the winter months temperatures only fluctuated an average of 0.1 - 0.3°C per day (Table 7.4). During the winter, the vernal hibernaculum's average daily difference in temperature ranged from 0.1 - 0.4°C, the coldest being in January.

TABLE 7.1 AVERAGE DAILY MEAN TEMPERATURE (°C) PER MONTH FOR *CLEMMYS GUTTATA* AND *GLYPTEMYS INSCULPTA* IN WEST VIRGINIA - JULY 2001 TO SEPTEMBER 2002

Data logger	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Cg05 *						6.5	3.7	5.3	7.0						
Cg07 *						5.3	3.1	4.1	7.7						
Cg09 *						6.4	2.9	3.2	6.4						
Vernal Hib						7.3	3.6	4.0	5.5	11.9	14.5	19.8	21.2	20.2	17.2
Cg Wetland Hib						8.5	5.3	6.2	6.9	10.5	12.6	15.9	17.6	17.7	15.9
Air at Vernal Area							1.7	2.2	5.8	13.3	16.3	22.2	23.1	21.6	17.7
Air at Cg Wetland							2.9	3.3	6.1	**	**	21.2	23.0	22.2	18.9
Gi03	19.3	21.8	16.8	11.8	10.1	8.1	6.8	7.6	9.0	14.2	16.7	21.3			
Gi08	20.4	22.1	16.7	12.0	10.1	8.3	7.0	7.7	**	**	**	**			
Gi12	**	**	**	11.1	9.7	7.7	6.3	7.2	8.6	13.8	16.9	21.1			
Gi13	21.1	21.4	17.0	12.6	11.0	9.9	8.6	9.2	9.6	14.3	17.6	21.6			
Gi17 ***					10.2	8.5	7.3	7.9	9.4	14.4	16.9	21.0	21.6	20.5	16.7
Gi18 ***					9.3	6.8	4.4	5.6	7.5	14.4	17.1	22.5	22.9	20.9	18.2
Gi hibernaculum					10.2	8.3	7.1	7.7	9.1						
Stream					10.0	8.0	6.8	7.5	8.9	12.7	13.9	17.2	17.8	17.0	15.2
Air near Stream							2.5	2.9	**	12.6	14.1	20.1	21.8	21.0	17.8
Weather Station 1	21.6	23.8	17.6	11.8		4.3									
Weather Station 2	21.1	22.2	16.2	11.6		5.8									

* Temperature recorder not attached until in hibernacula and removed on spring emergence.

** Data recorder failed.

*** First found 20 October 2001.

TABLE 7.2 MINIMUM TEMPERATURE (°C) PER MONTH FOR *CLEMMYS GUTTATA* AND *GLYPTEMYS INSCULPTA* IN WEST VIRGINIA - JULY 2001 TO SEPTEMBER 2002

Data logger	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Cg05 *						2.3	1.9	3.8	2.5						
Cg07 *						1.2	0.5	0.0	1.0						
Cg09 *						2.2	1.8	2.1	1.5						
Vernal Hib						4.3	3.2	3.2	3.1	7.9	8.0	16.4	17.2	16.2	12.5
Cg Wetland Hib						6.2	4.8	5.7	4.8	8.0	10.9	14.3	16.7	16.7	14.9
Air at Vernal Area							-16.1	-14.1	-16.1	-8.5	-2.4	6.5	5.9	6.2	2.7
Air at Cg Wetland							-4.7	-4.7	-4.7	**	**	7.8	7.5	8.1	4.2
Gi03	10.4	14.4	5.2	6.9	6.0	2.8	2.5	3.1	3.1	5.7	1.7	10.6			
Gi08	10.7	14.7	6.1	-0.4	6.1	3.2	3.2	3.5	**	**	**	**			
Gi12	**	**	**	-4.5	5.4	1.9	1.9	2.5	2.2	1.0	-0.8	7.7			
Gi13	10.9	12.1	6.0	2.2	2.5	7.1	5.7	6.3	4.8	4.0	4.3	9.5			
Gi17 ***					6.5	4.2	3.9	3.9	3.9	2.5	3.9	12.0	9.7	11.7	9.4
Gi18 ***					4.5	1.9	1.0	0.7	1.6	2.5	2.8	10.0	12.3	13.8	12.3
Gi hibernaculum					6.3	3.3	3.0	3.2	3.3						
Stream					6.0	3.1	2.8	3.1	3.1	5.4	8.3	13.2	13.2	13.2	11.5
Air near Stream							-4.8	-4.8	**	-4.6	-0.7	8.4	8.1	9.0	5.3
Weather Station 1	7.8	11.1	2.8	-6.1		-11.1									
Weather Station 2	7.2	11.7	3.3	-3.9		-9.4									

* Temperature recorder not attached until in hibernacula and removed on spring emergence.

** Data recorder failed.

*** First found 20 October 2001.

Table 7.3 Maximum temperature (°C) per month for *Clemmys guttata* and *Glyptemys insculpta* in West Virginia - July 2001 to September 2002

Data logger	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Cg05 *						10.7	7.8	8.1	29.9						
Cg07 *						11.0	22.8	14.4	36.3						
Cg09 *						10.3	5.7	6.6	32.8						
Vernal Hib						10.2	5.3	5.9	9.4	17.0	20.7	22.9	24.0	23.0	21.0
Cg Wetland Hib						10.0	6.5	7.1	8.6	13.5	14.6	17.6	18.2	18.5	16.7
Air at Vernal Area							31.0	24.6	37.4	42.0	41.6	44.8	46.2	43.8	40.7
Air at Cg Wetland							26.0	24.3	30.7	**	**	36.1	38.0	38.0	38.0
Gi03	40.3	41.2	37.5	25.3	18.2	14.1	11.8	11.8	16.1	39.9	41.6	44.4			
Gi08	39.2	37.2	38.4	33.3	14.2	13.3	12.1	11.6	**	**	**	**			
Gi12	**	**	**	28.3	14.4	12.9	11.2	10.9	32.5	42.6	40.4	37.9			
Gi13	40.0	40.0	34.8	31.1	25.0	12.9	12.1	11.5	31.1	39.1	42.6	40.8			
Gi17 ***					14.3	12.9	12.0	12.0	40.7	39.4	42.9	35.8	39.0	35.4	33.9
Gi18 ***					32.9	12.3	10.0	10.6	37.1	38.7	43.0	36.7	35.9	34.7	35.9
Gi hibernaculum					14.3	13.4	12.4	12.1	16.2						
Stream					14.1	13.2	12.3	12.0	16.4	21.5	20.6	22.1	22.1	21.8	19.4
Air near Stream							22.1	20.6	**	32.7	28.9	31.9	34.1	33.5	34.5
Weather Station 1	36.1	36.1	32.8	31.1		26.7									
Weather Station 2	33.9	33.9	29.4	29.4		25.0									

* Temperature recorder not attached until in hibernacula and removed on spring emergence.

** Data recorder failed.

*** First found 20 October 2001.

TABLE 7.4 AVERAGE DIFFERENCE PER DAY IN MAX / MIN TEMPERATURE (°C) PER MONTH FOR *CLEMMYS GUTTATA* AND *GLYPTEMYS INSCULPTA* IN WEST VIRGINIA -JULY 2001 TO SEPTEMBER 2002

Data logger	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Cg05 *						0.7	0.5	0.7	3.9						
Cg07 *						1.5	2.5	4.5	12.1						
Cg09 *						0.8	0.4	0.5	8.2						
Vernal Hib						0.3	0.1	0.2	0.4	1.3	3.4	2.2	1.9	1.9	2.3
Cg Wetland Hib						0.1	0.1	0.2	0.3	0.4	0.4	0.2	0.2	0.2	0.2
Air at Vernal Area							18.9	21.3	21.4	22.8	23.4	25.3	21.1	20.7	21.4
Air at Cg Wetland							14.5	16.3	16.1	**	**	18.1	15.5	17.5	20.0
Gi03	13.0	12.0	11.4	4.3	2.9	1.7	1.9	3.1	4.1	11.2	20.5	17.5			
Gi08	14.5	12.1	10.7	8.5	2.4	1.6	2.0	2.8	**	**	**	**			
Gi12	**	**	**	8.3	2.3	1.7	1.9	3.0	4.9	17.0	24.7	17.0			
Gi13	14.6	12.8	14.7	9.3	3.1	1.3	1.6	1.7	3.6	12.9	20.6	17.6			
Gi17 ***					2.3	1.6	2.1	2.8	5.5	16.0	20.0	16.8	12.8	12.7	11.1
Gi18 ***					5.0	2.4	2.8	3.8	5.2	15.4	21.4	16.1	9.8	10.7	12.3
Gi hibernaculum					2.4	1.8	2.3	3.4	3.7						
Stream					2.5	1.8	2.3	3.4	4.3	5.4	3.8	5.0	4.1	3.9	3.3
Air near Stream							11.3	13.9	**	14.0	12.3	13.6	11.7	13.0	14.7
Weather Station 1	15.5	14.6	16.3	19.5		12.5									
Weather Station 2	14.4	20.7	9.9	19.7		16.1									

* Temperature recorder not attached until in hibernacula and removed on spring emergence.

** Data recorder failed.

*** First found 20 October 2001.

From April through September the hibernaculum in the vernal area had higher temperatures than the one in the main wetland. The average daily mean temperatures for the rest of the activity season of April through September for the vernal hibernaculum ranged from 11.9-21.2°C. The warmest month for this area was July. This month had the highest average daily mean, minimum and maximum temperatures (Tables 7.1-7.3). Biggest average daily fluctuation in daily temperature was in May (3.4°C). From April through September, average daily mean for the main wetland ranged from 10.5-17.7°C. Highest daily mean and maximum temperatures were in August, and July and August were tied for highest minimum temperature (16.7°C). April and May had the most daily fluctuation in temperature, which was just 0.4°C.

The stream and Wood Turtle hibernaculum temperatures were nearly identical throughout the study months. From November 2001 through March 2002, the average daily mean temperature of the stream was 0.2 to 0.3°C (± 0.2° of error from the data logger) colder than that of the Wood Turtle hibernaculum (Table 7.1). From November through February, maximum temperature of the hibernaculum was slightly higher than the maximum stream temperature (Table 7.3). In March, the maximum temperature of the stream was 16.4°C which was 0.2°C higher than the hibernaculum. The minimum monthly temperatures of the stream were lower than the hibernaculum during those 5 months (Table 7.2). For December through February, the average temperature fluctuation between maximum and minimum temperatures per day was the same for the stream and hibernaculum (Table 7.4). In November, the hibernaculum fluctuated 0.1°C less than the stream and in March it changed 0.6°C less per day.

From November through March, average daily mean temperature ranged between 6.8-10.2°C for the stream and Wood Turtle hibernaculum. January was the coldest month for both. Warmest stream temperature recorded was 22.1°C recorded in June and July 2002 at. Coldest stream temperature was 2.8°C recorded in January 2002. Between December 2001 and September 2002, stream temperature varied 19.3°C.

January was the coldest month for average air temperature in the main wetland, vernal area, and along a wooded section of the stream. From January through March, the vernal area had cooler average air temperatures (1.7, 2.2, and 5.8°C, respectively) than the main wetland (2.9, 3.3, and 6.1°C, respectively). Average air temperature along the stream for January and February were 2.5 and 2.9°C. The coldest air temperature was -16.1°C recorded in January and March. The main wetland and stream air temperature data loggers did not record below -5°C, so it is unknown exactly how cold it got in those locations. January had the lowest daily fluctuation in temperature for all 3 locations.

The vernal area had slightly warmer temperatures than the Cg wetland during June and July and slightly cooler air temperatures in August and September. Average mean air temperature from April through September ranged from 13.3-23.1°C for the vernal area, 18.9-23.0°C for the main wetland, and 12.6-21.8°C along the stream. Largest average daily air temperature fluctuation was in

April for the stream (14°C), June for the vernal area (25.3°C), and September for the main wetland (20°C).

Lowest air temperatures were usually in the mornings, between 0500-0800 hrs. Air temperature generally peaked midday (between 1200-1500 hrs). Stream and Wood Turtle hibernaculum temperatures often peaked later on in the day after the air temperatures had started to decline from their peak (Figure 7.1). Graphs of the environmental temperatures from November through March can be seen in Appendix VI.

Spotted Turtle Temperatures:

Cg#05:

Temperature range of female Cg#05 during the months of December through March ranged from the low of 1.9°C in January (Table 7.2) to the high of 29.9°C in March (Table 7.3). Her average daily mean temperatures for December, January, February, and March were 6.5, 3.7, 5.3, and 7.0°C, respectively (Table 7.1). Her temperature remained fairly steady and follows the natural small dips and spikes in temperature of the hibernacula from mid-November through February (Figure 7.2, Appendix VII). When she was found in March she was facing out of the entrance tunnel of her hibernacula, about 30 cm from the entrance. She was very alert and appeared to be preparing to emerge from her hibernacula. Her data logger was downloaded on 8 March 2002 and she was placed back into her hibernacula in the same position she was found. The data indicates she emerged from her hibernacula shortly later on 8 March

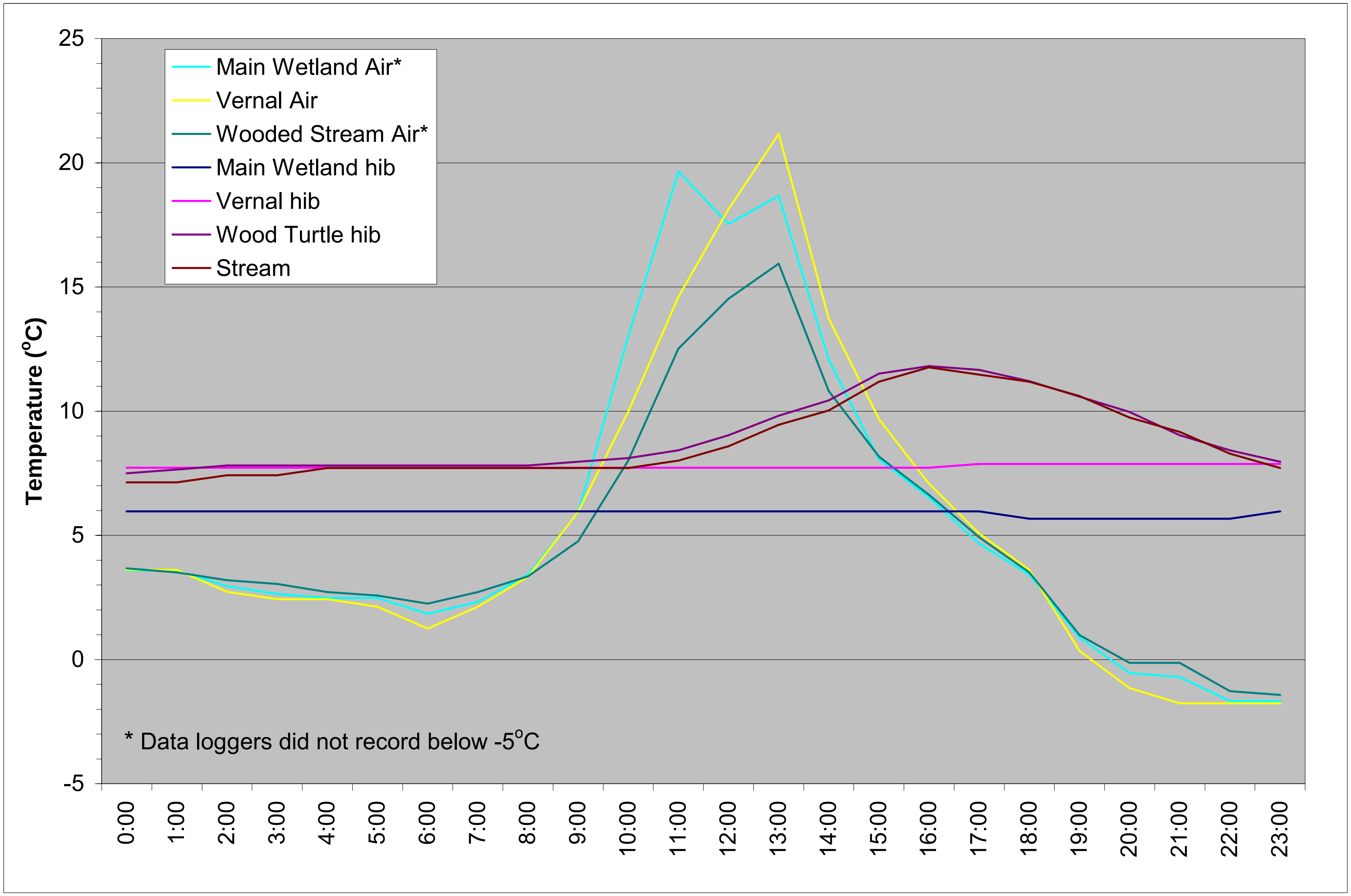

FIGURE 7.1. ENVIRONMENTAL TEMPERATURES BY TIME OF DAY. Example given is 3 March 2002.

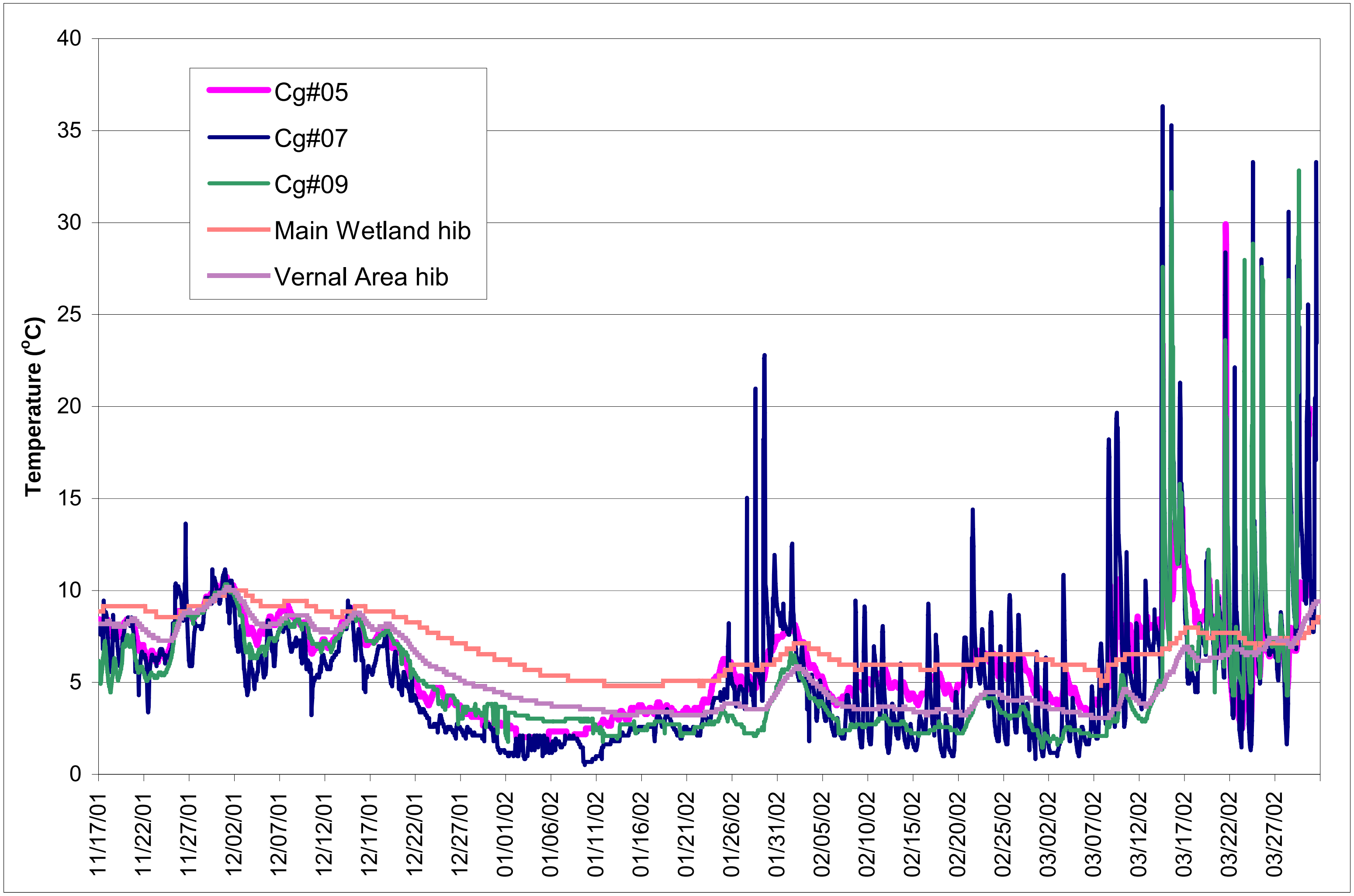

FIGURE 7.2. SPOTTED TURTLE AND HIBERNACULA TEMPERATURES FROM NOVEMBER 2001 – MARCH 2002.

and basked for a short period (Figure 7.3). On 9 March she had another small spike in temperature and for the rest of the month her temperature fluctuated more than the other months of the study. There were 3 more basking periods during that time, on 14, 21 and 30 March, where she reached temperatures of 23.4, 29.9, and 19.9°C, respectively. Her temperature exceeded the maximum air temperature by almost 11°C on 21 March. During the winter, the temperature when she was in her hibernaculum remained fairly constant. The average difference per day in her maximum and minimum temperatures was 0.7°C in December, 0.5°C in January, and 0.7°C in February (Table 7.4). The average fluctuation in temperature increased to 3.9°C in March, the month she exited hibernation.

Cg#07:

Male Cg#07's temperatures ranged from 0.0°C in February as the low (Table 7.2) to the high of 36.3°C in March (Table 7.3). His average daily mean temperatures for the over-wintering months were 5.3, 3.1, 4.1, and 7.7°C (Table 7.1). Cg#07 had more variation in his temperature than the other turtles (Figure 7.2, Appendix VII). He had colder minimum and higher maximum temperatures during all 4 months of data logging than the others. He had basking periods during several of the winter months (Figure 7.2). December was the only month that his temperatures had no spikes. His graph indicates he basked on 26 November 2001, and 25 and 27-30 January 2002. On 28 January his maximum temperature was 3°C below the maximum air temperature and on 29 January it was 1°C below maximum air temperature of 23.8°C (Figure 7.4). His

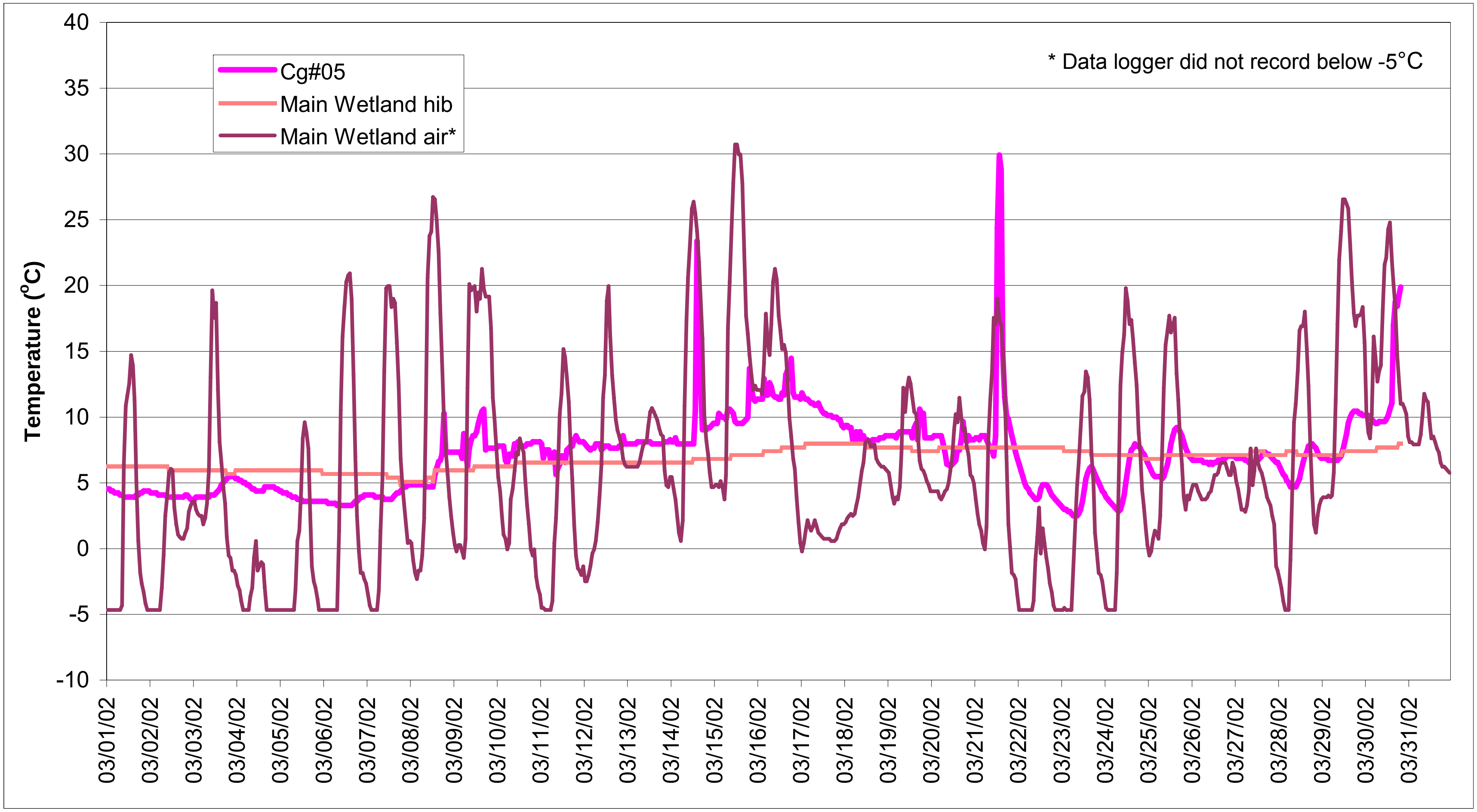

FIGURE 7.3. CG#05, HIBERNACULUM AND AIR TEMPERATURES FOR MARCH 2002.

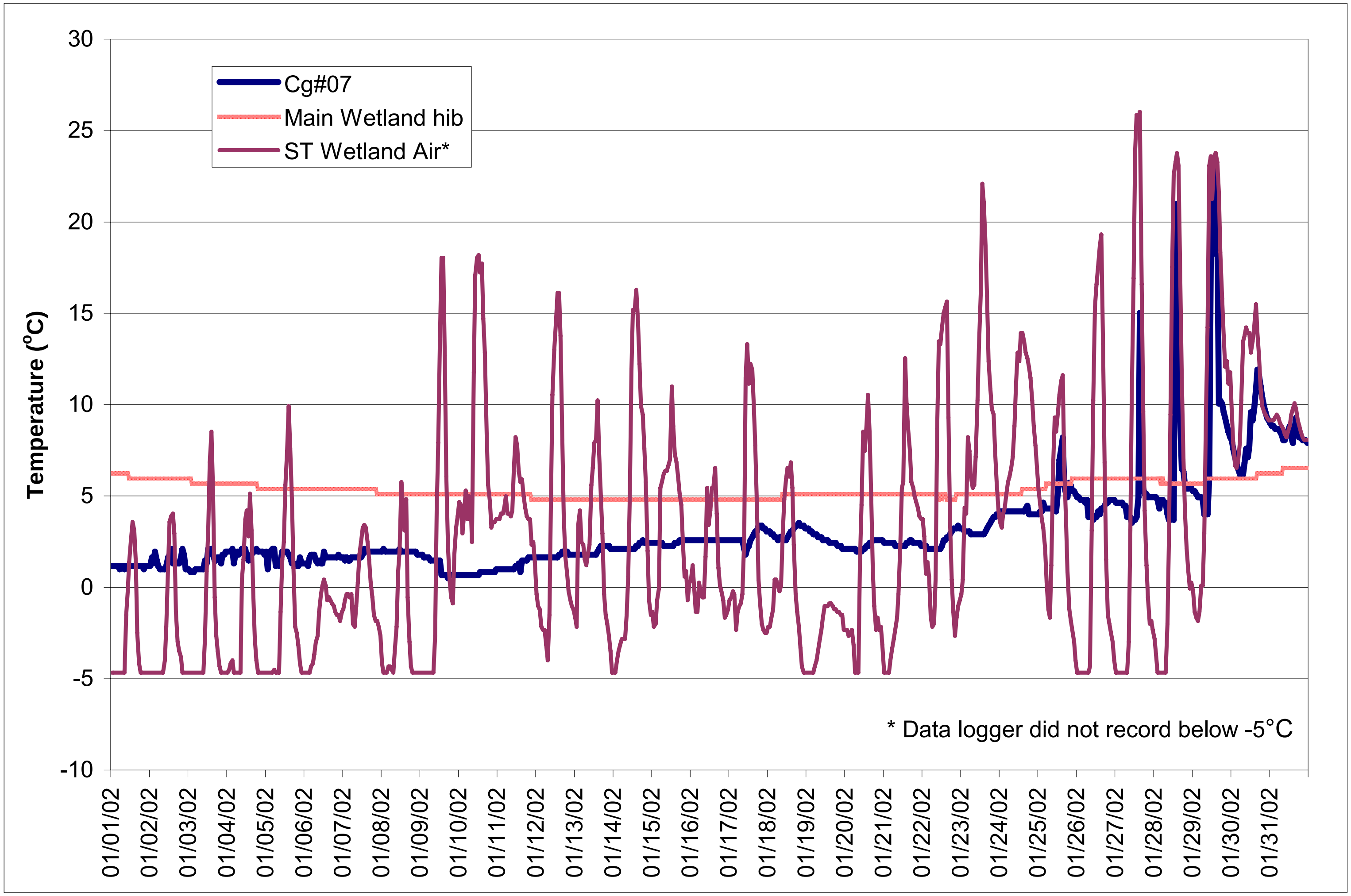

FIGURE 7.4. CG#07, HIBERNACULUM AND AIR TEMPERATURES FOR JANUARY 2002.

temperatures for February fluctuated throughout the month from basking temperatures over 14°C to dips close to 0°C (Figure 7.5). There were 24 days in March where his temperature exceeded that of the Spotted Turtle hibernaculum, and 10 of those days it also exceeded the maximum air temperature (Figure 7.6). His average daily fluctuation in temperature was 1.5, 2.5, 4.5, and 12.1°C from December through March, respectively (Table 7.4).

Cg#09:

The lowest temperature recorded for male Cg#09 was 1.8°C (Table 7.2) in January and the highest temperature reached during winter was 32.8°C in March (Table 7.3). The average daily mean of Cg#09 during the over-wintering months was 6.4, 2.9, 3.2, and 6.4°C (Table 7.1). His temperature did not spike all winter until 8 March when he was retrieved from the hibernaculum to download his data logger (Figure 7.2, Appendix VII). After that his temperature rose slightly from about 3°C to just over 5°C on 10 March 2003. The temperature of his hibernaculum started rising to almost 5^{o}C at that same time. He began basking on 14 March 2002 when his temperature and the hibernaculum temperature approached 5°C (Figure 7.7). He remained active for the rest of the month with his temperatures spiking almost daily. Cg#09 had external temperatures that were within 2°C of his hibernaculum during December, January, and February (Figure 7.2). Usually the hibernaculum temperature was slightly warmer than his temperature. The average difference per day in his maximum and minimum temperatures was 0.8, 0.4, 0.5 and 8.2°C (Table 7.4). His hibernaculum averaged 0.3, 0.1, 0.2, 0.4°C from December through March, respectively.

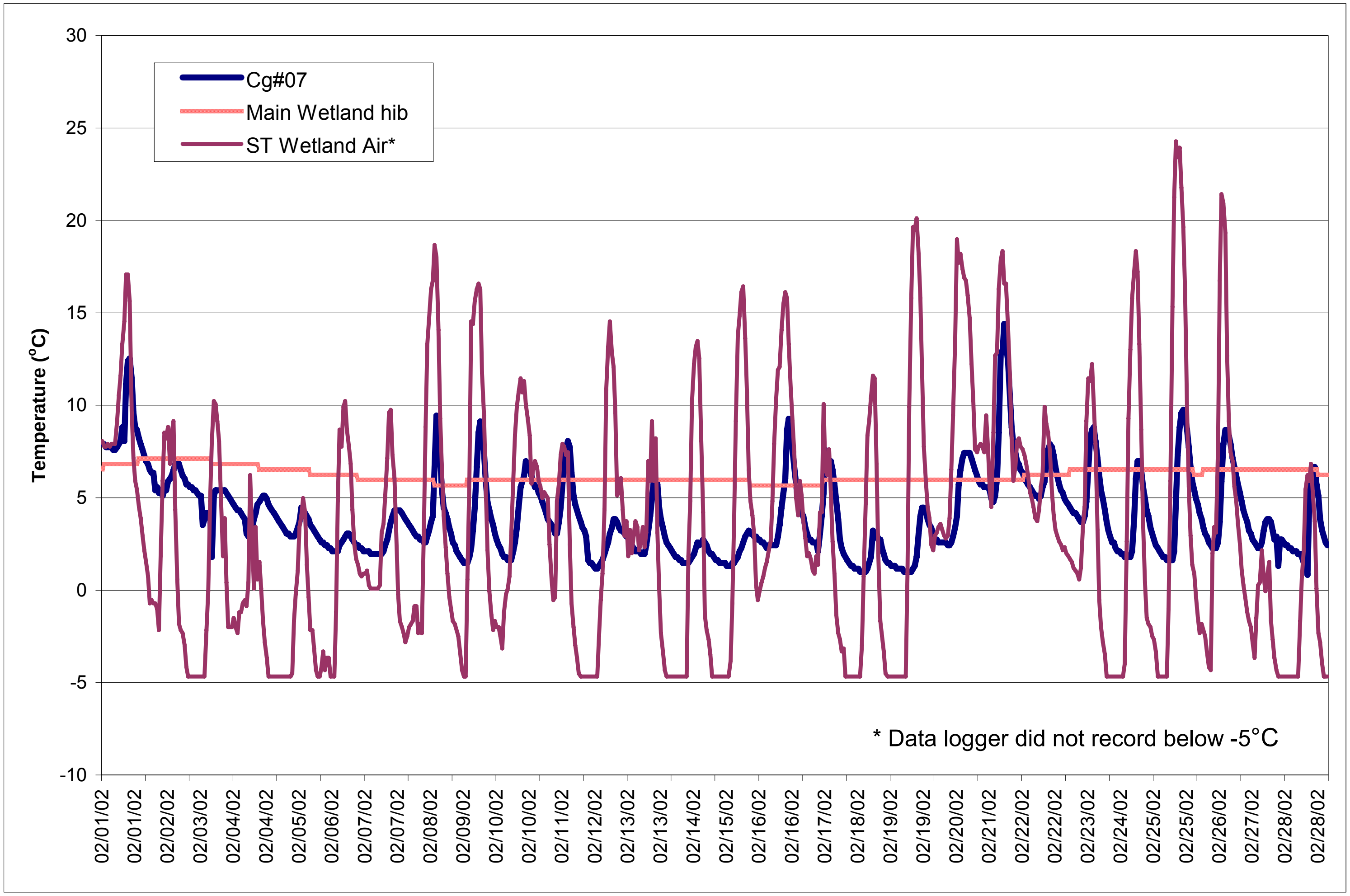

FIGURE 7.5. CG#07, HIBERNACULUM AND AIR TEMPERATURES FOR FEBRUARY 2002.

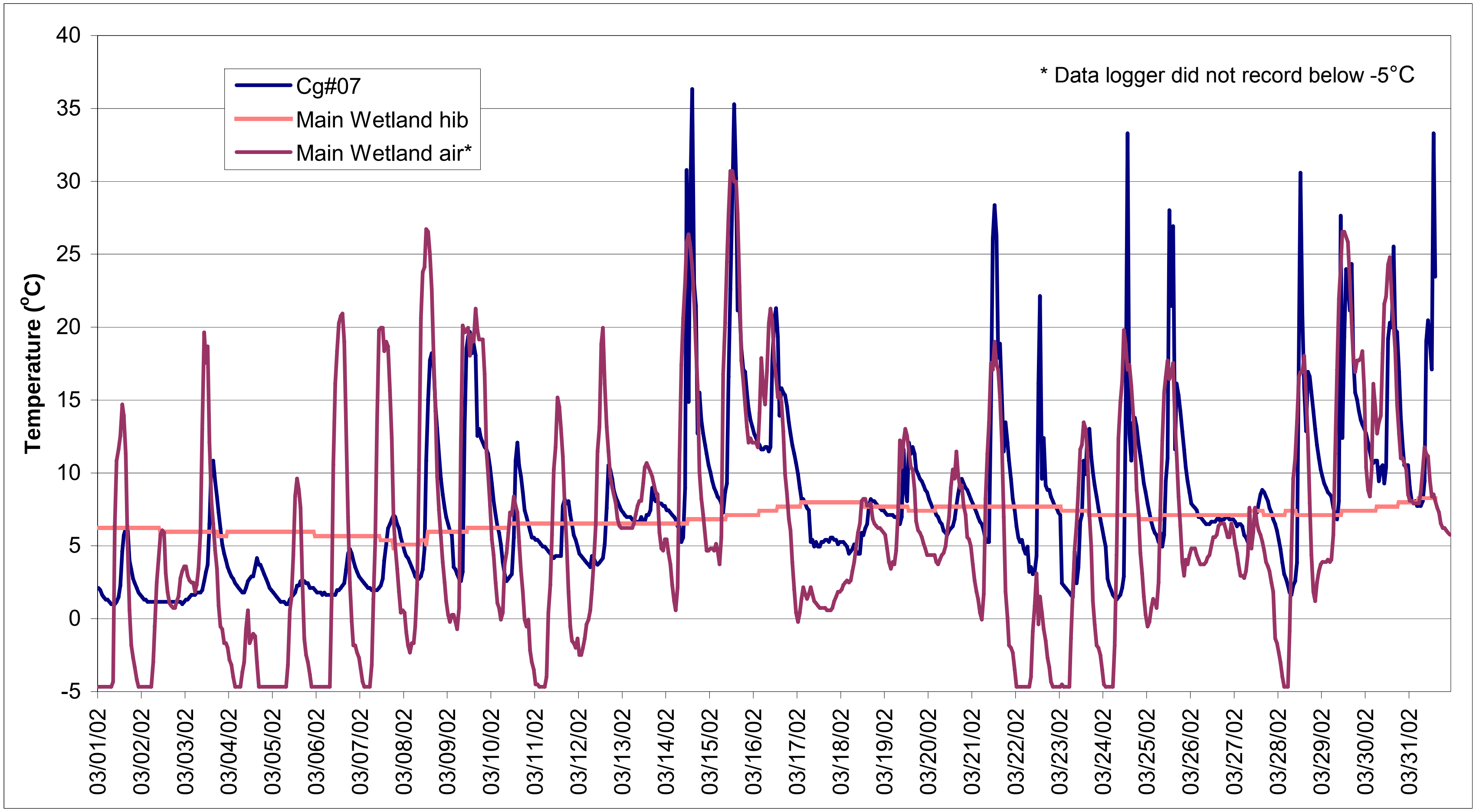

FIGURE 7.6. CG#07, HIBERNACULUM AND AIR TEMPERATURES FOR MARCH 2002.

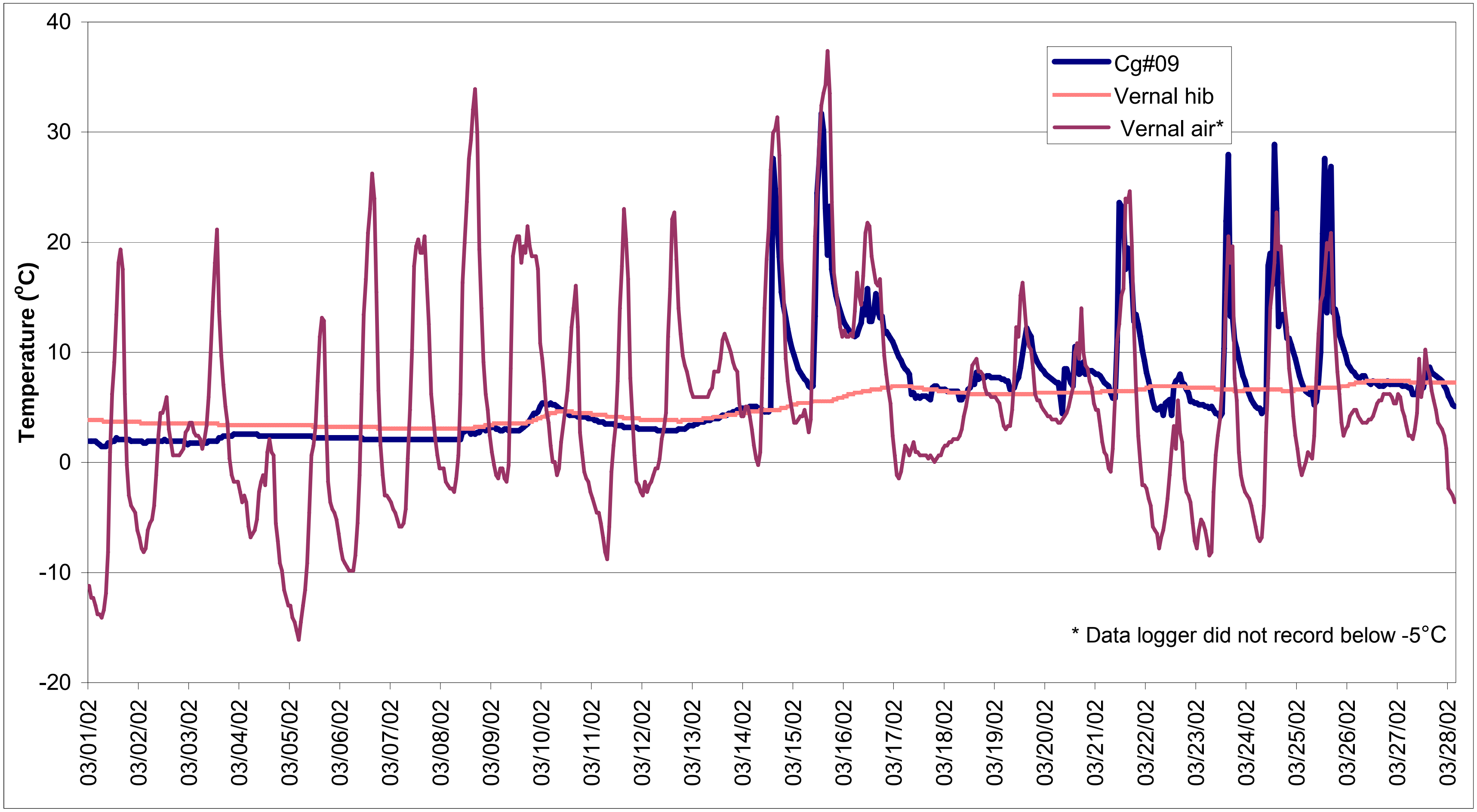

FIGURE 7.7. CG#09, HIBERNACULUM AND AIR TEMPERATURES FOR MARCH 2002.

Combined Accounts of Spotted Turtles:

Comparisons of all Spotted Turtles and hibernacula by month from November through February can be seen in Appendix VII. Spotted Turtles reached their coldest over-wintering temperatures during different months. The coldest temperature experienced by Cg#05, Cg#07, and Cg#09 was in January, February, and March, respectively (Table 7.2). The warmest over-wintering temperature for all Spotted Turtles occurred in March and was the time they all emerged from their hibernacula (Table 7.3, Figure 7.2). 14 March was the first day of spring that all 3 turtles basked at the same time. Basking by all 3 turtles on the same day in March occurred 5 times. Cg#05 and Cg#07 basked on same days 7 times. Cg#07 and Cg#09 basked on the same day 10 times. Cg#05 and Cg#09 never basked together on days that Cg#07 didn't bask. On 21 March 2005, Cg#05's temperature exceeded the other turtles' maximum temperatures. On 23 March and 29 March, Cg#09's temperatures exceeded the other turtles. Every other time, Cg#07 was the warmest.

Wood Turtle Temperatures:

Although both species were active periodically throughout the year, activity season was considered to be the time turtles emerged from hibernation in the spring until they retreated to the stream in the fall. The activity season of *G. insculpta* was defined as when they were mainly terrestrial and the over-wintering season was described as when they returned to the stream for the aquatic part of their life history. Female Gi#03 was observed basking on the bank of the stream on 19 March 2001. Although other *G. insculpta* found were still in the stream at that time, this was the beginning of the activity period. *Glyptemys insculpta* had begun to return to the stream by 15 September 2001, so this was when I considered over-wintering season to begin.

Although Wood Turtles were not tracked daily from fall 2001 through 2002, temperature readings of the data loggers made it possible to determine when turtles were on land or in water for extended periods of time. Figure 7.8 compared external temperatures of Wood Turtles to habitat type that each turtle was observed using. When turtles were on land the temperature fluctuated widely and peaked when turtles were basking. When turtles basked, their temperatures often rose above the daily maximum temperature of the weather station or air temperature data loggers. All turtles usually basked before they entered the water.

When turtles were in water the daily temperature fluctuation was significantly less than the air temperature fluctuation recorded at the weather station or by air temperature data loggers. In months turtles were in the stream, their temperatures conformed to the stream and hibernaculum temperatures.

Average daily mean, minimum, maximum, and average daily difference in maximum / minimum temperature per day of Wood Turtles can be seen in Tables 7.1-7.4. Comparison of the Wood Turtle temperature and hibernaculum by

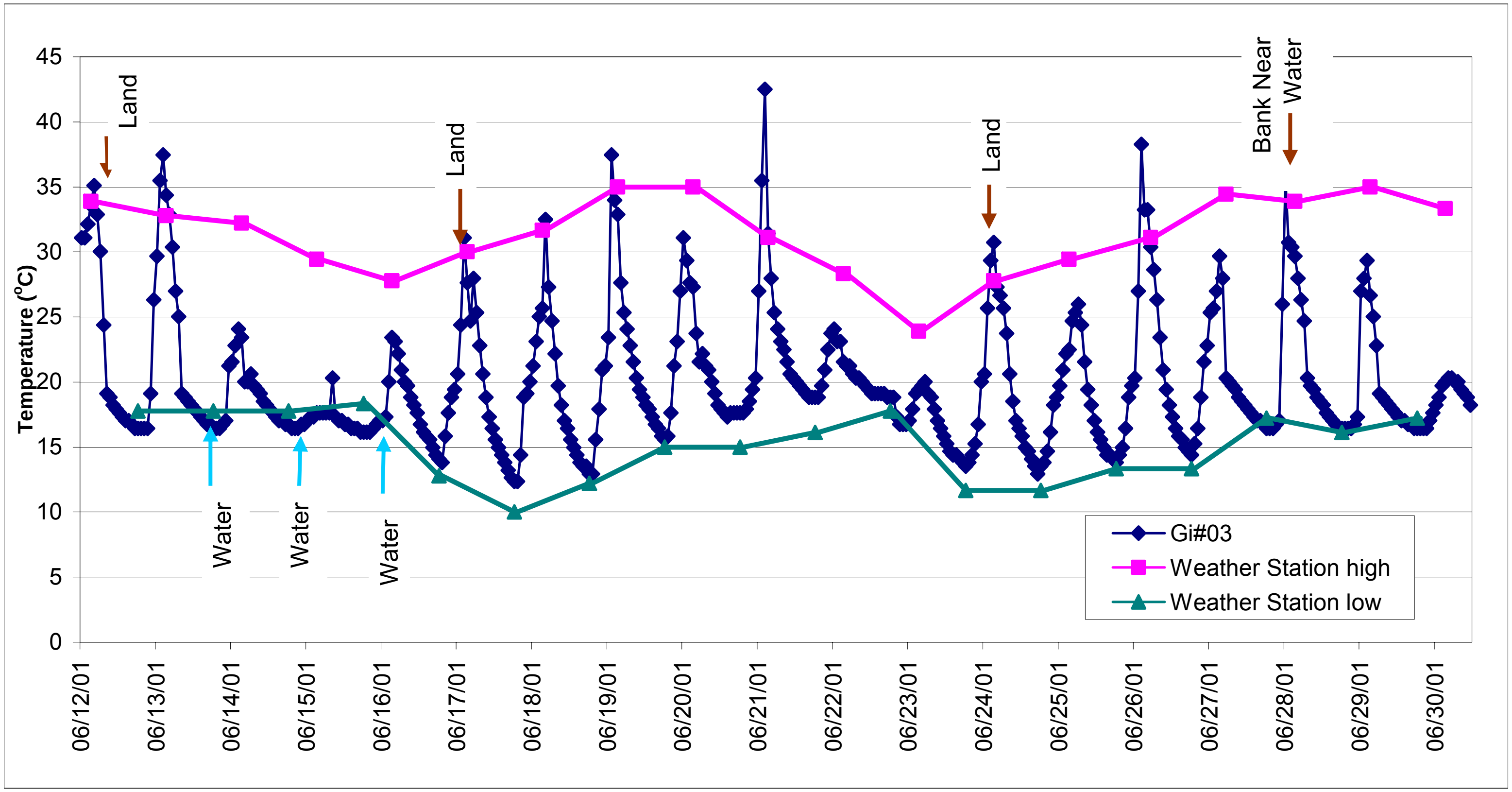

FIGURE 7.8. COMPARISON OF EXTERNAL WOOD TURTLE TEMPERATURES TO HABITAT TYPE OBSERVED USING.

month from October to March is represented in Figures 7.9-7.14. See the individual turtle descriptions for a detailed account of their thermal ecology.

Gi#03:

From July 2001 through June 2002, the lowest temperature Gi#03 experienced was 1.7°C on 22 May 2002 at 0500 and 0600 hrs. Between 0700 and 0800 hrs on that day, her external temperature rose from 1.94°C to 8.04°C. At that time, the stream was 8.58°C and air temperature was -0.67°C. Maximum external temperature this turtle experienced during the year was 44.4°C on 22 June 2002 at 1200 hrs. In her activity season months (July-September 2001, April-June 2002), her average daily mean temperature per month was between 14.2 – 21.8°C. Over-wintering means per month (October-March) were 6.8-11.8°C.

Detailed graphs of her thermal regime from 12 June 2001 through 30 June 2002 can be seen in Appendix VIII. Gi#03 migrated back into the stream in mid-September (Appendix VIII). This turtle spent noticeable amounts of time in the water from 17-19 September and from 22 September through the rest of the month. During October, she basked on 4-5th, 20th and 22-25th (Figure 7.9). The rest of the month her temperatures conformed to the stream temperatures. From November 2001 through March 2002, her temperature stayed fairly constant with the water temperature (Figure 7.10-7.14). November had 5 periods where her external temperature was higher than the stream temperature (2, 3, 8, 28, and 30 November). This also occurred on 1 and 24 December, with her temperature just 1 to 2°C warmer than the water temperature. Her temperature had no spikes

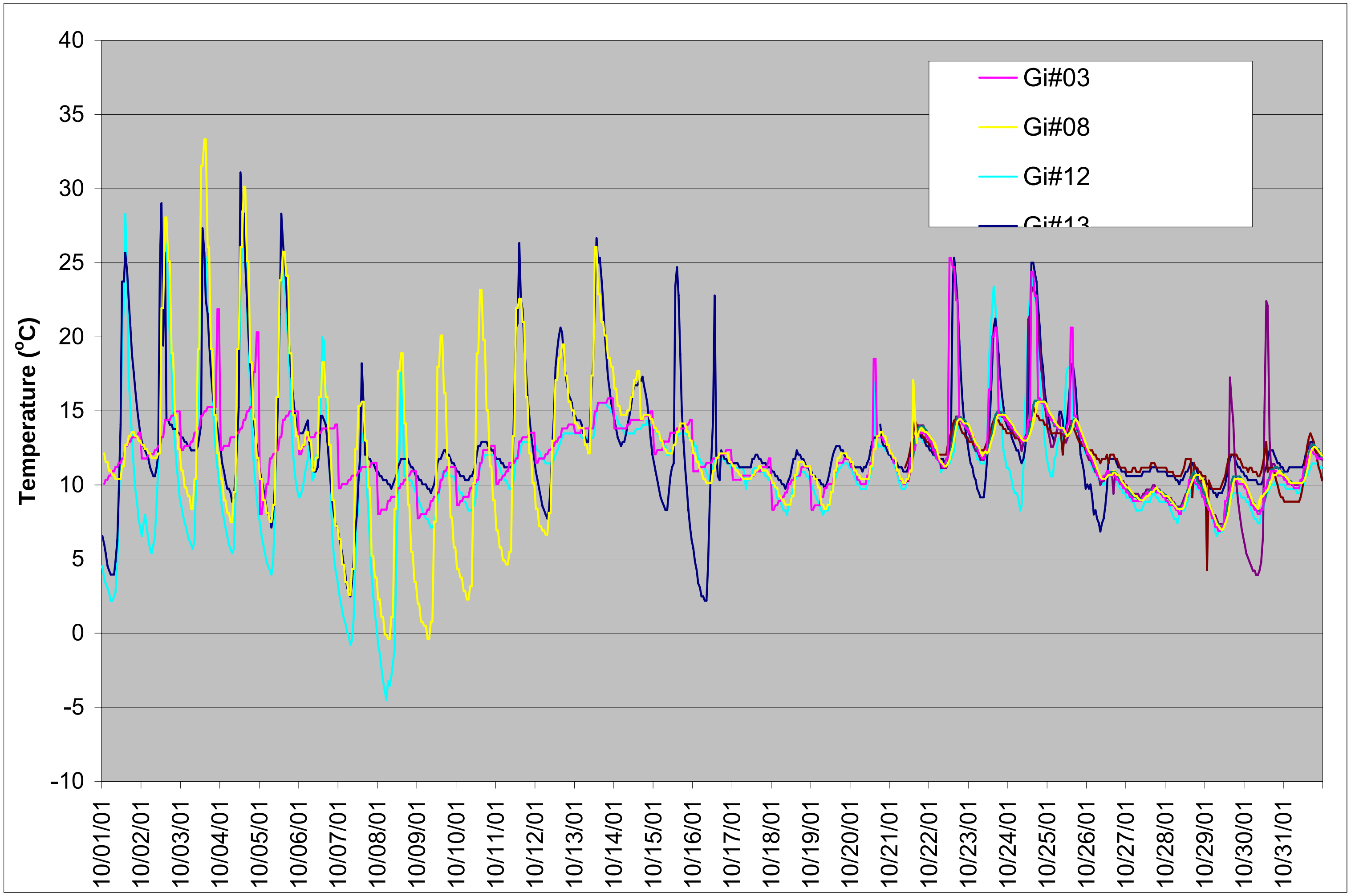

FIGURE 7.9. WOOD TURTLE AND HIBERNACULUM TEMPERATURES FOR OCTOBER 2001.

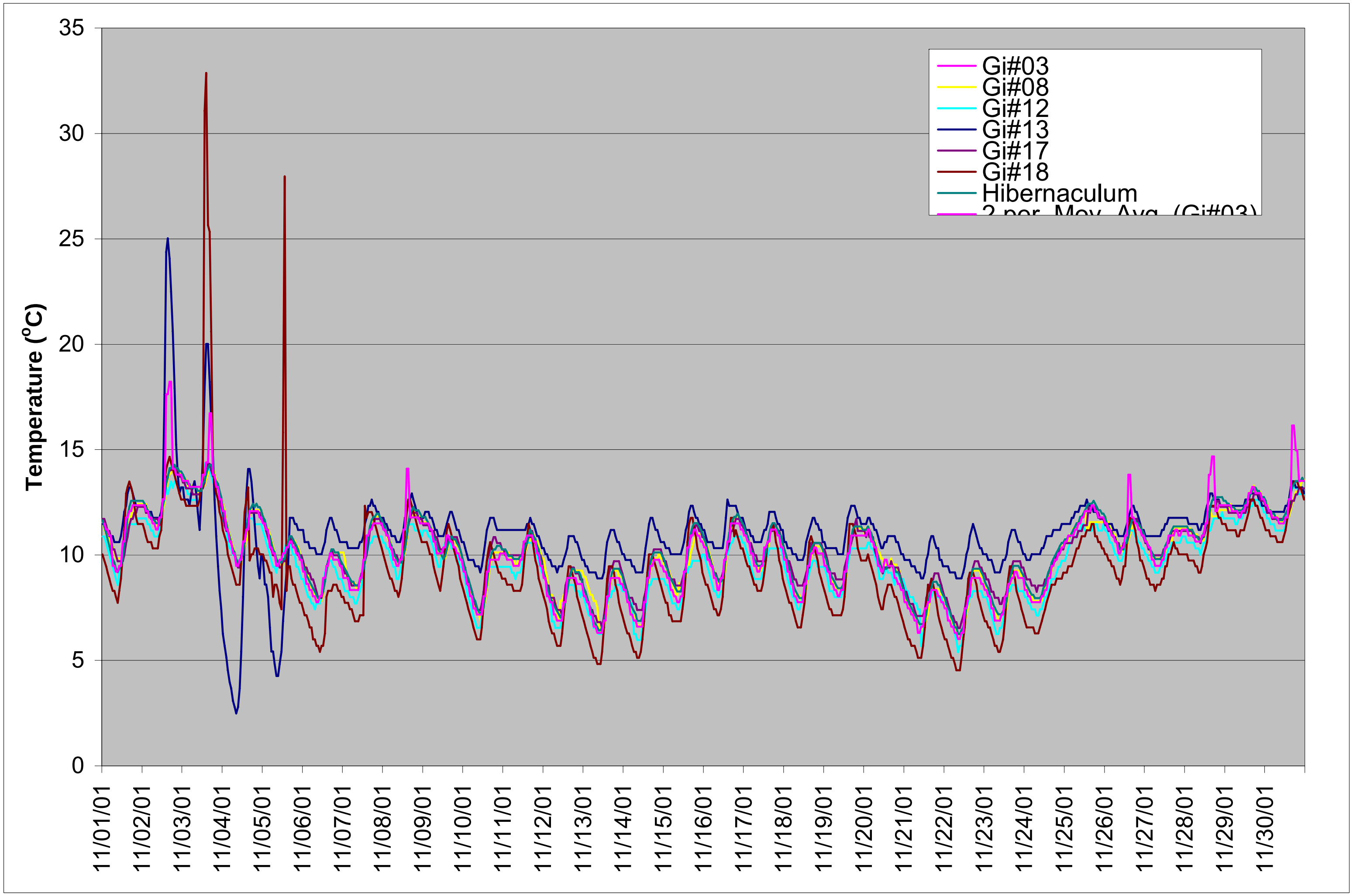

FIGURE 7.10. WOOD TURTLE AND HIBERNACULUM TEMPERATURES FOR NOVEMBER 2001.

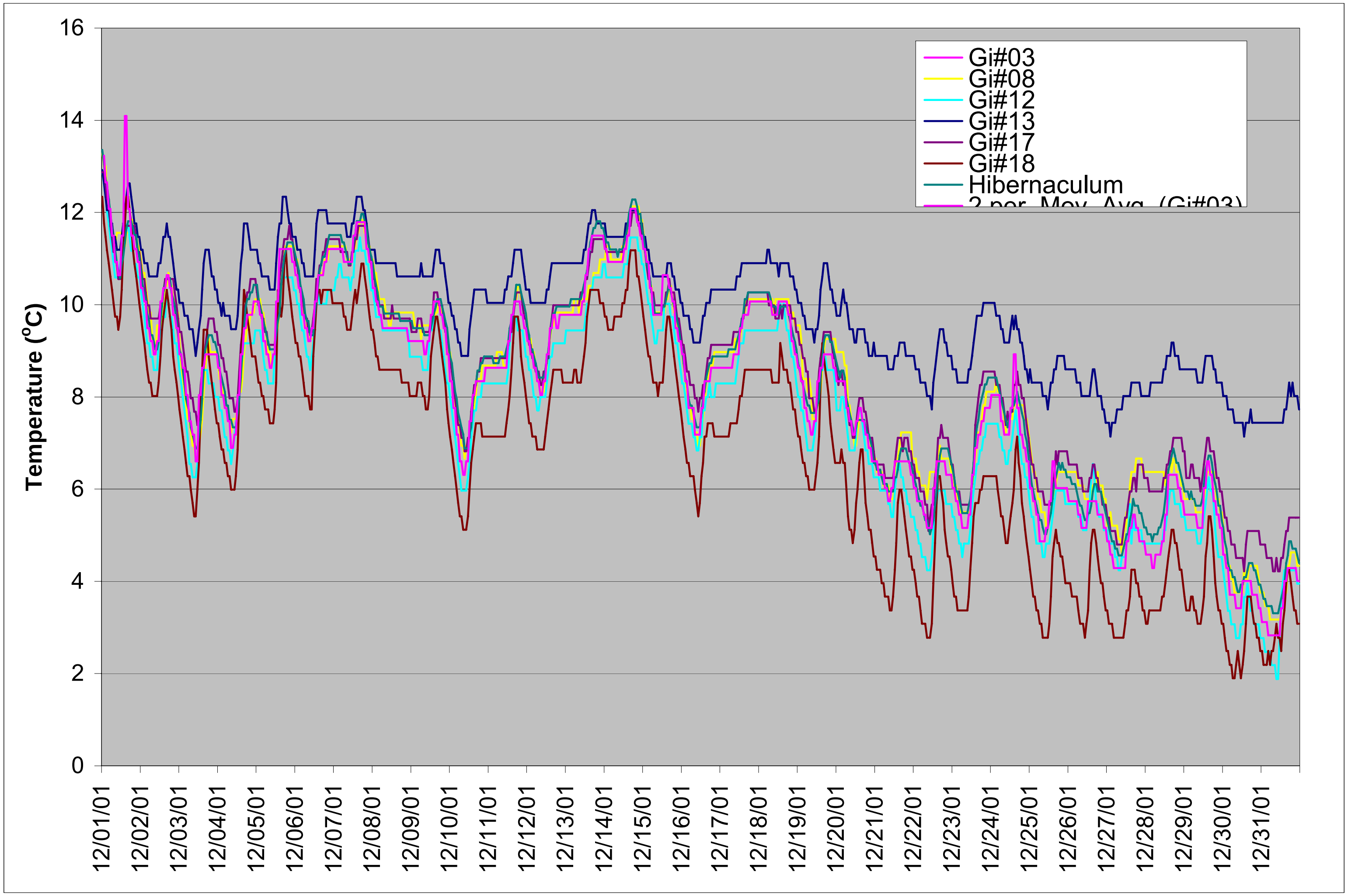

FIGURE 7.11. WOOD TURTLE AND HIBERNACULUM TEMPERATURES FOR DECEMBER 2001.

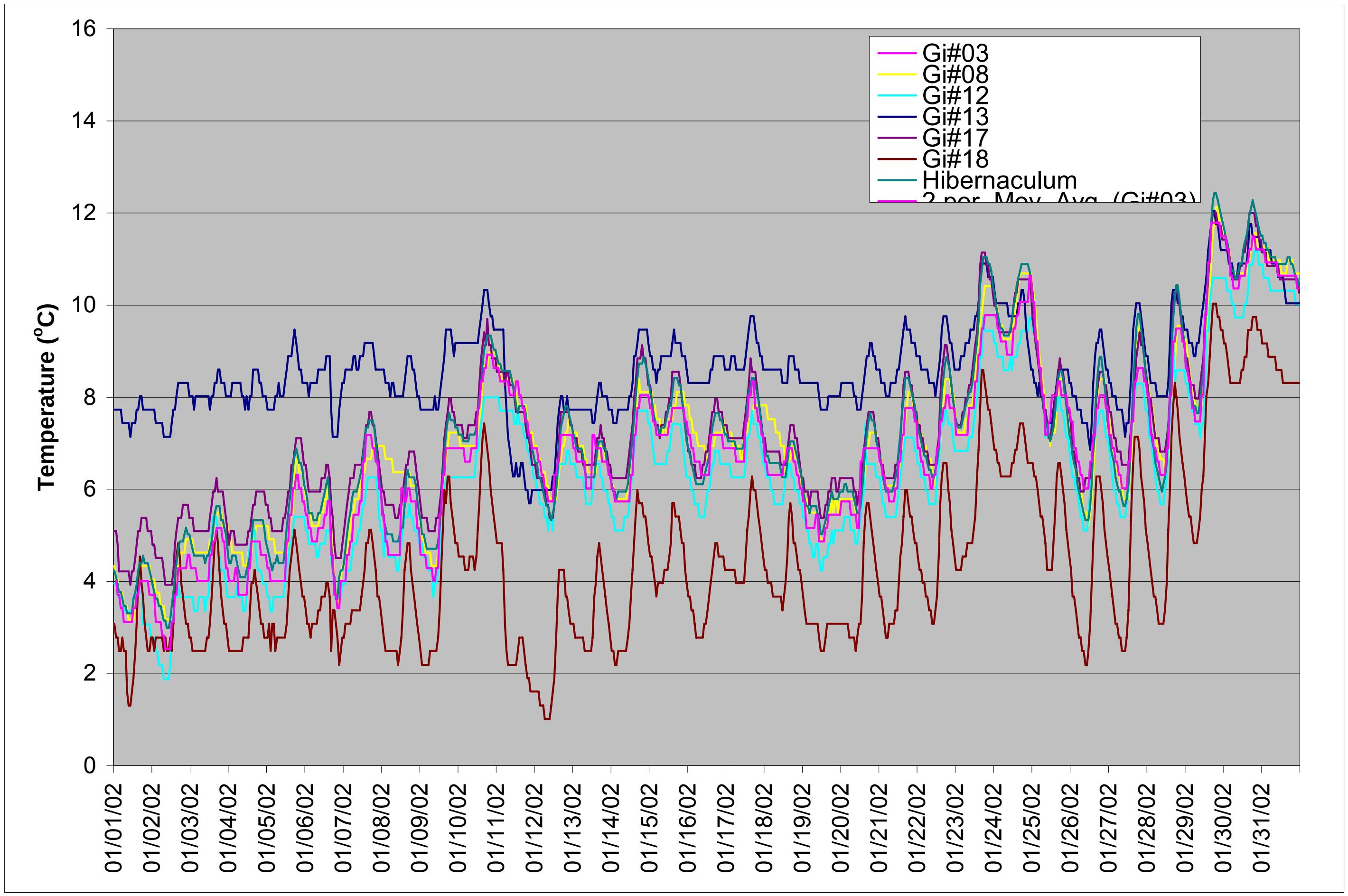

FIGURE 7.12. WOOD TURTLE AND HIBERNACULUM TEMPERATURES FOR JANUARY 2002.

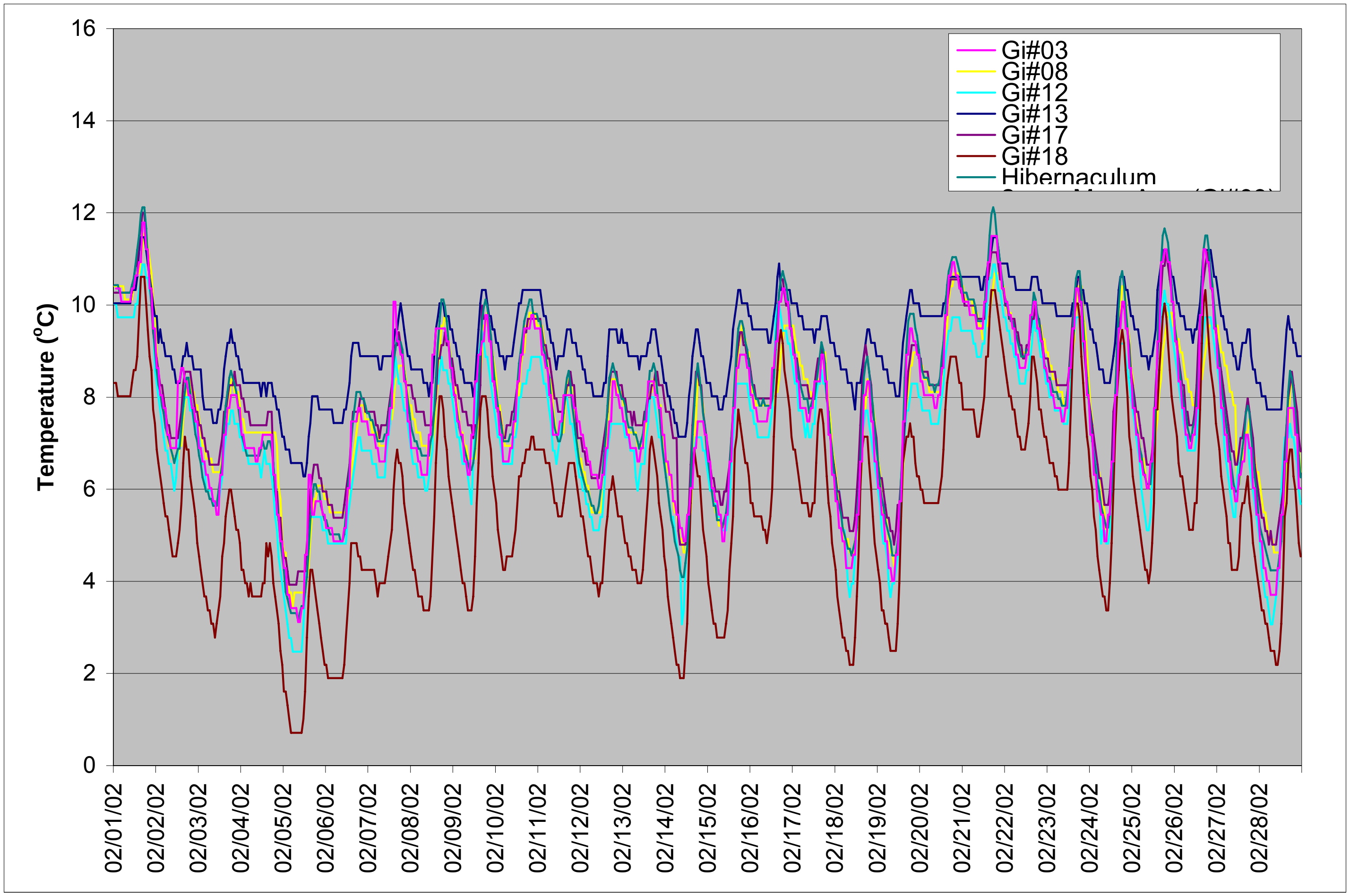

FIGURE 7.13. WOOD TURTLE AND HIBERNACULUM TEMPERATURES FOR FEBRUARY 2002.

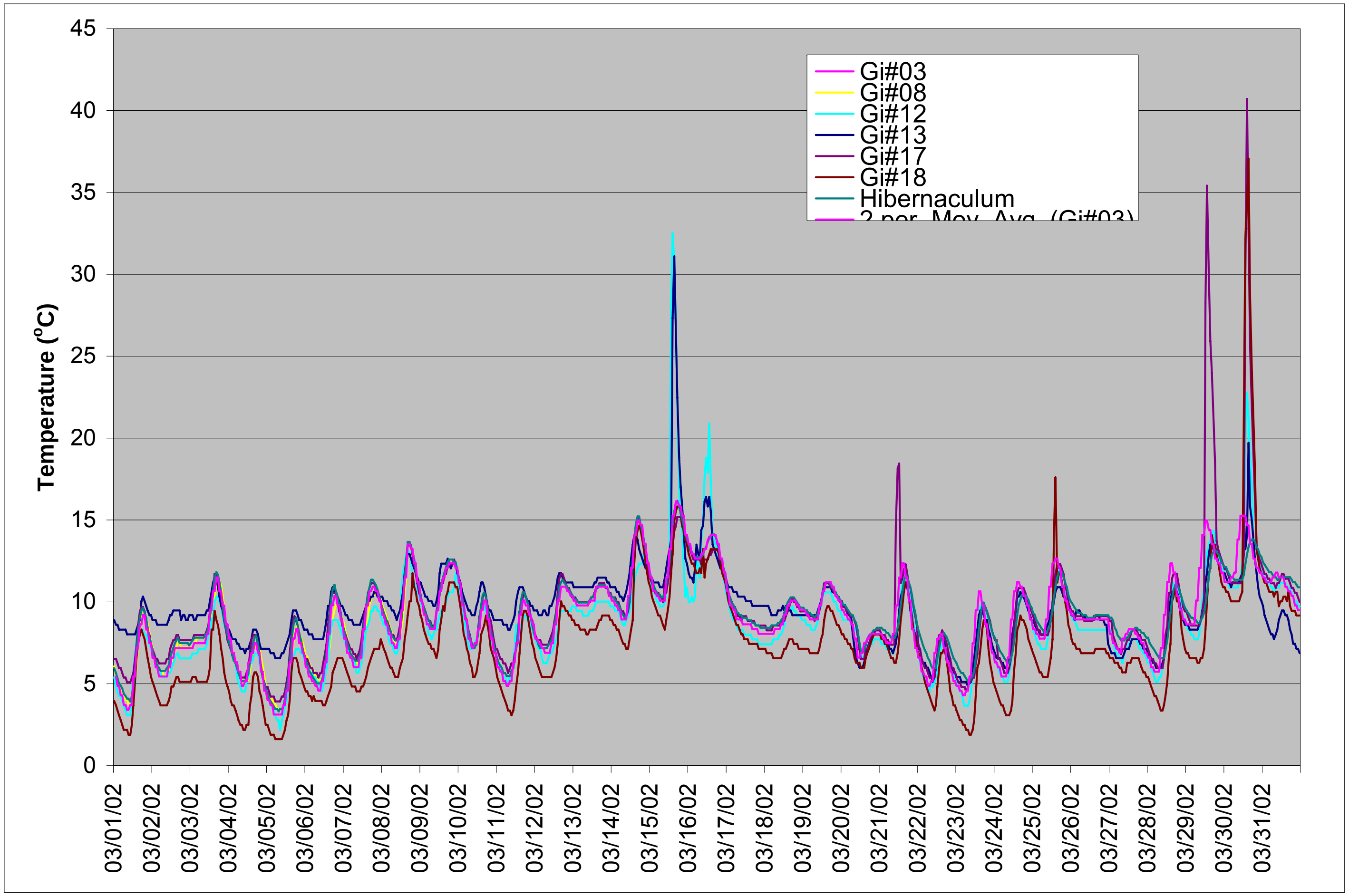

FIGURE 7.14. WOOD TURTLE AND HIBERNACULUM TEMPERATURES FOR MARCH 2002.

above stream temperature in January through the end of March 2002. She remained in the water until 8 April, when her maximum temperature for the day was 5°C above the hibernaculum temperature (Appendix VIII). She alternated basking and being in the water throughout the rest of the month. In May and June, her external temperatures had large fluctuations daily.

Gi#08:

The lowest temperature Gi#08 experienced was -0.4°C at 0600 hours on 8 and 9 October 2001. On those days the lowest recorded air temperature at the weather station was -3.3 and -5.0°C, respectively. Maximum external temperature this turtle experienced during the year was 39.2°C on 20 July 2001 at noon. Air temperature at the weather station that day reached a maximum temperature of 29.4°C. In her activity season months (July-September 2001) her average daily mean temperature per month was between 16.7–22.1°C. Over-wintering means per month (October-February) were 7.0-12.0°C.

Detailed graphs of her thermal regime from 13 June 2001 through 28 February 2002 can be seen in Appendix IX. She was in water from 11-13 September (Appendix IX). She returned to the water again on 22 September and remained there through 2 October. Then Gi#08 spent almost half of October (3 – 14) on land (Figure 7.9). Cold temperature did not trigger her to return to water. She remained on land even when her minimum daily temperature dropped to –0.4°C on 8 and 9 October. She entered the water on 14 October and remained there for the rest of the month, with the exception of one basking period on 21 October. Her temperatures conformed to hibernaculum temperatures from

November through 8 March (her data logger stopped functioning on that date), with no noticeable periods of emergence during that time (Figures 7.10-7.14).

Gi#12:

Lowest temperature Gi#12 experienced was -4.5°C on 8 October 2001 at 0500 hrs. Maximum external temperature this turtle experienced during the year was 42.6°C on 10 April 2002 at 1200 hrs. In her activity season months (April-June 2002), her average daily mean temperature per month was between 13.8–21.1°C. Over-wintering means per month (October-March) were 6.3-11.1°C.

Summer temperatures are not known for this turtle due to data logger malfunction. Detailed graphs of her thermal regime from 16 September 2001 through 30 June 2002 can be seen in Appendix X. This turtle retreated to the stream in October (Figure 7.9). Gi#12 was on land until 9 October when her minimum daily temperature dropped to -4.5°C and triggered her to enter the water. She stayed in the stream for most of the rest of month, except 20 and 23-25 October when she basked. From November through mid-March, there were no basking periods (Figures 7.10-7.14). She basked on 3 dates in March (15^{th}, 16^{th}, and 30^{th}). On 15 March, her external temperature reached a high of 32.5°C. She had 3 more basking periods in the first half of April. From 14 April to the end of the study on 30 June, her temperature fluctuated daily with the air temperature.

Gi#13:

The lowest temperature Gi#13 experienced was 2.2°C on 16 October 2001 at 0700 and 0800 hrs. Maximum external temperature this turtle experienced during the year was 42.6°C on 23 May 2002 at 1300 hrs. During activity season months (July-September 2001, April-June 2002) her average daily mean temperature per month was between 14.3-21.6°C. Over-wintering means per month (October-March) were 8.6-12.6°C.

Detailed graphs of her thermal regime from 14 June 2001 through 30 June 2002 can be seen in Appendix XI. Gi#13 returned to the water twice, after cold spells when her external temperature dropped to 2.5°C (7 October) and 2.2°C (16 October) (Figure 7.9). On 26 October, her temperature dropped to 6.8°C, after which she promptly entered the water without basking and remained there for the rest of the month. However, at the beginning of the month she stayed on land when the temperature was 4°C. Gi#13's temperature spiked and dipped from 2 to 5 November (Figure 7.10). On 2 and 3 November, her temperature rose to 25.0 and 20.0°C, respectively. At this time, the hibernaculum high was 14.3°C. Low temperatures on 4 and 5 November were 2.5 and 4.3°C, respectively. From 6 November 2001 through 14 March 2002 there were no temperature spikes (Figures 7.10-7.14). Her temperature had similar fluctuations to the hibernaculum in this time period, but she was consistently warmer than the hibernaculum. She hibernated in an old beaver dam approximately 120m from where the hibernaculum temperature was recorded. The first day her temperature indicated she basked was on 15 March. High for that day was 31.2°C. Her temperature rose briefly on 16 and 30 March. She emerged again on 10 April and basked most days the remainder of the month. In May and June she basked daily.

Gi#17:

The lowest temperature Gi#17 experienced was 2.5°C on 24 April 2002 from 0500 to 0600 hrs. Maximum external temperature this turtle experienced during the year was 42.9°C on 1 May 2002 at 1300 hrs. During activity season months (April-September 2002) his average daily mean temperature per month was between 14.4 – 21.6°C. Over-wintering means per month (November-March) were 7.3-10.2°C.

Detailed graphs of his thermal regime from 22 October 2001 through 12 October 2002 can be seen in Appendix XII. From 22-31 October, Gi#17 appeared to spend much of his time in the water (Figure 7.9). He emerged on 24-25 October where his temperature rose to 23.4°C. He emerged again from 29 to 30 October, where his temperatures fluctuated wildly from highs of 17.3°C and 22.1°C and a low of 3.9°C. His temperature conformed to hibernaculum temperature from 30 October 2001 through 20 March 2002 (Figures 7.9-7.14). His first basking period for 2002 occurred on 21 March when his temperature was elevated for 3 hours and peaked at 18.4°C. He basked again on 29 and 30 March, with his maximum external temperature reaching 35.4 and 40.7°C, respectively. He remained in the water during the first week of April. He emerged again on 8 April where he reached a temperature of 37°C. After this date he basked almost daily throughout the rest of the April, May, and June. From 13 to 15 July, his temperature conformed to water temperature and it fluctuated wildly the rest of the month. This turtle basked daily during August until he returned to the water for 3 days from 28 to 30 August. In September, he alternated between land and the water, but did not spend more than a day or 2 in the water at a time. In October his temperature was similar to water temperature approximately every other day until 6 October when he started spending longer amounts of time submerged. The last day of the study, 12 October, his temperature was still alternating between water and air temperatures.

Gi#18:

The lowest temperature Gi#18 experienced was 0.7°C on 5 February 2002 from 0400 to 1000 hrs. Maximum external temperature this turtle experienced during the year was 43.0°C on 15 May 2002 at 1500 hrs. During activity season months (April-September 2002) his average daily mean temperature per month was between 14.4–22.9°C. Over-wintering means per month (November-March) were 4.4-9.3°C.

Detailed graphs of his thermal regime from 22 October 2001 through 12 October 2002 can be seen in Appendix XIII. For the last 10 days of October, Gi#18's temperature conformed to the hibernaculum temperature most of the time (Figure 7.9). On 3 occasions (25, 28, and 29 October) his temperature dropped for 1 hour between 1.5-6°C. Gi#18 had 2 large temperature spikes on 3 and 5 November, reaching 32.9 and 28.0°C, respectively. From 6 November 2001 through 24 March 2002 there were no noticeable temperature spikes or drops and his temperature conformed to that of the stream (Figures 7.10-7.14). His temperature was consistently approximately 2-4°C cooler than the hibernaculum temperature throughout the winter months (the hibernaculum where temperature was recorded was not the one in which he resided). This turtle resumed basking on 25 and 30 March where his temperatures reached 17.6 and 37.1°C, respectively. He basked frequently in April with a few periods in the water, the longest being 3 to 7 April. In May and June, he basked daily. On 25 July he had a sharp drop in temperature where it plunged from 23.4 to 17.3°C within a few hours and conformed with the water temperature until 29 July. Mid and late August he again returned to the water for a significant period of time. He stayed in the water until 2 September and basked frequently through the rest of the month. His last significant basking event was on 6 October. His temperature fluctuated between air and water temperatures until the study ended on 12 October.

Combined Accounts of Wood Turtles:

Fall migration of Wood Turtles to the stream occurred in September and October. Wood Turtles had periods of emergence from the stream during September and October. They were observed active on the stream bottom in late December and early March. From November through March, all Wood Turtles were found underwater. Only 1 had minor temperature spikes in December, but she probably did not emerge from the water at that time. General emergence of Wood Turtles from the stream occurred from 15 March through 8 April.

From November through March, Gi#18 had the coldest average temperature of the Wood Turtles studied. After that, he had the highest average mean temperature in April, and June through September and second highest in May 2002. This turtle's range was the farthest upstream (south) of any of the turtles radio-tracked. Gi#13 had the highest mean temperature of the Wood Turtles from November through March. Her hibernaculum was closest to Gi#18 of all the turtles radio tracked.

Extreme lowest temperatures for all Wood Turtles were recorded in the morning hours between 0400 and 1000 hrs, with the coldest usually being between 0500 and 0800 hrs. Lowest temperature recorded for any Wood Turtle was -4.5°C. Half (n = 3) of the lowest temperatures were recorded in October before the turtles entered the stream for the winter. One male turtle's lowest temperature was in mid-winter (5 February 2002). A male and female had their lowest temperatures in the spring (24 April and 22 May 2002, respectively). The males were first captured on 20 October 2001, which was after the extreme lows of 3 females, so it is unknown if their coldest temperatures were in the same time period in the fall.

All but one extreme maximum was recorded between 1200 and 1300 hours. One temperature maximum was recorded at 1500 hrs. Three of the extreme maximum temperatures were recorded in May 2002 (2 males, 1 female). The 3 remaining females had their highest temperature in July 2001, April 2002, and June 2002, respectively.

Spotted vs. Wood Turtles:

Spotted Turtles had cooler average over-wintering temperatures than Wood Turtles (Table 7.1). From December through March, mean temperatures of individual Spotted Turtles ranged from 2.9-7.7°C. Mean Wood Turtle temperatures ranged from 4.4-9.9°C. Minimum temperature for Spotted Turtles was cooler than Wood turtles by 0.7°C in December, 1.4°C in January, 2.5°C in February, and 1.2°C in March. Compared to Spotted Turtles, Wood Turtle maximum temperature was 3.1°C warmer in December, 10.7°C cooler in January, 2.4°C cooler in February, and 4.4°C warmer in March.

Spotted Turtles emerged from hibernacula earlier than Wood Turtles. Two of the Spotted Turtles emerged on 8 and 10 March, while the third one remained active throughout the winter. The earliest Wood Turtle emergence was 15 March and latest was 8 April.

DISCUSSION

Analysis of temperatures recorded on data loggers allowed me to determine aquatic versus terrestrial habitat use for periods when telemetry locations were not taken. Temperature data loggers showed the date and time turtles returned to the stream and the duration of their stay. Movements from land to water were occasionally triggered by extremes in either hot or cold temperature. Data loggers were also used in other studies to determine periods turtles were in hibernacula or basking (Litzgus et al. 1999). Studies have been conducted to determine the extremes in temperature turtles can endure (Hutchison et al. 1966). Data recorded in this study demonstrated what temperatures turtles were actually exposed to in the wild and showed what thermoregulating they did to control their temperature. Body temperatures closely correlate with water and substrate temperatures that surround them (Hutchison 1979).

Spotted Turtles:

Spotted Turtle temperatures recorded in this study do not necessarily indicate the coldest temperatures these turtles may experience because their data loggers were not attached until they entered their hibernaculum. Once they were in their hibernaculum, both Spotted and Wood Turtle temperatures remained roughly constant. Spotted Turtle temperatures had similar patterns to hibernaculum temperatures and were protected from the extreme fluctuations of air temperatures throughout the winter. Wood Turtles experienced their coldest temperatures during the transition months between their activity period and over-wintering period (October, April, May). This may also be true for Spotted Turtles, whose temperatures began fluctuating wildly after they emerged from their hibernacula. Further studies of their thermal ecology need to be conducted throughout the year to determine the extremes they experience.

When Spotted Turtles bask their temperatures can be significantly greater than air and water temperatures (Haxton and Berrill 2001). In Ontario, Spotted Turtles became active in April when the average daily water temperature was 7-9.2°C and average daily air temperature was 4.2-7°C (Haxton and Berrill 2001). The only movement of a Spotted Turtle over winter was during a January thaw when air temperature reached a maximum of 10°C (Haxton and Berrill 2001). That turtle reentered the hibernacula and did not move again throughout the winter. In general, activity of Spotted Turtles was from mid-April to late October (Haxton and Berrill 2001). Turtles in another Ontario study entered hibernacula in September or October and emerged in mid to late April (Litzgus et al. 1999). Their body temperatures when they entered hibernacula were between 12-16°C.

Similar to my study, 1 Spotted Turtle in Ontario had a data logger attached to its carapace over winter (Litzgus et al. 1999). This turtle's temperatures were stable throughout the winter, ranging from 0.3 to 3.9°C. The lowest temperatures were from the end of February through early April. This turtle began basking the second week of April.

In a Pennsylvania population, *C. guttata* were active at water temperatures of 8.5-32°C (Ernst 1976). Foraging occurred at a minimum of 14.2°C (Ernst 1976). In a population in Massachusetts, turtles were still active as late as 10 November swimming under ice near their hibernaculum (Milam and Melvin 2001). Mean critical thermal maxima for *C. guttata* was 41.98°C (Hutchison et al. 1966).

Near the northern limit of the range in Ontario, Spotted Turtles were active from mid to late April through late October and early November (Haxton and Berrill 1999, Litzgus et al. 1999, Haxton and Berrill 2001). In Pennsylvania, turtles remained active throughout most of the year except February, October and November (Ernst 1976).

Wood Turtles:

In Pennsylvania, Wood Turtles were able to withstand warm temperatures better and were more active on land during the day than *C. guttata* and *G. muhlenbergii* (Ernst 1986) and they basked more frequently than Wood Turtles

(Ernst 1986). Wood Turtles' body temperatures closely correlate with water and substrate temperatures that surround them (Ernst 1986, Hutchison 1979, Farrell and Graham 1991, Ross et al. 1991, Tuttle 1996), so the temperatures I recorded externally were very similar to their actual body temperature when they were submerged or dug in. Basking temperatures in my study greatly exceeded air temperatures, as has been seen in other studies (Farrell and Graham 1991).

Mean critical thermal maxima was 41.3°C for *G. insculpta* (Hutchison et al. 1966). Maximum external temperature recorded in this study was 44.4°C, but that does not necessarily indicate the actual temperature of the turtle. Those extreme temperatures may be an artifact of attaching a dark probe externally or just a small beam of sunlight might had hit the sensor where the turtle was resting and caused the data logger to heat faster than the turtle that has a larger mass. Nutting and Graham (1993) found that the mean preferred body temperature of Wood Turtles was 27.5±0.13°C.

In another West Virginia study, Wood Turtles over wintered from October through March in a pool in the river in water temperatures 2-9°C (Niederberger and Seidel 1999). Radio-tracked turtles in that study were found in water 1-14°C. In my West Virginia population, water temperature from November through March ranged between 2.8-16.4°C. Coldest temperature noted was a pair mating in January in water 1°C (Niederberger and Seidel 1999). Coldest temperature experienced by New Jersey turtles was 0.0°C (Farrell and Graham 1991). From November through March, the coldest temperature experienced by a Wood Turtle in my study was 0.7°C, although the extreme coldest temperature (-4.5°C) occurred during October. In New Jersey, inactive Wood Turtles had mean cloacal temperatures of 9.5°C and active turtles had mean temperatures of 16.2°C (Farrell and Graham 1991).

Niederberger and Seidel (1999) reported that the latest a Wood Turtle was observed out of the water was 23 October and earliest emergence was early March. Turtles in my study basked occasionally through 6 November, and 1 female had temperature spikes until 24 December. In southeastern Pennsylvania, Wood Turtles were active all months except December through February (Ernst 2001). In that population, earliest terrestrial activity was 11 March and latest was 28 November. In central Pennsylvania, Wood Turtles were inactive from late October or November until late March or early April (Kaufmann 1992). Latest a New Hampshire *G. insculpta* was reported basking was 11 November on the bank of the stream (Tuttle 1996). Harding and Bloomer (1979) found that due to longer winters, Wood Turtles in northern Michigan entered hibernation earlier and emerged in the spring later than a more southern population from New Jersey. Michigan turtles became inactive between late September and mid-October (Harding and Bloomer 1979). From mid-May through early October, New Jersey Wood Turtles were terrestrial (Farrell and Graham 1991).

CHAPTER 8

Abnormalities, Injuries, Illnesses and Ectoparasites

INTRODUCTION

Shell abnormalities are occasionally found in Spotted Turtles (Ernst 1976) and Wood Turtles (Harding and Bloomer 1979**,** Brooks et al. 1992, Tuttle 1996, Ernst 2001). Incidents of atypical scute arrangements and shell growth of these turtles in West Virginia have not previously been published.

Predation is becoming an increasing problem as people alter the environment and make it more beneficial to turtle predators such as raccoons and skunks (Harding and Bloomer 1979). Injuries to *C. guttata* (Ernst 1976, Belmore 1980) and *G. insculpta* have been reported in Michigan (Harding and Bloomer 1979), New Hampshire (Tuttle 1996), New Jersey (Farrell and Graham 1991), and Pennsylvania (Ernst 2001).

The occurrence of leeches on Wood Turtles has been well documented. Locations observed include New Hampshire (Tuttle 1996), New York (Koffler et al. 1978), New Jersey (Koffler et al. 1978, Harding and Bloomer 1979, Farrell and Graham 1991), Pennsylvania (Hulse and Routman 1982, Ernst 2001), Michigan (Harding and Bloomer 1979), Wisconsin (Brewster and Brewster 1986), Ontario (Siddall and Desser 1992), Quebec (Walde et al. 2003), and West Virginia (Niederberger and Seidel 1999). They have also been reported on Spotted Turtles (Ernst 1976, Ernst 2001, Belmore 1980). Blood-sucking flies have been reported on Wood Turtles (Harding and Bloomer 1979, Tuttle 1996).

The objective of this chapter is to discuss the presence of abnormalities, injuries, illnesses, and ectoparasites in a population of Spotted and Wood Turtles in West Virginia.

RESULTS

Spotted Turtle Scute Anomalies and Atypical Shell Growth:

Spotted and Wood Turtle carapaces normally have 1 cervical scute, 5 vertebral scutes down the midline, and 4 pleural scutes and 12 marginal scutes on each side (Figure 8.1). Anomalies were found in the scute array of some individuals of both species.

Atypical scute patterns were present on 3 of 21 Spotted Turtles (14.3%) (Table 8.1). Cg#03 had supernumerary marginals with 13 on each side. Dovetail syndrome, where the vertebrals are divided into extra scutes, was present in 2 *C. guttata*. Cg#06 had vertebral 4 divided into 3 scutes and vertebral 5 divided into 2 (8 vertebrals total). Cg#16 had the anterior left corner of vertebral 4 divided into a second scute (6 vertebrals total). None of the captured Spotted Turtles had atypical scute patterns on their plastrons.

Juvenile Spotted Turtle Cg#11 exhibited atypical shell growth, possibly caused by an injury. This turtle looked as if the carapacial scutes of right and left pleural 1 and parts of vertebral 1 and 2 had been removed and all that was visible was a black under layer. Gular and humeral scutes were absent on the plastron and all that remained was a discolored yellow area.

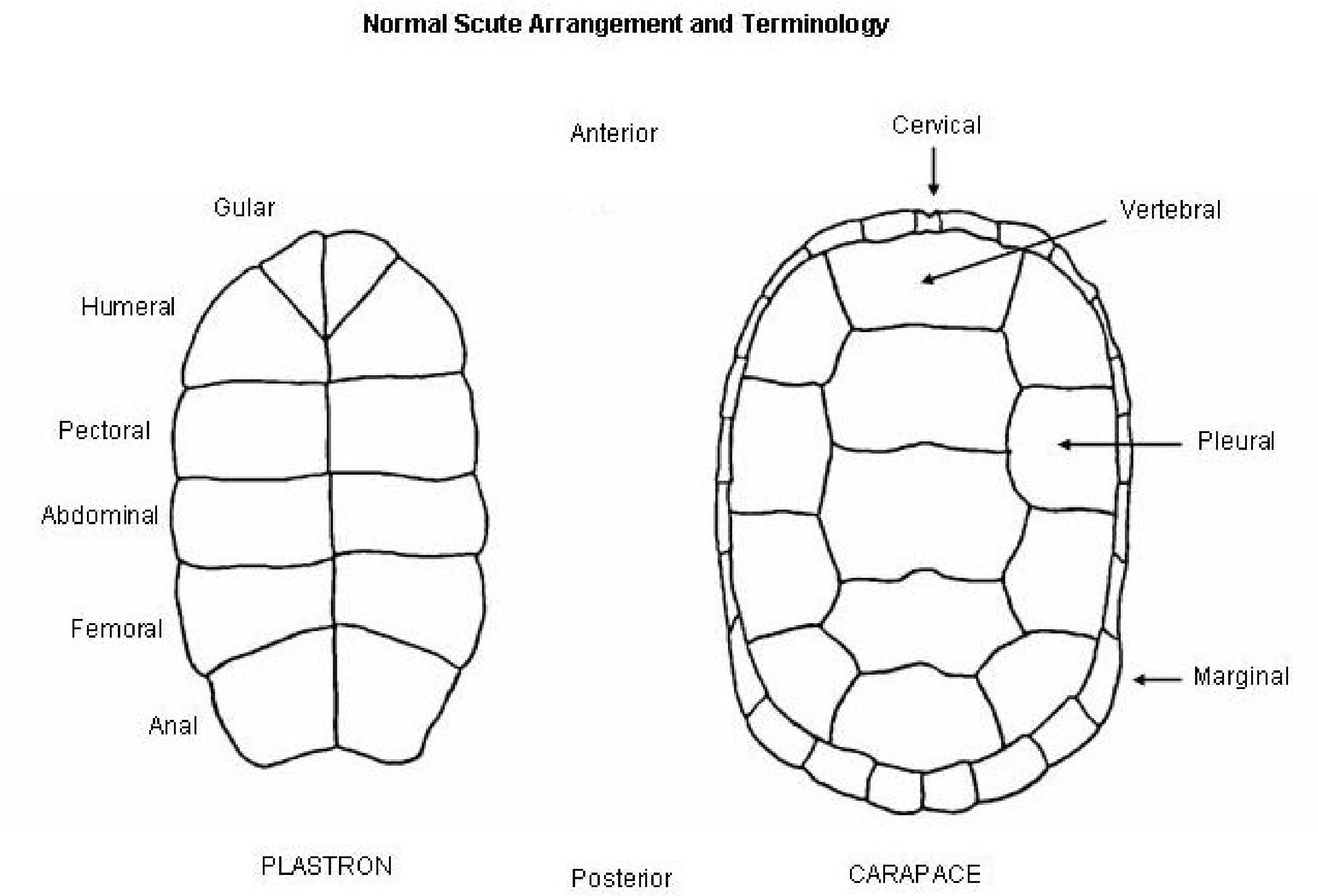

FIGURE 8.1. NORMAL SCUTE ARRANGEMENT AND TERMINOLOGY.

TABLE 8.1 . ATYPICAL SCUTE PATTERNS IN SPOTTED AND WOOD TURTLES

Spotted Turtle	**Dovetailed Ventrals**	**Supernumerary Pleurals**	**Supernumerary Marginals (L/R)**	**Less Marginals (L/R)**	**Atypical Bridge**	**Total # Turtles**
Normal	(5)	(4/4)	(12/12)			
Cg03			X (13/13)			1
Cg06	X (8)					1
Cg16	X (6)					1
Total	**2**	**0**	**1**	**0**	**0**	**3 (3/21)**
Percent Total	**9.5%**	**0.0%**	**4.8%**	**0.0%**	**0.0%**	**14.3%**

Wood Turtle	**Divided Ventrals**	**Supernumerary Pleurals**	**Supernumerary Marginals (L/R)**	**Less Marginals (L/R)**	**Atypical Bridge**	**Total # Turtles**
Normal	(5)	(4/4)	(12/12)			
Gi11				X (12/11)		1
Gi13			X (13/13)			1
Gi15					X (tiny extra)	1
Gi16	X (6)					1
Gi19	X (8)	X (5 Left)				1
Gi24	X (7)	X (5 Right)				1
Gi28			X (12/13)			1
Total	**3**	**2**	**2**	**1**	**1**	**7 (7/50)**
Percent Total	**6%**	**4%**	**4%**	**2%**	**2%**	**14%**

Wood Turtle Scute Anomalies and Atypical Shell Growth:

Seven out of 50 *G. insculpta* (14%) had atypical scute patterns (Table 8.1).

Dovetail Syndrome was present in 3 (6%) adult male Wood Turtles (Gi#16 had 6 vertebrals, Gi#19 had 8 vertebrals, and Gi#24 had 7 vertebrals). Gi#16 had a small 6th vertebral within the caudal end of the vertebral 5. Gi#19 had vertebrals 3, 4, and 5 divided into 5 scutes and vertebral 2 had a small extra scute on its left margin. Left pleural scute 1 was divided into 2 scutes and the inside right margin of the 1st right pleural was raised into a lump. Gi #24 had vertebral scutes 3 and 4 divided into 4 triangular shaped scutes, for a total of 7 vertebral scutes. This turtle also had 5 right pleural scutes, as number 4 was divided into two. Supernumerary pleural scutes were only found in these 2 turtles (4%).

Other scute anomalies were present on the marginal scutes and bridge. Two turtles (4%) had supernumerary marginal scutes. Adult female Gi#13 had 13 marginals on each side. Gi#28, a two-year-old, had 12 left marginals and 13 right marginals, with R12 divided into 2. Juvenile Gi#11 had less than the normal amount of scutes with 12 left and 11 right marginal scutes (2%). Juvenile Gi#15 had a bridge anomaly, which was a tiny extra scute on the right rear leg pocket by the base of marginal R7. No plastron anomalies were noted in Wood Turtles.

Atypical shell growth was found on 5 adult turtles (10%). In addition to his scute anomalies, adult male Gi#16 was kyphotic, which meant his shell appeared humped (Carr 1952). He had a very tall carapace where the margins of pleurals

1 and 2 and vertebral 2 on both the right and left sides were compressed in giving the shell a “pinched” triangular appearance. His carapace to dorsal-ventral height ratio was 191 mm: 74 mm. He also had a well-healed section of his beak missing. It is unclear whether these abnormalities were natural or came from an injury. Another adult male had a very tall, domed carapace. His CL to DVH ratio was 188mm to 73 mm. These 2 males had a DVH approximately 5mm higher than expected (see Figure 4.20).

There were 2 *G. insculpta* that had a flat, pancake like appearance to their carapaces. Male Gi#20 was 194 mm in carapace length and 66 mm in dorsal-ventral height which was approximately 5 mm less than expected (Figure 4.20). Female WT#44 had a carapace length of 188 mm and a dorsal-ventral height of 64 mm which was approximately 8mm less than expected (Figure 4.20).

Juvenile Gi#09 had very deep sutures on the left side of his carapace at the seams of costals 1 and 2 with marginals 4, 6, and 7.

Spotted Turtle Injuries and Markings:

Ten of 21 (47.6%) Spotted Turtles had injuries, ranging from small nicks in their carapace or plastron to missing appendages (Table 8.2). Six (28.6%) of the turtles had one-half a scute or tail or more of damage or were missing appendages.

One Spotted Turtle (4.8%), adult male Cg#07, was missing his left front foot. This turtle also had a stubbed tail and the carapace was mutilated by many chew marks on its marginal and pleural scutes. There was also a small puncture hole in its bridge and right femoral scute that appeared to have been made by canines of a mammal.

TABLE 8.2. SPOTTED TURTLE INJURIES AND MARKINGS

Turtle ID	Missing Appendages *	Missing Digits *	Tail Tip Missing	1/2 or More Tail Missing	Drill Holes	1/2 Scute or More Carapace Damage	Marginals Chipped or Chewed	Hole in Carapace	1/2 Scute or More Plastron Damage	Hole in Plastron	Hole in Bridge	Facial Injury	Abscess	Shell Rot	Other / Notes
Cg02							X								
Cg05			X			X				X				X	
Cg07	X (LF)			X		X	X	X		X	X				
Cg08		X (1 LF)													
Cg11			X			X			X						discolored p. & c.
Cg12		X (1 LF)													
Cg14		X (1 RF)													
Cg17								X							
Cg18		X (1 RR)													
Cg19						X	X							X	
Total	1	4	2	1	0	4	3	2	1	2	1	0	0	2	
% (of 21)	4.8	19.0	9.5	4.8	0.0	19.0	14.3	9.5	4.8	9.5	4.8	0.0	0.0	9.5	
Spotted Turtles with any damage													10 of 21		47.6%
Spotted Turtles with large amounts of damage (1/2 scute or tail or missing appendages)													6 of 21		28.6%

* LF = Left Front, RF = Right Front, LR = Left Rear, RR = Right Rear

Digits were lost on each of 4 Spotted Turtles (19.0%). Two of the turtles were missing toenails on their left front foot, 1 was missing a toenail on its right front foot, and a toenail was missing on the right rear foot of another turtle.

The tail tip was missing from 2 Spotted Turtles (9.5%) and half of the tail was amputated from another turtle (4.8%).

Large sections of damaged carapace (1/2 a scute or more or multiple marks) were observed on 4 Spotted Turtles (19.0%). Female Cg#05 exhibited that damage, which included a hole in her carapace. Cg#07 had extensive damage to his marginals, as well as a hole in his carapace, plastron and bridge. This characteristic was also was exhibited by juvenile Cg#11 whose plastral and carapacial discoloration has been discussed earlier. This turtle was the only one who also exhibited one-half a scute or more of plastron damage. Cg#19 had large chew marks on her marginal scutes.

Chips or chew marks on the marginal scutes were observed on 3 turtles, Cg#02, Cg#07, and Cg#19 (14.3%). Holes in the carapace were observed on turtles Cg# 07 and Cg#17. Cg#05 and Cg#07each had a hole in their plastron (9.5%). Cg#07 also had a hole in his bridge.

Shell rot was observed on 2 Spotted Turtles (9.5%). The rot was noticed on radio tracked female Cg#05 on 18 August 2001 when her transmitter was removed for replacement. The rotten scute was marginal R12 and had a foul odor. The transmitter did not overlay this scute so it was probably not the source of infection. I dug away the rotten tissue, which was black and soft, with a pocketknife. The scute was empty with the bone visible underneath. On 13

September 2001, the turtle was found with 15 ants on her carapace, but she seemed to be in good health and there was no noticeable odor. When revisited on 20 October 2001, the scute had healed. Adult female Cg#19 was captured on 30 March 2002 who also had shell rot on her carapace.

Wood Turtle Injuries / Markings:

Of 50 Wood Turtles found during this study, 32 individuals or 64%, had some amount of damage to their body (Table 8.3). Thirteen (26%) had large amounts of damage, with one-half or more of a scute or tail damaged or were missing appendages. Nineteen others only had minor marks or chips on them.

Three Wood Turtles (6%) were missing appendages. On 19 March 2001, a small adult female Gi#03 was first found. She had lost her right front foot. The wound appeared fresh. The tip of the leg bone was exposed where the foot had been amputated. She also had an open wound on her stubby tail, which had been broken at a right angle and was missing 4 digits on her feet. There were no teeth marks on her carapace. Juvenile Gi#23 was found on 26 December 2001 about 1 mile upstream (south) of the female in a communal hibernaculum. This turtle was missing its right front foot and had a stubby tail. It did not have any marks on its carapace or plastron. At the same location, juvenile Gi#36 was captured on 31 March 2002 missing its left front leg. It had a very short, stubby tail, a small notch broken off the margin of its right gular scute, and missing digits 2, 3, and 4 of its right front foot. No Wood Turtles were missing any rear legs.

TABLE 8.3. WOOD TURTLE INJURIES AND MARKINGS (CONTINUED ON NEXT PAGE)

Turtle ID	Missing Appendages *	Missing Digits *	Tail Tip Missing	1/2 or More Tail Missing	Drill Holes	1/2 Scute or More Carapace Damage	Marginals Chipped or Chewed	Hole in Carapace	1/2 Scute or More Plastron Damage	Hole in Plastron	Hole in Bridge	Facial Injury	Abscess	Shell Rot	Other / Notes
Gi#01							X								
Gi#02		X (RF)	X		X		X								
Gi#03	X (RF)	X (LF,RR)		X											
Gi#04							X								
Gi#05					X		X		X						
Gi#08		X (RF)					X								
Gi#09							X								
Gi#11										X (small)					
Gi#12							X			X (tiny)					
Gi#14							X		X						
Gi#16		X (LR,RR)					X		X			X			
Gi#17									X						
Gi#18									X						
Gi#19							X		X						
Gi#20							X		X						
Gi#21							X								
Gi#23	X (RF)			X		X									
Gi#24							X								
Gi#25						X	X								

TABLE 8.3. WOOD TURTLE INJURIES AND MARKINGS CONTINUED

Turtle ID	Missing Appendages *	Missing Digits *	Tail Tip Missing	1/2 or More Tail Missing	Drill Holes	1/2 Scute or More Carapace Damage	Marginals Chipped or Chewed	Hole in Carapace	1/2 Scute or More Plastron Damage	Hole in Plastron	Hole in Bridge	Facial Injury	Abscess	Shell Rot	Other / Notes
Gi#26													X		
Gi#27						X	X								
Gi#31				X											
Gi#32			X				X								
Gi#33			X												
Gi#34			X				X								
Gi#35			X				X								
Gi#36	X (LF)	X (RF)		X											
Gi#37			X				X								
Gi#39			X				X								
Gi#44			X												
Gi#47			X												
Gi#48			X												
Total	3	5	10	4	2	3	20	0	7	2	0	1	1	0	
% (of 50)	6%	10%	20%	8%	4%	6%	40%	0%	14%	4%	0%	2%	2%	0%	
Wood Turtles with any damage													32 of 50		64%
Wood Turtles with large amounts of damage (1/2 scute or tail or missing appendages)													13 of 50		26%

* LF = Left Front, RF = Right Front, LR = Left Rear, RR = Right Rear

Five turtles were missing digits or nails (10%) (Table 8.3). Three turtles were missing claws on their right front legs only. One turtle was missing digits on the left front and right rear legs. The fifth turtle had digits missing on both the left and right rear feet. Most digits any one Wood Turtle lost was 4 from Gi#03, who also had lost her front leg. She was missing digits 3, 4, and 5 on her left front foot and digit 3 on her right rear foot.

Fourteen turtles (28%) had at least part of their tail missing. Ten (20%) had the tips of their tails missing and 4 (8%) had lost a large portion (1/2 or more) of their tails. Large, old adult male Gi#45 had a very worn carapace and plastron but had a very long, complete tail.

Two adult *G. insculpta* (4% of the study population) were found whose marginals were marked with drill holes from a previous study that was conducted in 1991-1993 (Niederberger pers. comm.). Male Gi#02 had drill holes in L10R10. Female Gi#05 had drill holes in L9L12.

Large sections of carapace were damaged (one-half a scute or more or multiple marks) on 6% (3) of the Wood Turtles. Twenty (40%) had one or more chips out of the marginal scutes and at least 2 of these had marginals that appeared to have been chewed by rodents or other mammals. One had right marginals 2, L2 and L10-12 gnawed. The other has bite marks on L8-12, and R12.

Seven had one-half scute or more plastron damage (14%). Two (4%) had a hole in their plastron.

Kyphotic adult male Gi#16 had a well-healed wound on the left caudal side of his upper jaw where a section of the jaw was missing. He also had a chip out of his right femoral scute and right marginal 12. His left rear foot was missing digit 2 and right rear nail 3 was stubbed short.

Ilnesses:

On 27 May 2001, juvenile Gi#10 was found basking in the grass between the old road and the stream. It had air bubbles coming out of its nose and its breathing had a wheezing sound. It seemed to have an upper respiratory tract infection and the turtle appeared to be basking to recuperate. The turtle was never recaptured so it is unknown if it recovered. It had 7 annuli and weighed 282 g.

Juvenile Gi#09 was found on 2 April 2002 with its eyes swollen, with a thick film over them and unable to open them. The pupils were not visible through the film and the turtle seemed unable to see. It was basking on a log above its hibernaculum. There was still slightly damp mud on its carapace and it appeared to have recently emerged from the stream. The turtle was recaptured on 4 April 2002, stationary, in the middle of the stream bottom. The turtle appeared alert and its eyes could open with the pupils visible. There was an almost transparent thin film over the eyes. The turtle closed its eyes tightly often, but after watching it for 15 minutes, it appeared to be behaving normally and much healthier. On 1 April 2003, the turtle was recaptured. At this time, the turtle’s eyes had some swelling around the edges but not to the degree that it had been found the previous year after its hibernation.

One dead female Wood Turtle was found on 17 June 2001 a half meter from the stream. Her body was mostly decayed, but the bones and shell were intact.

On 9 March 2002, juvenile Gi#26 was found with an abscess on its left hind foot. It was captured while it ran down the bank of the stream toward the water and the abscess did not appear to hinder its movement.

No illnesses were noted for Spotted Turtles during this study.

Ectoparasites:

Leeches (*Placobdella parasitica*) were observed attached to Wood and Spotted Turtles. They were found attached to the carapace, plastron, legs and leg pockets, and head and neck regions. Unidentified biting flies were observed on Wood Turtles but no other types of ectoparasites were observed on Spotted Turtles. Table 8.4 shows the months that leeches were found on Spotted and Wood Turtles.

TABLE 8.4. MONTHS LEECHES OBSERVED (2001, 2002, AND 2003 COMBINED). Red squares indicate months that turtles were found carrying leeches; white squares are months no leeches were observed.

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wood Turtle										
Spotted Turtle										

Spotted Turtle Leeches:

Leech parasitism was observed on Spotted Turtles on 4 occasions during May, June and July 2001. Of 260 Spotted Turtle captures, leeches were found 1.5% of the time. No Spotted Turtle was captured more than once harboring leeches. All of the Spotted Turtles with leeches were found in water. No other types of ectoparasites were observed on Spotted Turtles.

On 30 May 2001, male Cg#07 was swimming in 15 cm of water in the main Spotted Turtle channel with 2 leeches attached to his leg. A small juvenile, Cg#08, was found on 31 May 2001 with 1 leech attached to its leg. On 16 June 2001, male Cg#09 had 3 leeches attached to its carapace. This turtle was captured in the vernal pool area in a box trap with a snapping turtle. Cg#12 was captured on 9 July 2001 with 1 leech attached.

Wood Turtle Leeches:

Parasitism of Wood Turtles by leeches was observed during March, June and October 2001 and April and October 2002, and March 2003. Of 50 Wood Turtles captured, 8 turtles (16%) harbored leeches at least once during the study. Wood Turtles were captured with leeches only 9 times out of 230 times (3.9%). Only one Wood Turtle, female Gi#12, was captured twice carrying leeches. Other turtles were only observed once with leeches. Six turtles that had leeches were captured in water and 2 were dry on land when they had leeches. One of the dry turtles with leeches was found on the stream bank 0.8 m from the water. On 2 April 2002, Gi#18 was found 14 m from the stream, which is the farthest from the water a Wood Turtle was found carrying leeches.

March was the month with the most captures of leeches on Wood Turtles, with 4 instances. Leeches were found on turtles twice in April and October, and once in June. No leeches were found on Wood Turtles from May through the beginning of October.

Leeches parasitized 2 of 7 Wood Turtles (28.6%) captured on 19 March 2001. Adult female Gi#03 had 2 adult leeches attached to her hind legs. She had fresh wounds on her right front leg and tail where they had been recently amputated. She was basking 0.8 m from the water's edge and had dried mud on her carapace. Adult male Gi#07 was submerged in the stream and had many (30+) juvenile leeches attached to his appendages and shell. Leeches were mainly observed in the protected limb socket areas of the turtle. This turtle was captured walking on the sandy stream bottom in 0.65 m of water.

One leech was found attached to the carapace of Gi#12 on 14 June 2001 while she was submerged in the main fishing pond. She was located in the stream on 20 October 2001 with 1 leech attached to her foreleg.

On 2 April 2002, a leech was found on each of 2 turtles. Juvenile Gi#41 was submerged in the creek with a leech attached to its carapace. This turtle had 7 annuli and a plastron length of 119mm and was the smallest one found with a leech attached. A male, Gi#18, was found hidden under dry leaves 14m from the stream. He was completely dry and there was one large adult leech attached to his right rear leg in the protected region that could be pulled into the shell.

Male Gi#24 was being parasitized by at least 9 juvenile leeches on 13 October 2002. One was on the lower lid of his right eye, 3 more were on his head, 1 was on marginal carapacial scute R12, 2 were on its right rear leg and 2 were on its left front foot. Green algae were also observed on the carapace. He was found in the water.

On 31 March 2003, Gi#46 had at least 3 leeches attached to his body. The female he had just mated with had no leeches. On 31 March 2003, Gi#48 had 1 large leech attached to one of his legs. All 3 turtles had been submerged in the stream.

Wood Turtle Biting Insects:

On 1 June 2002, small biting flies that resemble black flies were observed flying around and alighting upon 4 Wood Turtles in the floodplain region by the stream about a ½ mile upstream (south) of the bridge. They were collected but not positively identified. They had brown/black bodies and their abdomens appeared red because they were full of blood. This was the only day throughout the study that these blood-sucking insects were observed.

Hundreds of biting flies were flying around male Gi#17 found at 9:55 a.m. EST. His carapace was still damp and he was 30 m from the stream. Gravid female Gi#35 was found at 10:55 about 35 m south of the Gi#17. She had approximately 12 black flies on her carapace. A juvenile Wood Turtle and a juvenile Eastern Box Turtle were found in the floodplain at 10:30 a.m. EST between Gi#17 who was 24 m north and Gi#35 who was 15 m south of them. Neither of these turtles had flies around them. Gi#43 and an adult box turtle were found at 11:08 a.m. and 11:30 a.m. EST in the same vicinity and were free of ectoparasites. Female #44 and male Gi#45 were found together at 12:00 EST on 1 June 2002 south of the other turtles in the floodplain area and both had flies around them. The female had dried mud on her carapace and hundreds of biting flies around her while the male who was 2 m north of her but did not have as many. None of the turtles pulled into their shells or made attempts to avoid the flies during the period they were being observed.

DISCUSSION

Scute Anomalies and Atypical Shell Growth:

There is very little literature on scute abnormalities in *C guttata*. In one study, 5.3% of Spotted Turtles at the same site had shell anomalies (Ernst 1976).

The percentage of carapacial scute abnormalities is higher than plastral abnormalities in turtle populations. The percentage of Wood Turtles exhibiting atypical carapacial scute arrangements in this study (14%) was most similar to a population in New Hampshire (17%) (Tuttle 1996). In Michigan, 2% of the population had scute abnormalities (Harding and Bloomer 1979). 4.5% of Wood Turtles showed scute anomalies in southeastern Pennsylvania (Ernst 2001). Similar to my study, no plastral abnormalities were found in Michigan or New Jersey (Harding and Bloomer 1979).

Spotted Turtle Injuries:

Of the *C. guttata* I encountered in West Virginia, 28.6% had large amounts of shell damage, one-half a scute or tail or more, or were missing appendages. In a Pennsylvania study, 17.9% of adult Spotted Turtles had injuries (Ernst 1976).

Wood Turtle Injuries:

Fifteen of 88 (17%) of Wood Turtles in southeastern Pennsylvania had injuries (Ernst 2001). In my West Virginia study, 26% of the Wood Turtles captured had at least one-half a scute or tail, or appendages damaged.

In southeastern Pennsylvania, 6.8% of *G. insculpta* (6 of 88) had lost appendages, all on rear legs (Ernst 2001). In New Hampshire, 9% of the Wood Turtles observed were missing appendages and 29% were missing portions of their tail (Tuttle 1996). Those results are similar to this study in West Virginia, where 6% of the Wood Turtles had lost appendages and 28% had at least a portion of their tail missing.

Amputation of Wood Turtle legs and tails was probably caused by a mammalian predator, most likely a raccoon (Ernst et al 1994). Beaver have also been reported to chew on Wood Turtle shells (Ernst et al. 1994). Raccoons, skunks, opossums, snapping turtles, large fish, birds, and feral cats and dogs prey upon hatchlings and juveniles (Harding and Bloomer 1979). At this study site, beaver activity was very prevalent and signs of raccoons and other mammals were abundant in areas frequented by the turtles. One female that had lost a front leg spent her summer months in an area frequently used by people. Raccoons and their sign were frequently seen in this area, as would be expected since it is a subsidized predator. At least 2 turtles had their marginal scutes chewed by a mammal. Beaver activity was common along most of the stream section studied, so they may have caused some of the damage. Some of the tips of tails may have been lost to frostbite, as has been suggested in other studies (Ernst 2001). In my study, one female Wood Turtle experienced temperatures as cold as –4.5^{o}C, so frostbite would be possible. Tail tips may have been lost to predators or conspecifics (Saumure and Bider 1998).

Leeches:

Placobdella parasitica has been commonly reported parasitizing *C. guttata* (Ernst 1976, 2001, Belmore 1980) and *G. insculpta* (Koffler et al. 1978, Harding and Bloomer 1979, Hulse and Routman 1982, Brewster and Brewster 1986, Siddall and Desser 1992, Farrell and Graham 1991, Niederberger and Seidel 1999, Saumure and Bider 1996, Tuttle 1996, Ernst 2001).

Spotted Turtles in a Pennsylvania study had a 12.1% incidence of leech infestation which was significantly lower than the rate of leech infestation in Wood Turtles at the same location, which was 38.6% (Ernst 2001). These finding are similar to this study, where the rate of leech infestation in Spotted Turtles was much lower than Wood Turtles. Leeches parasitized Spotted Turtles 1.5% of the time and Wood Turtles 16% of the time. The rate of leech parasitization in Pennsylvania was higher in both species than my West Virginia population.

The frequency of leeches parasitizing Wood Turtles was lower in my study (16%) than Niederberger's study in West Virginia, which reported over 50% of all turtles captured in the water had leeches (1999). A possible explanation is that the study was in a large, riverine system, while this study was in a small trout stream. In Pennsylvania, 38.6% of the Wood Turtles captured harbored *P. parasitica* (Ernst 2001). In a New Jersey study, leech infestation rate in Wood Turtles was found to be almost 90% (Farrell and Graham 1991).

October had the highest occurrence of leech infestation in New York (Koffler et al. 1978), Pennsylvania (Hulse and Routman 1982), and New Hampshire (Tuttle 1996). However, in one study in Pennsylvania the highest infestation occurred from April to August in an area where Wood Turtles spent much of their summer months in wet areas such as floodplain pools (Ernst 2001). New Jersey had the highest infestation of leeches in April, followed by November and October, respectively (Koffler et al. 1978). Another New Jersey study reported that leeches were found in early spring usually before May (Harding and Bloomer 1979). In a Michigan study, the Wood Turtles were infested with leeches during the entire activity period (Harding and Bloomer 1979).

My results were similar to Koffler et al.'s results that there was little leech infestation from May until October (Koffler et al. 1978). No leeches were found from May through September in this study. Koffler et al. (1978) reported that during those months, 1% of turtles carried leeches. Brewster and Brewster (1986) indicated a drop of leech infestation after June. The reason leeches were not present in the summer months is most likely due to the fact that Wood Turtles spend much of this time on land and basking (Koffler et al. 1978). There were two instances in July and one in August of leech infestation in New Hampshire (Tuttle 1996). Ernst (2001) found April to August to have the highest rate of leech infestation at a study site in Pennsylvania.

Masses of young leeches have been reported on Wood Turtles in October and November (Koffler et al. 1978, Hulse and Routman 1982). In my study, small masses of juvenile leeches were found on Wood Turtles on 19 March 2001 (more than 30 leeches) and 13 October 2002 (9 leeches). These juveniles were not tightly grouped but found distributed over the shell and appendages, mostly in the limb socket areas. Hulse and Routman (1982) reported tightly packed masses of juvenile leeches without spaces between each individual. In New Hampshire, masses of tightly packed leeches were found on 16 Wood Turtles (Tuttle 1996).

Koffler et al. (1978) believed that leeches remain on *G. insculpta* over the winter, and that the turtles are a food source for the young leeches that have been deposited on them. Ernst (1971) believed that leeches are dormant over the winter, because of low percentages of the infestation from October to March.

Niederberger (1993) only observed leeches on Wood Turtles that were in the water. I observed Wood Turtles with leeches on land on 2 occasions; the farthest from the stream was 14 m. Most of turtles with leeches in a New Hampshire study were found on land, up to a distance of 71 m from a brook (Tuttle 1996). Only 33% of the turtles captured in that study that harbored leeches were found in the water.

In my study, leeches were observed on the face, neck, appendages, and cloacal area, but were most commonly seen in the limb sockets, on the carapace, or plastron. In West Virginia, Niederberger and Seidel (1999) observed leeches most commonly “along the anterior plastral seam” or near the vent at the base of the tail. In Pennsylvania, leeches preferred the inguinal cavity, nuchal area, and axillary cavity (Hulse and Routman 1982). Koffler et al. (1978) indicated that in New York and New Jersey the leeches were commonly found on the plastron, under the marginals, in the inguinal cavity, and near the cloaca. The axillary area and neck was less commonly infested (Koffler et al. 1978). In northwestern New Jersey, limb sockets, plastron, tail, and sometimes the carapace harbored leeches. Tuttle (1996) found leeches in New Hampshire attached to various areas over the turtles’ body.

Koffler et al. (1978) reported the smallest Wood Turtle with leech infestation was 88mm in plastron length. The smallest leech-infested turtle in this study had a plastral length of 199mm.

Wood Turtle Biting Insects:

Similar observations of blood-sucking flies on Wood Turtles have been reported in other studies (Harding and Bloomer 1979, Tuttle 1996). In Pennsylvania, a basking female was observed being swarmed by over 12 mosquitoes (Ernst 2001). Tuttle (1996) reported an incidence of distress in one turtle that was being harassed by biting flies, while the other turtles with flies in that study showed no outward signs of distress. Discomfort was not noticeable in the turtles in this study, although blood-sucking insects were observed in association with 4 Wood Turtles over the period of a day.

CHAPTER 9
Behavioral Notes

INTRODUCTION

Foraging behavior has been documented in *Clemmys guttata* (Ernst 1976, 1982) and *Glyptemys insculpta* (Harding and Bloomer 1979, Ernst 1986, Farrell and Graham 1991, Tuttle 1996, Ernst 2001). Mating and nesting behavior have also been well documented in both species. Spotted Turtles were observed mating in many studies (Ernst 1967, 1970, 1982, Ernst and Zug 1994). Wood Turtle mating and nesting behavior has been documented (Harding and Bloomer 1979, Ernst 1986, Brooks et al. 1991, Farrell and Graham 1991, Tuttle 1996).

Foraging, mating, and nesting of *C. guttata* have not been documented in West Virginia prior to this study. In West Virginia, Wood Turtle stomach contents were examined and mating behavior was recorded (Niederberger 1993, Niederberger and Seidel 1999).

Due to the little information published on the subject in West Virginia, the objective of this study was to record various behaviors exhibited by a population of Spotted and Wood Turtles in West Virginia.

RESULTS

Spotted Turtle Foraging:

Spotted Turtles were not observed foraging.

Wood Turtle Foraging:

Foraging by Gi#03 was observed on 19 August 2001 at 0940 hrs. She was one body length away from the form she had been in the previous day and was seen eating a small Virginia Creeper (*Parthenocissus quinquefolia*). On 13 September 2001, Gi#03 was found at 1442 hrs basking with a gooey substance in her mouth that was probably a slug, although it was not identifiable.

On 1 June 2002, Gi#12 female was found at 0905 hrs under a rose bush with remnants of an earthworm on her chin.

Spotted Turtle Mating:

No Spotted Turtles were observed mating.

Wood Turtle Mating:

Mating acts were observed on 26 December 2001, 2 April 2002, 14 October 2002, 31 March 2003, and 1 April 2003 (Table 9.1). All mating acts witnessed took place within the stream channel upstream of the pond.

TABLE 9.1. COMPARISON OF FEMALE AND MALE WOOD TURTLES OBSERVED IN MATING ACTS, WITH DATE AND TIME OF EACH EVENT.

Date	Time	Female ID	Mass (g)	Carapace Length (mm)	Male ID	Mass (g)	Carapace Length (mm)
12/26/01	13:46	Gi#06	770	185	Gi#07	1040	194
04/02/02	9:00	Gi#05	1275	199	Gi#37	880	192.5
10/14/02	9:50	Gi#20	1080	187	Gi#16	930	191
03/31/03	10:09	Gi#12	900	184	Gi#46	1120	205
03/31/03	12:23	Gi#35	955	186	Gi#19	995	195.5
04/01/03	9:20	Gi#12	900	184	Gi#46	1120	205

Five pairs of Wood Turtles were observed during mating attempts on 6 occasions. One pair of Wood Turtles (Gi#12 and Gi#46) was observed mating on 2 consecutive days. The first day they were found together they were inadvertently disturbed. The following day the pair was observed mating in the same location. The 4 other pairs were only found mating once. No turtle was found mating with different partners. It is unknown if the acts were successfully completed.

Males were larger in mass and carapace length in 3 of the mated pairs (Table 9.1). Male Gi#07 was 35% larger in mass and 5% larger in carapace length than his mate Gi#06. Male Gi#46 was 24% larger in mass and 11% larger in carapace length than his mate Gi#12. Male Gi#19 was 4% larger in mass and 3% larger in carapace length than his mate Gi#35.

Female Gi#05 was 45% larger in mass and 34% greater in carapace length than her mate Gi#37. Female Gi#20 was 16% larger in mass, but she was 2% smaller in carapace length than her mate Gi#16.

The smallest female observed mating based on mass was Gi#06 (770 g) and based on carapace length was Gi#12 (184 mm). The smallest male observed mating based on mass was Gi#37 (880 g) and based on carapace length Gi#16 (191 mm). The smallest males were 110 g larger in mass (14%) and 7 mm larger in carapace length than the smallest females (3%).

The largest female observed mating, Gi#05, had a mass of 1275 g and carapace length of 199 mm. She was 66% larger in mass (505 g) and 8% larger in carapace length (15 mm) than the smallest female observed mating. The largest male observed mating was Gi#46 who had a mass of 1120 g and carapace length of 205 g. He was 27% larger in mass (240 g) and 7% larger in carapace length (14 mm) than the smallest males. The largest female weighed 155 g (14%) more but her carapace length was 6 mm (3%) smaller than the largest male.

Spotted Turtle Nesting:

No Spotted Turtles were observed nesting during the course of this study although nests were found on two consecutive years in the same location in the moss covered log under which Cg#09 hibernated during the winter of 2001-2002. Both years the condition of the eggs shells indicated successful hatching rather than nest predation. Eggs were found hidden in the moss and had slits where the turtles had emerged. The first nest was found on 19 October 2001 and contained eggshells from 3 eggs. The following year, a nest was found on 13 October 2002 and it contained 5 (possibly 6) eggshells.

Wood Turtle Nesting:

No Wood Turtles were observed nesting at this site during the course of the study, although gravid females were found. Females Gi#13 and Gi#35 were gravid on 1 June 2002. Many juvenile Wood Turtles (n=18) were found, so some nests must have been successful in recent years. Juveniles were found as young as 1 annulus. Elsewhere in West Virginia, I observed a Wood Turtle nesting in Morgan County on a sandy hillside bank along a road on 25 May 2001.

Other Turtle Nesting:

The only species of turtle observed nesting at this site was a Painted Turtle on 31 May 2002 nesting between two of the man-made ponds. During the fall of 2001 eggshell fragments of painted turtles and snapping turtles were found in the vicinity of the man-made ponds.

DISCUSSION

Foraging

During this study, Wood Turtles were observed foraging on only 3 occasions. Food items consumed were Virginia Creeper, an earthworm, and possibly a slug. These types of food items have been previously reported for West Virginia Wood Turtles (Niederberger and Seidel 1999), but due to the extremely small sample size of this study, comparisons of food consumption cannot be made.

Niederberger and Seidel (1999) examined the stomachs contents of 16 West Virginia Wood Turtles. Of the 13 turtles captured in a terrestrial setting, 46% had eaten earthworms, 38% beetles, millipedes or slugs, 69% vegetation, and 23% carrion. The main food element was earthworms in 23% of the turtles, beetles, millipedes and slugs in 23%, carrion in 23%, and vegetation (mainly greenbrier (*Smilax*)) in 15%. Stomachs were empty in 3 males that were captured in October, November, and March in the river.

Wood Turtles in Pennsylvania consumed the leaves of cinquefoil and violets, flowers, fruit, mushrooms, and invertebrates (Strang 1983). In New Hampshire, successful worm stomping was observed, as well as consumption of several species of mushrooms (Tuttle 1996).

Mating

Although no Spotted Turtles were observed courting or mating in this study, these activities peak late March and April in Pennsylvania (Ernst 1976). In that state, Spotted Turtles were observed courting from 9 March to 16 May and copulation took place on March to 20 April (Ernst 1976).

Peaks in *G. insculpta* mating are during the spring and fall, although mating can occur any time during the active season (Ernst et al. 1994). In this study, mating pairs were observed in March, April, October and December. Another West Virginia study had results similar to mine, where courtship was observed from September through December and copulation was observed in March and April (Niederberger and Seidel 1999). For Pennsylvania Wood Turtles, courtship or mating occurred from 11 March through 31 May and on 10 October (Ernst 2001). Wood Turtles in Michigan were observed mating 4 times in late June and 4 times in early September (Harding and Bloomer 1979). In New Jersey, most mating took place in April, May, and September, but also was observed in October and November (Harding and Bloomer 1979). Wood Turtles in Quebec displayed courtship and mating behaviors from May through November, with most occurring in October (Walde et. al 2003).

Wood Turtles usually mate in shallow water (Ernst et al. 1994). All mated pairs observed in this study were within the stream channel. Occasionally mating pairs are observed terrestrially (Harding and Bloomer 1979, Ernst 1986, Niederberger and Seidel 1999), however this was not observed in this study. In

West Virginia, Niederberger found a pair mating 30 m from the river (Niederberger and Seidel 1999).

Mating acts were observed between 0900 and 1300 hrs. This differs from some other studies where most courtship occurs in late afternoon (Harding and Bloomer 1979, Ernst et al. 1994). However, in Quebec, Wood Turtles were observed mating most frequently during midday (Walde et al. 2003).

Nesting

Successfully hatched eggs were collected in October on 2 consecutive years, but it is unknown when they were laid or hatched. In Pennsylvania, nests were made in June (Ernst 1976). They hatched in late August or September or emerged in April after over-wintering in the nest (Ernst 1976). *Clemmys guttata* in Ontario, the northern part of their range, nested on 29 June (Chippindale 1989) and from 14 to 29 June (Litzgus and Brooks 1998). Number of eggs observed in my study (3 eggs, and 5 possibly 6 eggs) was similar to Pennsylvania clutches of 3 to 5 eggs (Ernst 1976).

No *G. insculpta* nests were found during this study so nesting and nest emergence times are unknown, although I observed a female nesting elsewhere in West Virginia on 25 May 2001. No nesting was observed by Niederberger and Seidel (1999) in West Virginia, but they did find a road killed female with fully developed eggs on 9 June (1999). Wood Turtles in Pennsylvania nested from 4 to 19 June (Ernst 2001). In New Jersey, nesting occurred between 5 June and 7 July (Harding and Bloomer 1979). New Hampshire Wood Turtles nested from 5 to 13 June (Tuttle 1996). In Michigan nesting was from 12 to 29 June (Harding and Bloomer 1979).

Hatchling nest emergence occurred in Pennsylvania from 14 September through 11 October (Ernst 2001). In New Jersey studies, Wood Turtle hatchlings emerged from mid-August to early October (Harding and Bloomer 1979) and between 23 and 28 August (Farrell and Graham 1991). In New Hampshire, hatchlings emerged from 13 to 29 August (Tuttle 1996). Hatching occurred in Michigan on 4 September (Harding and Bloomer 1979).

CHAPTER 10

Management Implications and Future Research

Despite this area being used by fisherman, the population of both Wood and Spotted Turtles at the study site appear to be much larger than previously believed. Although the turtle populations are apparently stable at present time, they should continue to be monitored. It has been documented that recreational use of an area has caused the decline of Wood Turtles in Connecticut (Garber and Burger 1995). Possible management would be developing a plan for mowing fields Wood Turtles utilize in summers that takes into account their presence. Local governments have proposed drawing large amounts of water from the stream, so it is important to determine what affect that would have on the habitats and turtles. Finding additional locations of Spotted Turtles and new locations of Bog Turtles in West Virginia may also require intensive trapping regimes (Rosenbaum personal communication).

There should be further analysis of the data collected in this study. A closer examination will be given to seasonal habitat use and behavior of this population of Spotted and Wood Turtles. There will be a more in-depth examination of the turtles' thermal ecology. Data collected from the data loggers will be used to analyze in greater detail daily and seasonal activity patterns. It would be interesting to compare these temperature regimes to more northern populations of Wood Turtles and northern and southern populations for Spotted Turtles. Smaller data loggers (such as I-buttons) could be used to record the thermal regime of the Spotted Turtle activity season as well as over-wintering season. Additional work could be conducted studying courtship and mating, identifying nesting areas, and hatchling emergence of Spotted and Wood Turtles. Trapping area should be expanded to incorporate further man-made ponds and wet areas to determine if there are additional Spotted Turtle locations in the area. Additional thermal ecology and habitat studies would be good for other the turtle species that occur in this area, such as box, stinkpot, painted, and snapping turtles.

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APPENDIX I

Vegetation Observed at Thesis Site

Family Name	Common Name	Scientific Name	Stream Area	Gi Upland	Main Wetland and Vernal	Main and Vernal Upland
Sphagnaceae	Sphagnum	*Sphagnum* spp.			x	
Polypodiaceae	Sensitive Fern	*Onoclea sensibilis*	x		x	
Polypodiaceae	New York Fern	*Thelypterus noveboracensis*				
Polypodiaceae	Spinulose Shield Fern	*Dryopteris spinulosa*				
Pinaceae	White Pine	*Pinus strobus*		x		
Pinaceae	Scrub Pine	*Pinus virginiana*		x		
Typhaceae	Broad-leaved Cattail	*Typha latifolia*			x	
Sparganiaceae	American Burreed	*Sparganium americanum*			x	
Sparganiaceae	Small Burreed	*Sparganium chlorocarpum*			x	
		Arthraxon hispidus				
Paniceae	Panic Grass	*Panicum* spp.			x	
Cyperaceae	Spikerush	*Eleocharis* sp.			x	
Cyperaceae	Woolgrass	*Scirpus cyperinus*			x	
Cyperaceae		*Carex* spp.			x	
Cyperaceae		*Carex tribuloides*			x	
Cyperaceae	Tussock Sedge	*Carex stricta*			x	
Araceae	Skunk Cabbage	*Symplocarpus foetidus*			x	
Juncaceae	Yard Rush (Wiregrass)	*Juncus tenuis*			x	
Juncaceae	Common Rush	*Juncus effusus*			x	
Liliaceae	Trout Lily	*Erythronium americanum*		x		
Salicaceae	Black Willow	*Salix nigra*			x	
Corylaceae	River Birch	*Betula nigra*	x			
Corylaceae	Smooth Alder	*Alnus serrulata*			x	
Fagaceae	American Beech	*Fagus grandifolia*		x		
Fagaceae	Swamp White Oak	*Quercus bicolor*		x		
Fagaceae	Red Oak	*Quercus rubra*		x		
Ulmaceae	Elm	*Ulmus* sp.		x	x	x

Urticaceae	Stinging Nettle	*Urtica dioica*			x	
Urticaceae	False Nettle	*Boehmeria cylindrica*			x	
Polygonaceae	Common Smartweed	*Polygonum hydropiper*			x	
Polygonaceae	Mild Water Pepper	*Polygonum hydropiperoides*	x		x	
Polygonaceae	Water Smartweed	*Polygonum punctatum*				x
Polygonaceae	Halberdleaf Tearthumb	*Polygonum arifolium*			x	
Polygonaceae	Pennsylvania Smartweed	*Polygonum pensylvanicum*			x	
Ranunculaceae	Roundlobe Hepatica	*Hepatica americana*		x		
Magnoliaceae	Tuliptree	*Liriodendron tulipifera*		x		
Cruciferae	Cress	*Cardamine* sp.		x		x
Platanaceae	Sycamore	*Platanus occidentalis*	x			
Rosaceae	Cherry	*Prunus*	x			
Rosaceae	Blackberrry	*Rubus* sp.		x		x
Rosaceae	Multiflora Rose	*Rosa multiflora*		x		x
Rosaceae	Shadbush (Serviceberry)	*Amelanchier* sp.	x	x		
Rosaceae	Shrubby Hawthorn	*Crateagus*		x		
Anacardiaceae	Poison Ivy	*Rhus radicans*	x	x		
Aceraceae	Red Maple	*Acer rubrum*	x	x	x	x
Aceraceae	Sugar Maple	*Acer saccharum*	x	x		
Vitaceae	Virginia Creeper	*Parthenocissus quinquefolia*		x		
Vitaceae	Fox Grape	*Vitis labrusca*		x		x
Thymelaceae	Autumn Olive	*Elaeagnus umbellata*		x		
Umbellaceae	Queen Anne's Lace	*Daucus carota*		x		x
Cornaceae	Silky Cornel	*Cornus amomum*			x	
Ericaceae	Rhododendron	*Rhododendron* sp.	x	x		
Convolvulaceae	Common (Love Vine) Dodder	*Cuscuta gronovii (grousii)*			x	x
Orobanchaceae	Beechdrops	*Epifagus virginiana*		x		
Plantaginaceae	Common Plantain	*Plantago rugelii*			x	x
Rubiaceae	Bedstraw	*Galium* spp.			x	x
Rubiaceae	Partridge Berry	*Mitchella repens*		x		
Rubiaceae	Buttonbush	*Cephalanthus occidentalis*			x	
Caprifoliaceae	Tartarian Honeysuckle	*Lonicera tatarica*		x		
Caprifoliaceae	Smooth Arrowwood	*Viburnum recognitum*			x	
Dipsacaceae	Common Teasel	*Dipsacus sylvestris*		x		x
Asteraceae	Common Joe-Pye Weed	*Eupatorium fistulosum*		x		x

Asteraceae	Goldenrod	*Solidago* sp.		x		x
Asteraceae	Daisy Fleabane	*Erigeron* sp.		x		
Asteraceae	Black-eyed Susan	*Rudbeckia hirta*		x		
Asteraceae	Wild Sunflower	*Helianthus* sp.		x		x
Asteraceae	Yellow Ironweed	*Verbesina alternifolia*			x	
Asteraceae	Fireweed	*Erectites hieracifolia*			x	
Asteraceae	Wild Lettuce	*Lactuca canadensis*		x		x
Juglandaceae	Shagbark Hickory	*Carya ovata*	x	x		
Liliaceae	Common Greenbrier	*Smilax rotundifolia*		x	x	
Pinaceae	Hemlock	*Tsuga canadensis*	x	x		
Corylaceae	Hop Hornbeam	*Ostrya virginiana*		x		
Oleaceae	White Ash	*Fraxinus americana*			x	
Asclepiadaceae	Common Milkweed	*Asclepias syriacea*		x		x
Balsaminaceae	Jewelweed	*Impatiens capensis*	x		x	

APPENDIX II

Incidental Wildlife Species Observed at Thesis Site

Amphibians

Marbled Salamander	*Ambystoma opacum*
Jefferson Salamander	*Ambystoma jeffersonianum*
Spotted Salamander	*Ambystoma maculatum*
Red-spotted Newt	*Notophthalmus v. viridescens*
Northern Red Salamander	*Pseudotriton r. ruber*
Long-tailed Salamander	*Eurycea l. longicauda*
Northern Spring Salamander	*Gyrinophilus p. porphyriticus*
Northern Dusky Salamander	*Desmognathus fuscus*
Northern Slimy Salamander	*Plethodon glutinosus*
American Toad	*Bufo a. americanus*
Gray Treefrog	*Hyla versicolor*
Northern Spring Peeper	*Pseudacris c. crucifer*
Green Frog	*Rana clamitans melanota*
Pickerel Frog	*Rana palustris*
Wood Frog	*Rana sylvatica*

Reptiles

Northern Watersnake	*Nerodia s. sipedon*
Eastern Gartersnake	*Thamnophis s. sirtalis*
Eastern Ribbonsnake	*Thamnophis s. sauritus*
Northern Ring-necked Snake	*Diadophis punctatus edwardsii*
Northern Brownsnake	*Storeria dekayi*
Black Ratsnake	*Elaphe guttata*
Eastern Snapping Turtle	*Chelydra s. serpentina*
Stinkpot	*Sternotherus odoratus*
Eastern x Midland Painted Turtle	*Chrysemys p. picta x marginata*
Eastern Box Turtle	*Terrapene c. carolina*
Spotted Turtle	*Clemmys guttata*
Wood Turtle	*Glyptemys* (= *Clemmys*) *insculpta*

Birds

Green Heron	*Butorides virescens*
Great Blue Heron	Ardea herodias
Canada Goose	*Anser canadensis*
Wood Duck	*Aix sponsa*
Mallard	*Anas platyrhynchos*
Hooded Merganser	*Lophodytes cucullatus*
Turkey Vulture	*Cathartes aura*
Wild Turkey	*Meleagris gallopavo*
Ruffed Grouse	*Bonasa umbellus*

Killdeer	*Charadrius vociferus*
Mourning Dove	*Zenaida macroura*
Belted Kingfisher	*Ceryle alcyon*
Red-bellied Woodpecker	*Melanerpes carolinus*
Northern Flicker	*Colaptes auratus*
Pileated Woodpecker	*Dryocopus pileatus*
American Crow	*Corvus brachyrhynchos*
Tufted Titmouse	*Baeolophus bicolor*
Black-capped Chickadee	*Poecile atricapillus*
American Robin	*Turdus migratorius*
Gray Catbird	*Dumetella carolinensis*
Northern Mockingbird	*Mimus polyglottos*
Yellow Warbler	*Dendroica petechia*
Common Yellowthroat	*Geothlypis trichas*
Scarlet Tanager	*Piranga olivacea*
Eastern Towhee	*Pipilo erythrophthalmus*
Song Sparrow	*Melospiza melodia*
Dark-eyed Junco	*Junco hyemalis*
Northern Cardinal	*Cardinalis cardinalis*
Red-winged Blackbird	*Agelaius phoeniceus*
Common Grackle	*Quiscalus quiscula*
American Goldfinch	*Carduelis tristis*

Mammals

Black Bear	*Ursus americanus*
Raccoon	*Procyon lotor*
Red Fox	*Vulpes fulva*
Woodchuck	*Marmota monax*
Eastern Gray Squirrel	*Sciurus carolinensis*
Eastern Fox Squirrel	*Sciurus niger*
American Beaver	*Castor canadensis*
Eastern Cottontail	*Sylvilagus floridanus*
White-tailed Deer	*Odocoileus virginiana*

APPENDIX III

Daily Site Report

***Clemmys* Turtle Daily Site Report 2001**

Date: 6/21/01 **Start Time:** 4:00 **(E.S.T.)** **Finish Time:** 6:00 **(E.S.T.)**

Observer(s) ANB, only **Man hours worked** ________

Site Description: Location name: ________ **Site #** ________

GPS: ________ **USGS Quad** ________

County: ________ **Town:** ________ **State:** WV

Elevation: ____ **ft. to** ____ **ft.** **Acres:** ________ **Owner(s):** ________

Directions to site: ________

Management uses: ________ **Threats:** ________

# of turtles handled: 3 ***C. guttata*** / ***C. insculpta*** ________ ***C. muhlenbergii***

Other: ________

Vernal pool area 4:10pm

Start Time: Air Temp: 26.5 **(°C) Soil Temp:** 21 **(°C) Water Temp (surface):** 24 **(°C)**

Water pH: ________ **Wind:** breezy **Wind dir:** ________ **Cloud Cover:** 100 **%**

Precipitation: overcast, rain and T'storms predicted **Notes:** feels cool, comfortable temp

ST channel area N of dam

End Time: Air Temp: 26.5 **(°C) Soil Temp:** 23.5 **(°C) Water Temp (surface):** 30.5 **(°C)**

Water pH: ________ **Wind:** breezy **Wind dir:** ________ **Cloud Cover:** 80 **%**

Precipitation: " **Notes:** occ. drop of rain

Main st area - channel

~~**Habitat description (plants/soils/slope/aspect/land uses):**~~ Air Temp - 30°C, Water Temp - 26.5°C, Soil Temp - 27.5°C, sunny - 50% cloud cover, warmer, occ. drop of rain.

channel towards woods

Air: 30°C, Water - 29.5°C, Soil - 27.5°C, warm, sunny, cloud cover - 5%, clearing up

Habitat quality: ____ **Excellent** ____ **Good** ____ **Fair** ____ **Poor**

Explain: ________

Faunal obs.: gray treefrogs calling

Other notes: set one large baited trap in main channel (ST area) See data sheet.

Did not check all transmittered turtles today

APPENDIX IV

Daily Trap Report

***Clemmys* Turtle Daily Trap Report**

Date: 6 / 6 /2001 **Start Time:** 13:40 **Finish Time:** 15:00

Investigator(s): ANB, KAB

Total Man/hours: 2:40 **Number of traps set:** 8 **Trap Nights / Night:** 8

Location Name: **GPS:**

USGS Quad: **Town:** **County:** **State:** WV

Site #/Info: **Map Attached?** Yes / No

Weather:

Start Time: Air Temp: 34 (°C) **Water Temp:** 28 (°C) **Cloud Cover:** 90 %

Wind: calm **Wind dir.:** **Precipitation:** soil temp 21°C, some sun shining, warm, rain predicted

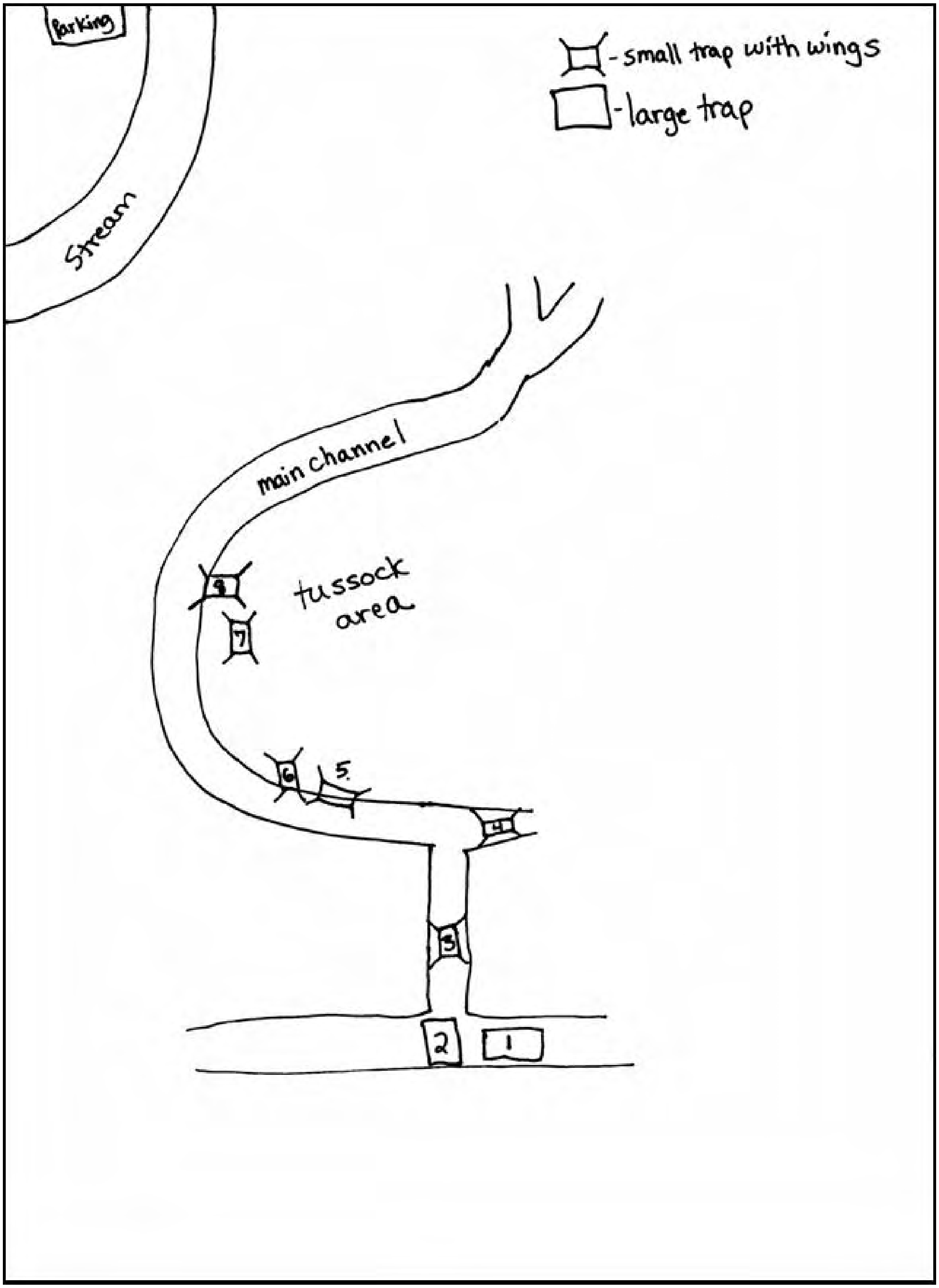
End Time: Air Temp: (°C) **Water Temp:** (°C) **Cloud Cover:** %

Wind: **Wind dir.:** **Precipitation:**

Comments: rained overnight so more water in channels today. Water level is still low though
Trap locations on back

Species	Trap Number																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Wood Turtle																				
* Spotted Turtle	1																			
Bog Turtle																				
E. Snapping Turtle																				
Eastern Painted Turtle																				
Red-spotted Newts			2																	
Green Frog		1																		
Green Frog tadpole		3																		

* Spotted Turtle L1R1 (150.024)



Parking
- small trap with wings
- large trap
Stream
main channel
tussock area
9
7
6
5
4
3
2
1

APPENDIX V

Individual Turtle Data Sheet

WT09

Turtle Data Sheet For *Clemmys* Study in West Virginia

Date: 5/23/01 **Capture Time:** 9:33 **(E.S.T.)** **Investigator(s)** ANB, ARB

Species: C. insculpta **Sex (M, F, JUV, HATCH, UNK):** JUV

ID: L 3 **R** 7 **Marked this capture?** Yes No **Weight (g):** 176

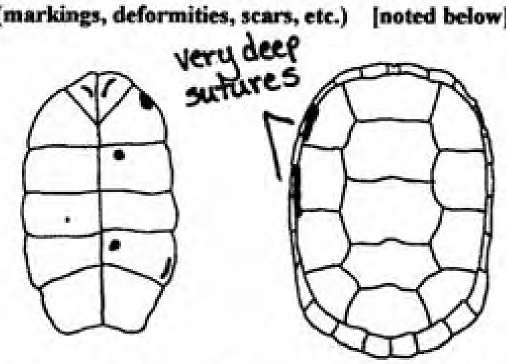
Transmitter ? Yes No **Frequency?** ——— **Annuli: [worn]** 4

Gravid? Yes No N/A **Carapace Length (mm)** 110.2 **Width (mm)** 87.5 **Height (mm)** 42.7

Plastron Length (mm) 100.9 **Width (mm)** 56.9 **Ectoparasites?** Yes No

---

Specimen Characters (markings, deformities, scars, etc.) [noted below]



Photos: Yes No 2 carapace, 1 plastron

Site name: ________ **Site #:** ____ **GPS:** ________

Method of capture: Trap Hand ________ **Trap #:** ____

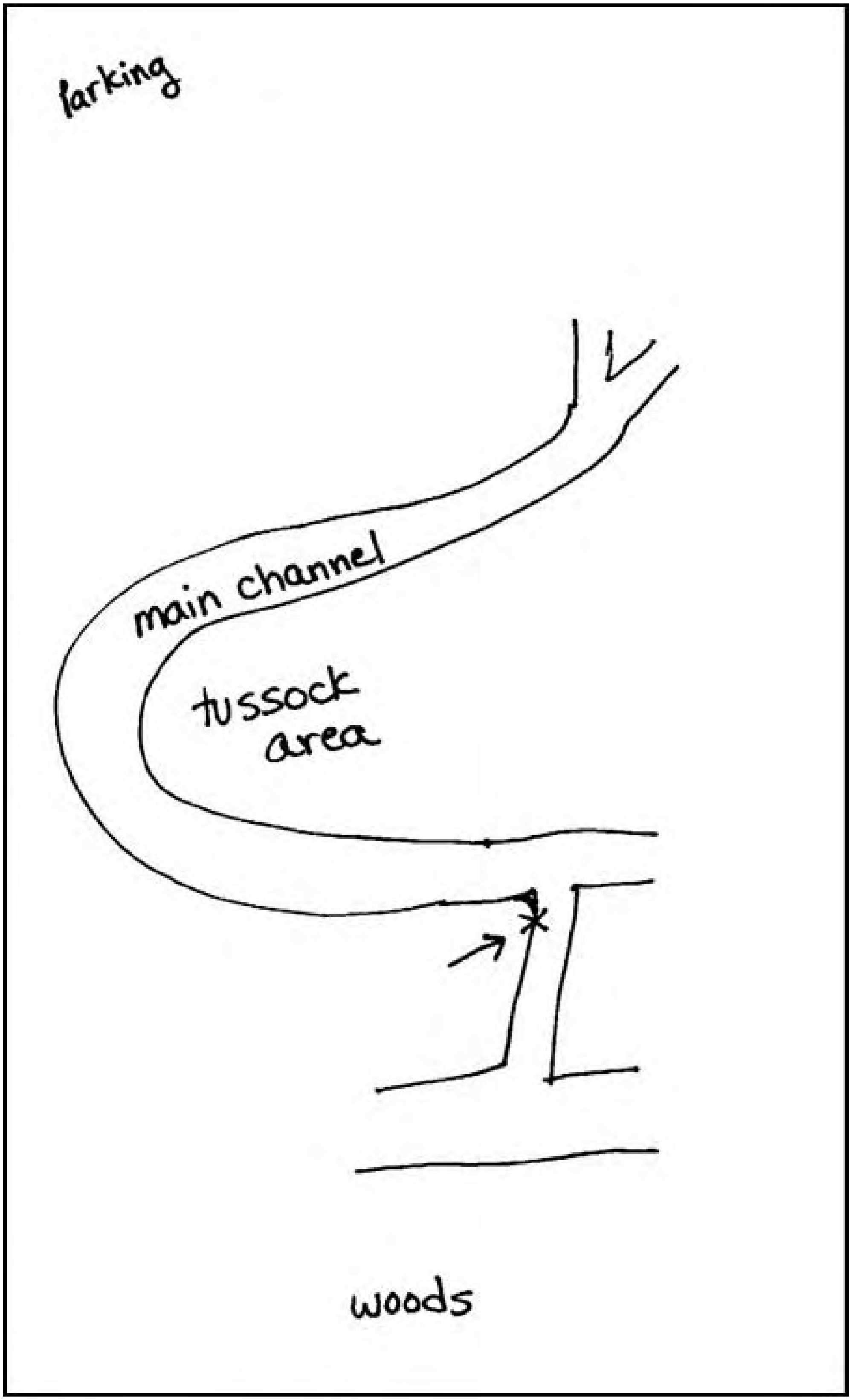
Behavior: in trap basking walking swimming stationary feeding mating escaping nesting other ________

Behavioral notes: fully exposed, head and legs slightly out

Habitat: [in trap] on shore 10 cm above water level between clumps of sensitive fern and Carex, near woods - 3 m from edge of open meadow **Micro-habitat: [in trap]** **Water temp:** 18 **°C** **Air temp:** 21.5 **°C**

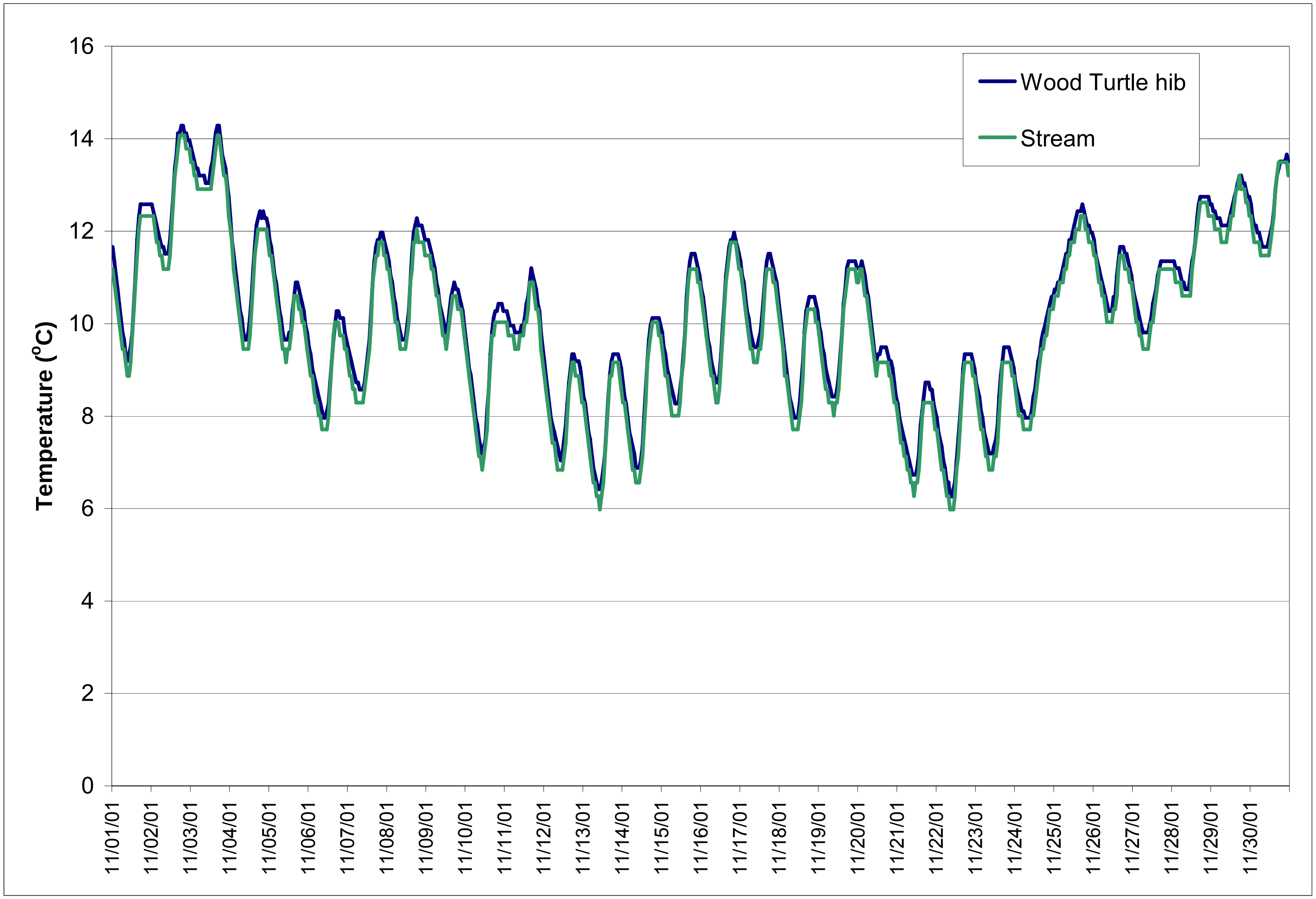
Substrate type ________ **Substrate temp:** 15 **°C**

Notes: Too small to apply transmitter, location drawing on back

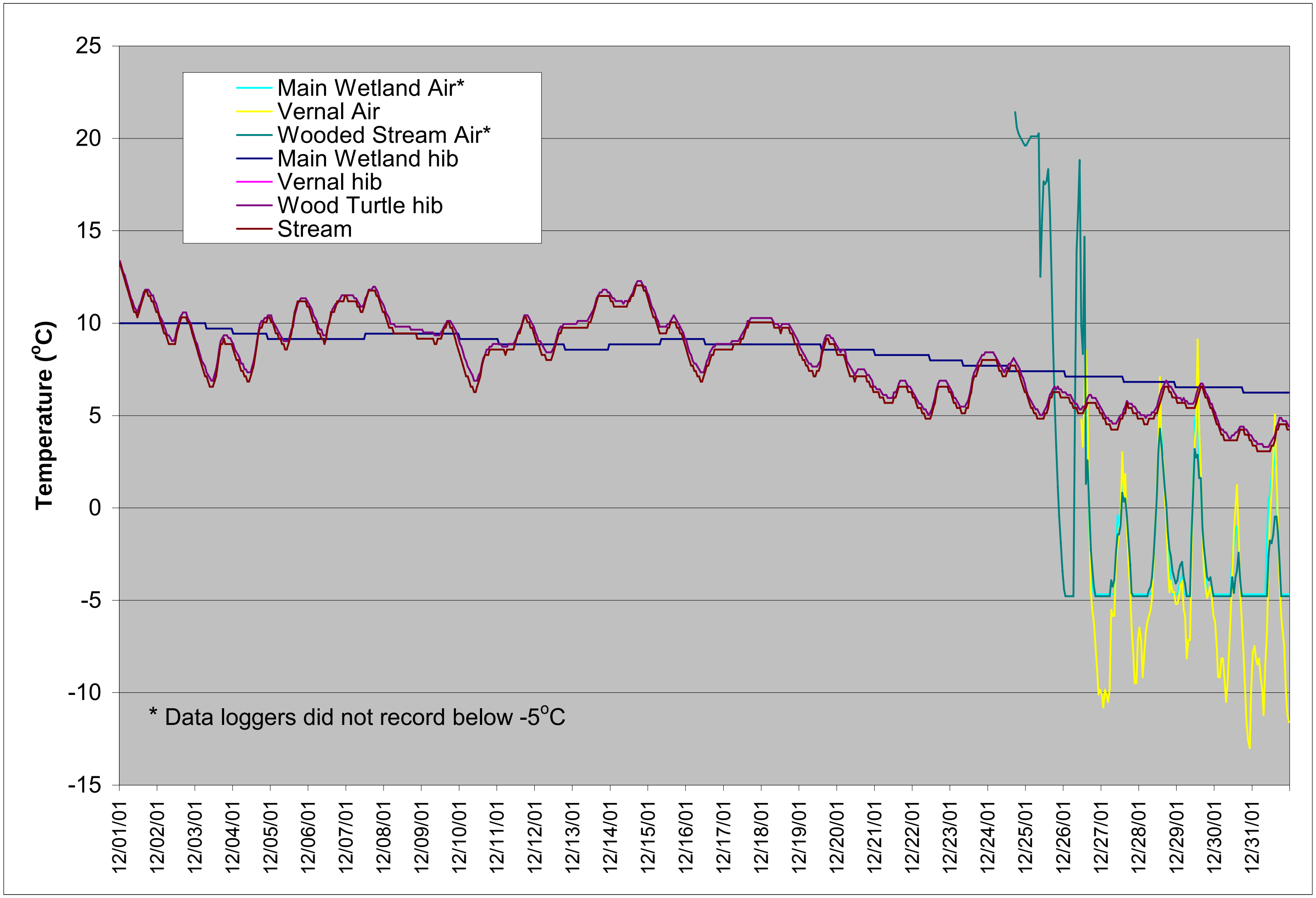

Parking
main channel
tussock
area
woods

APPENDIX VI

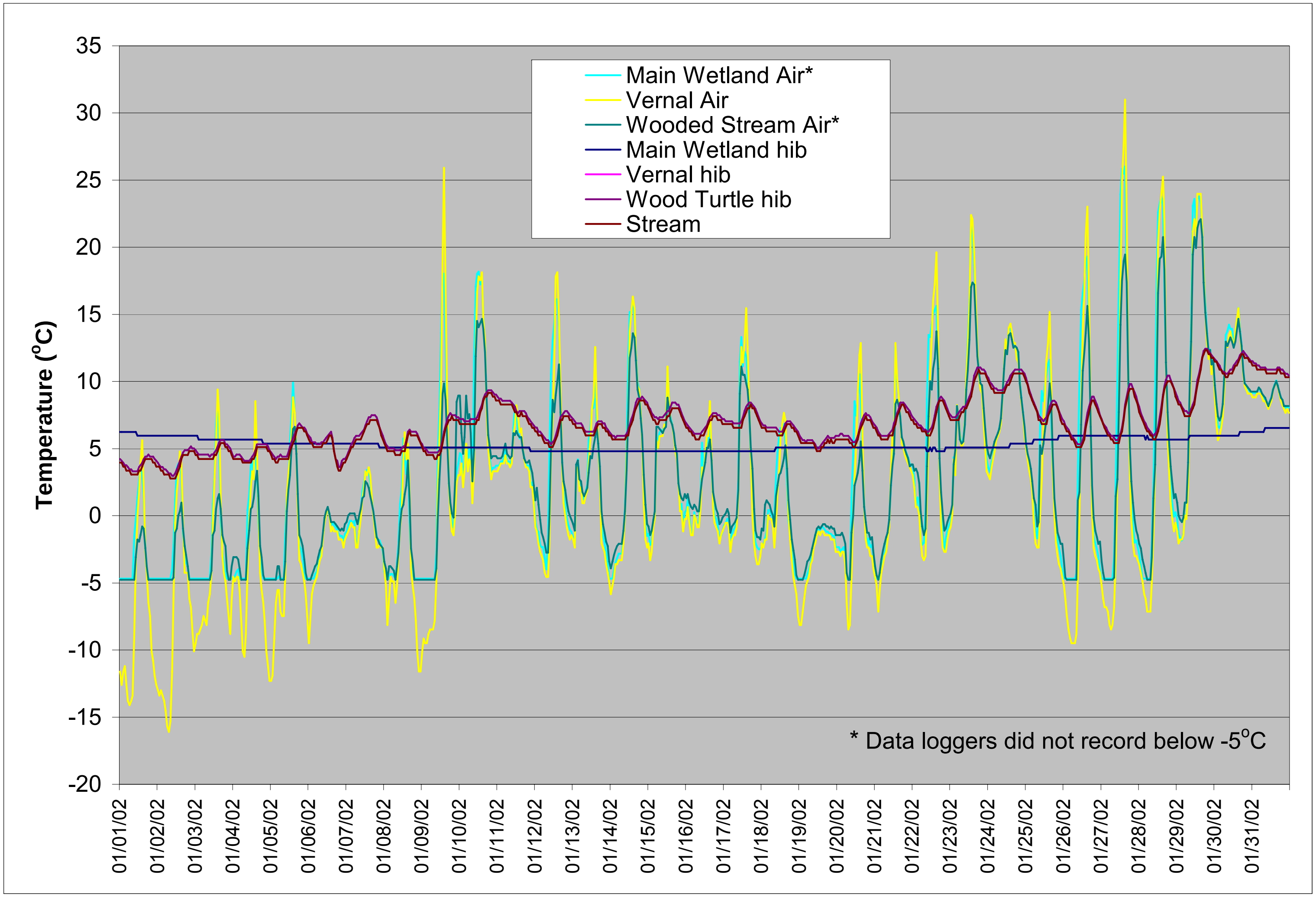
Environmental Temperatures



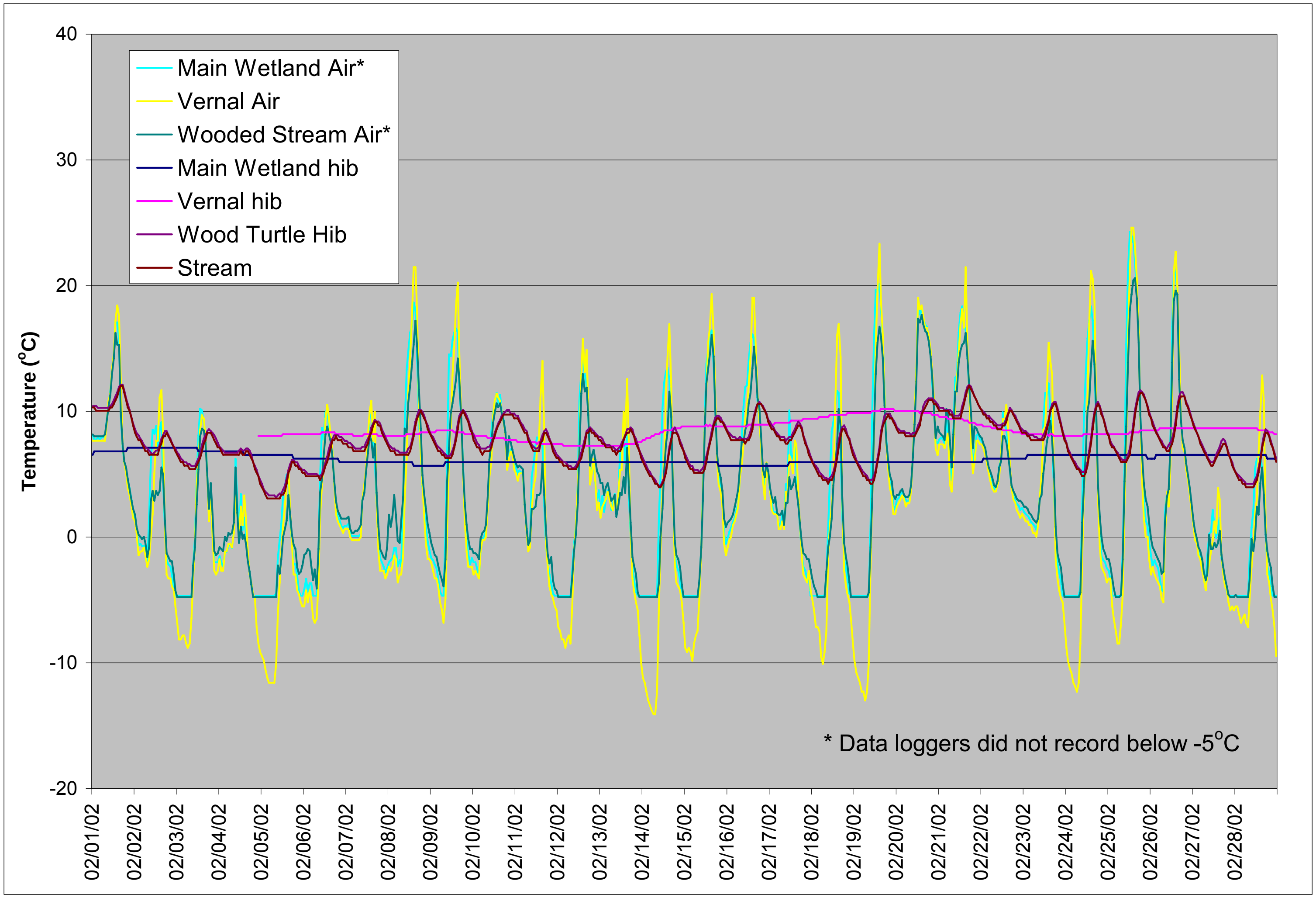
Environmental temperatures for November 2001.



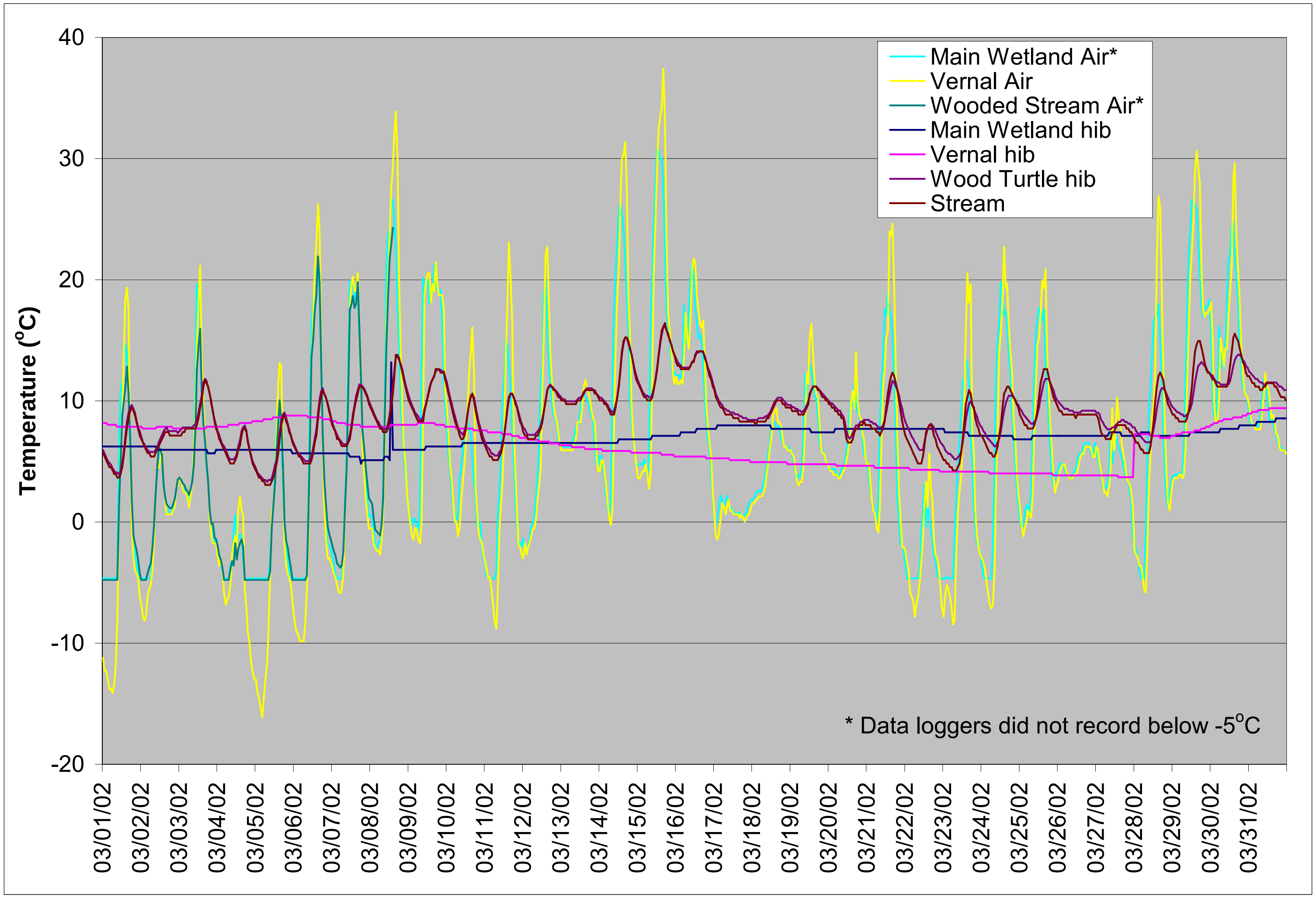
Environmental temperatures for December 2001.



Environmental temperatures for January 2002.



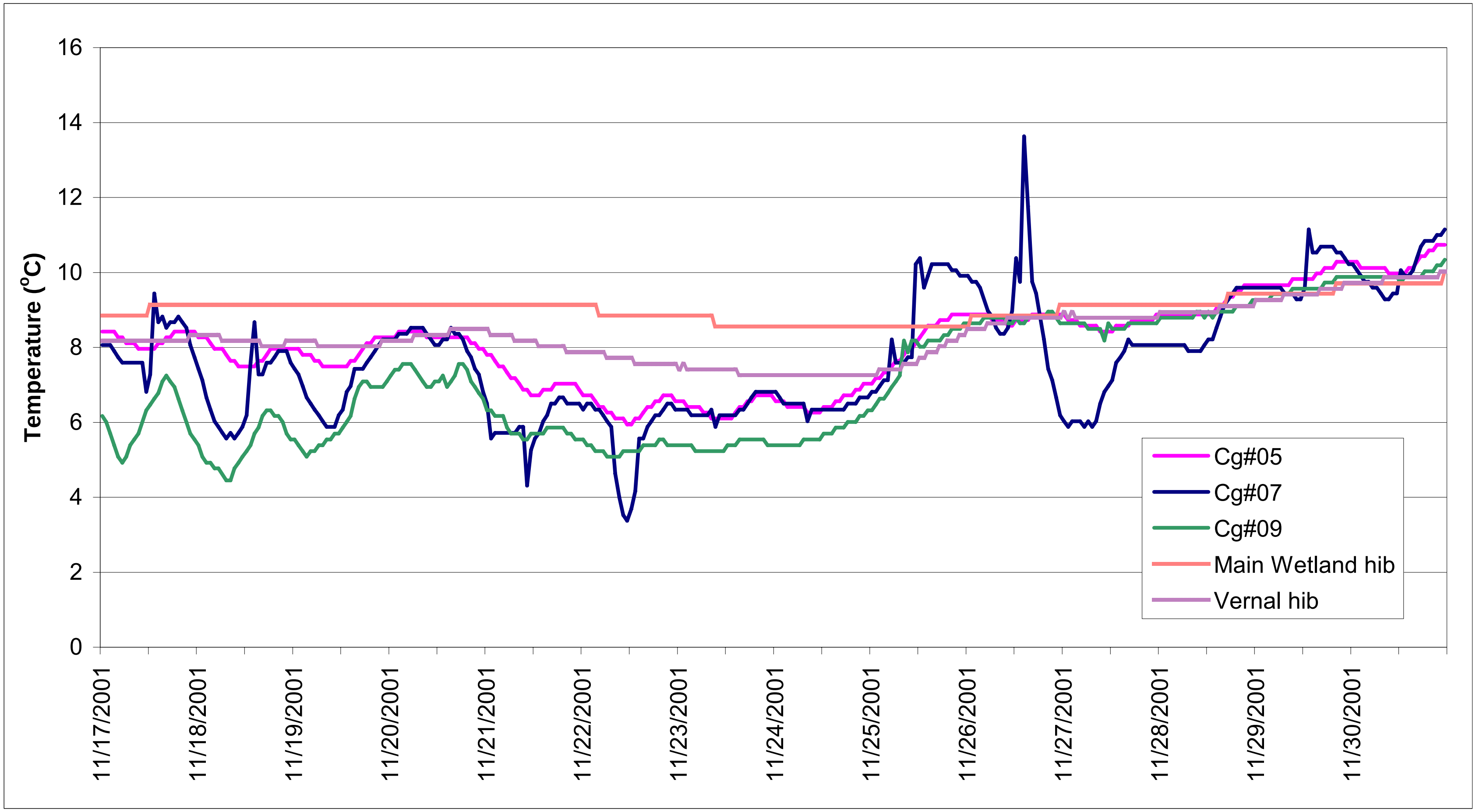
Environmental temperatures for February 2002.



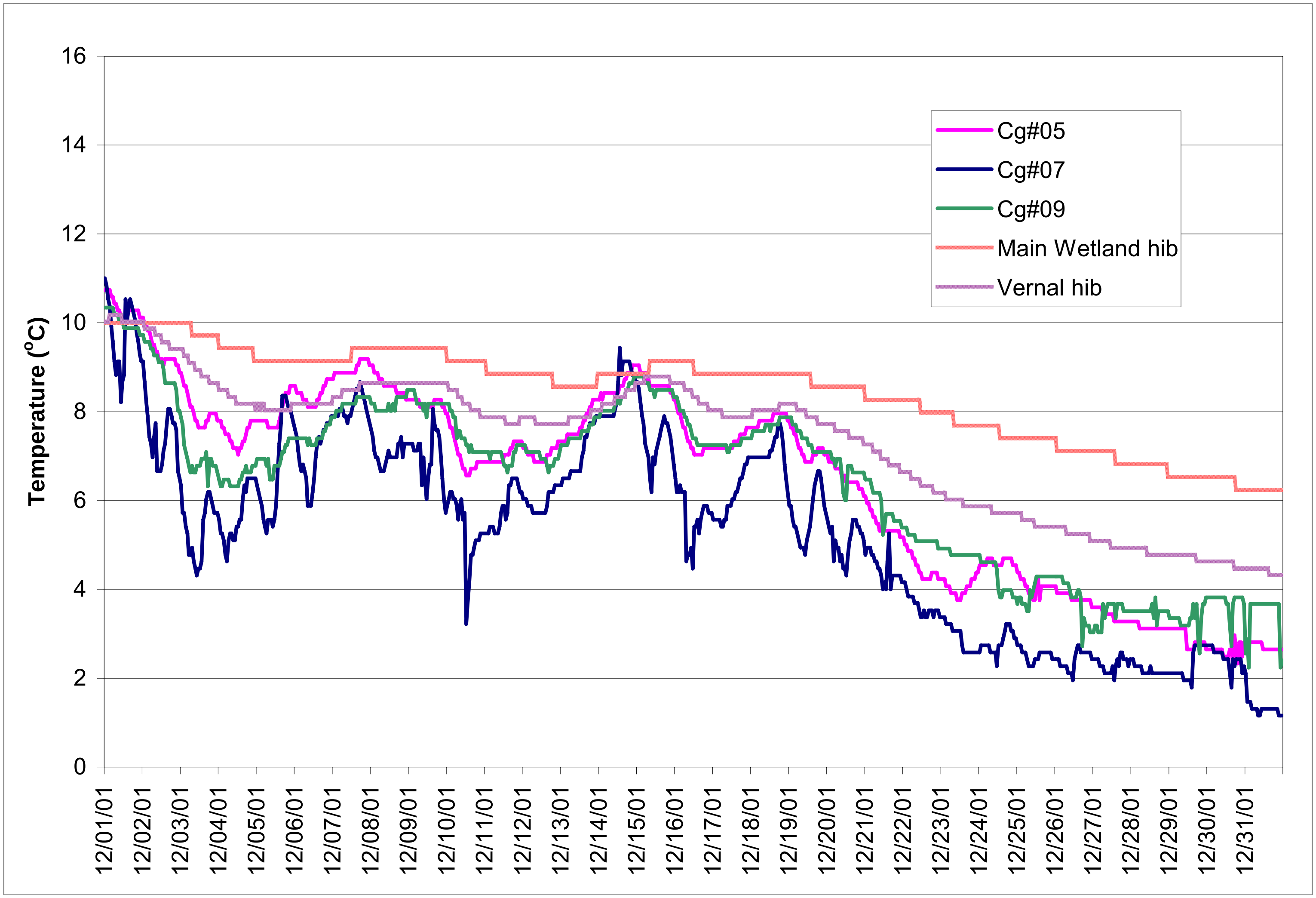
Environmental temperatures for March 2002.

APPENDIX VII

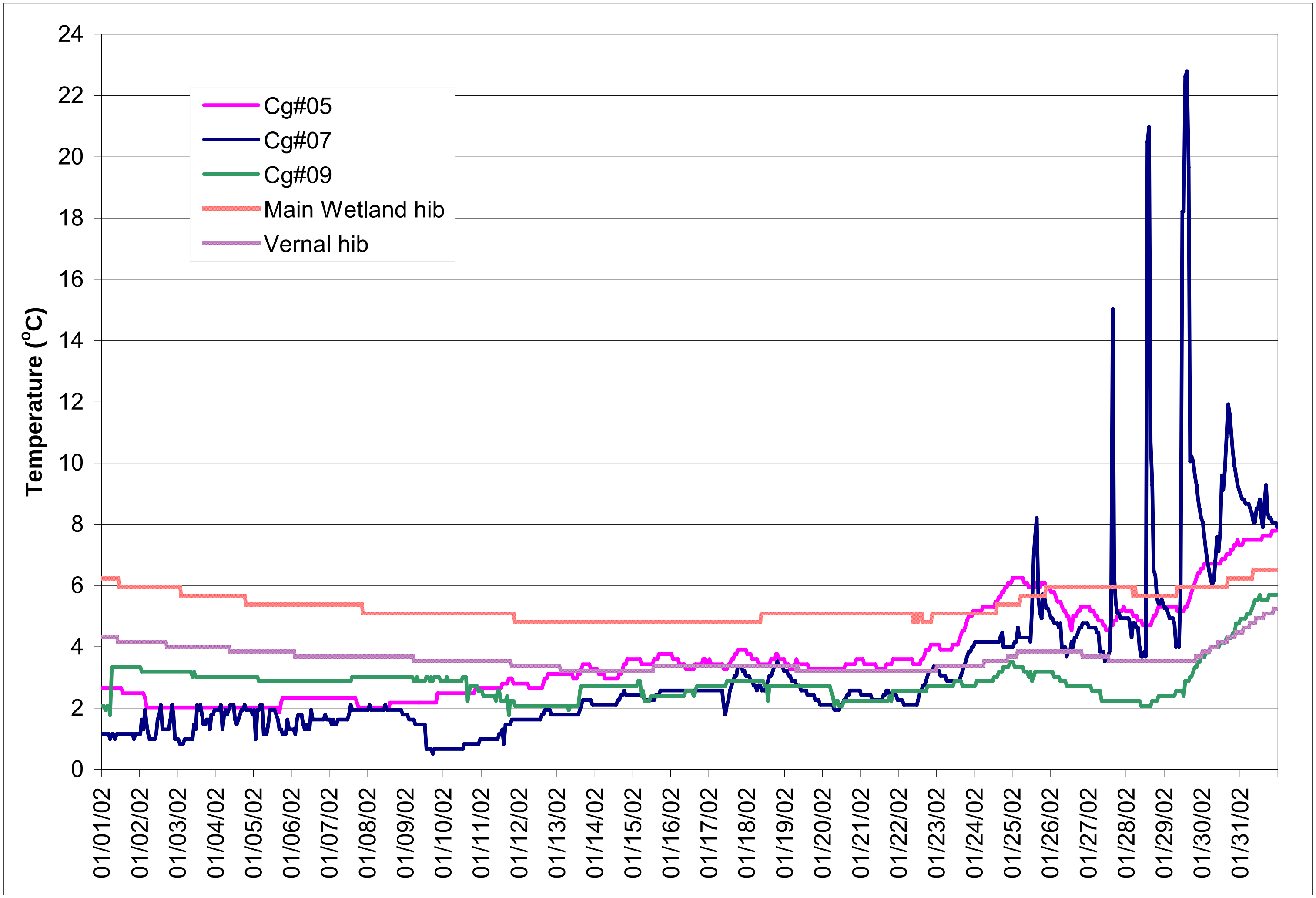
Spotted Turtle (*Clemmys guttata*) Temperatures



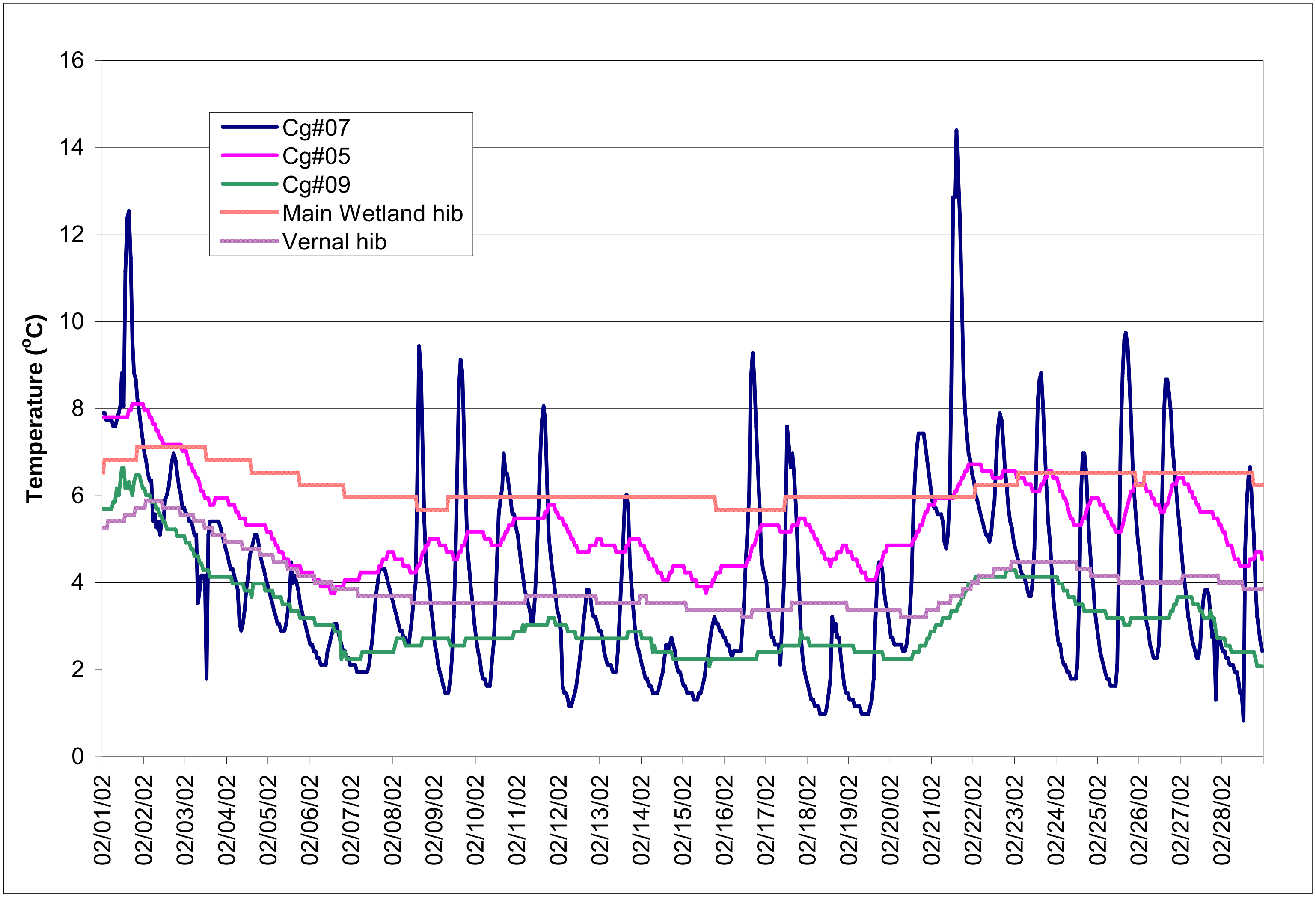
Spotted Turtle and hibernaculum temperatures for November 2001.



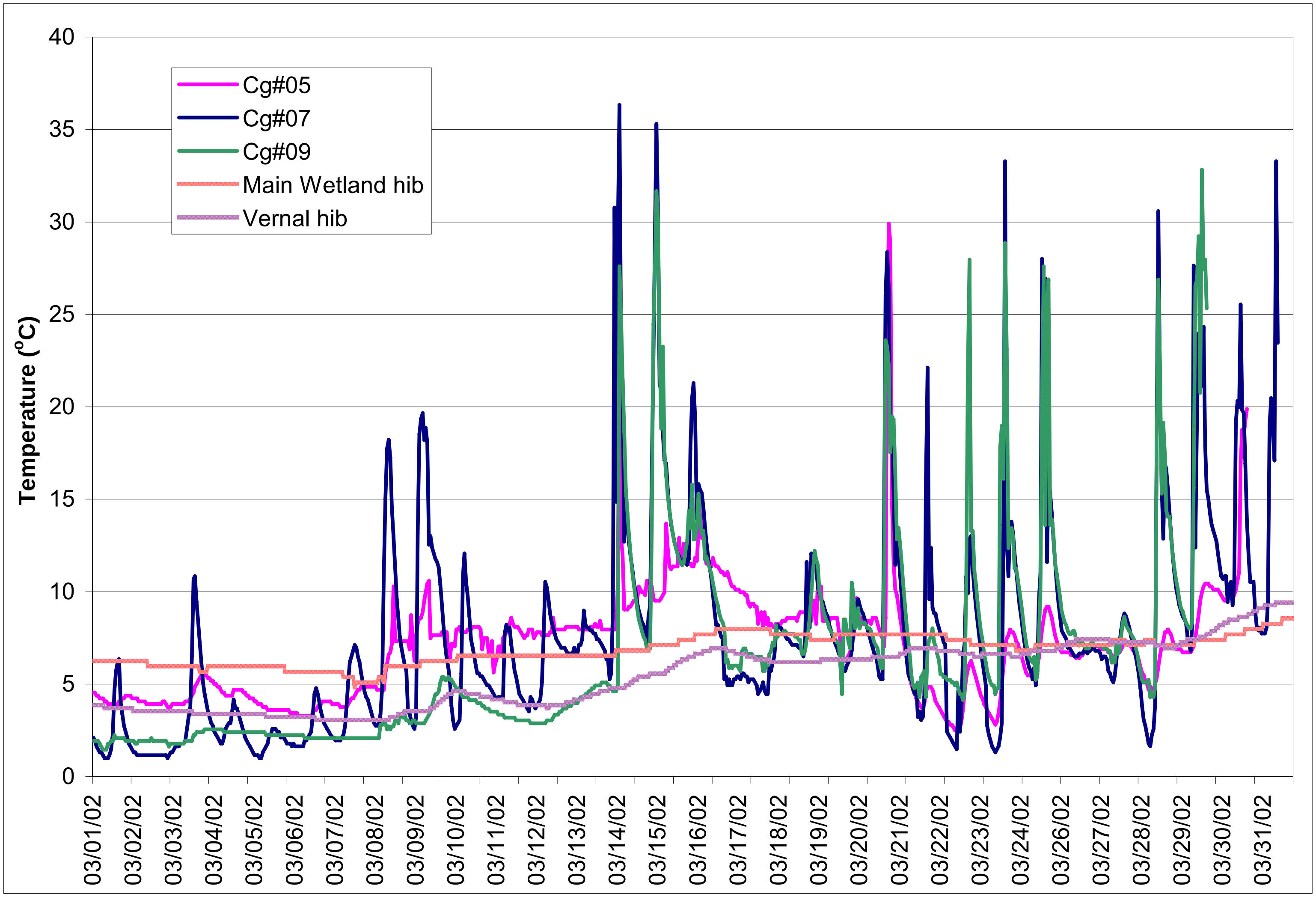
Spotted Turtle and hibernaculum temperatures for December 2001.



Spotted Turtle and hibernaculum temperatures for January 2002.



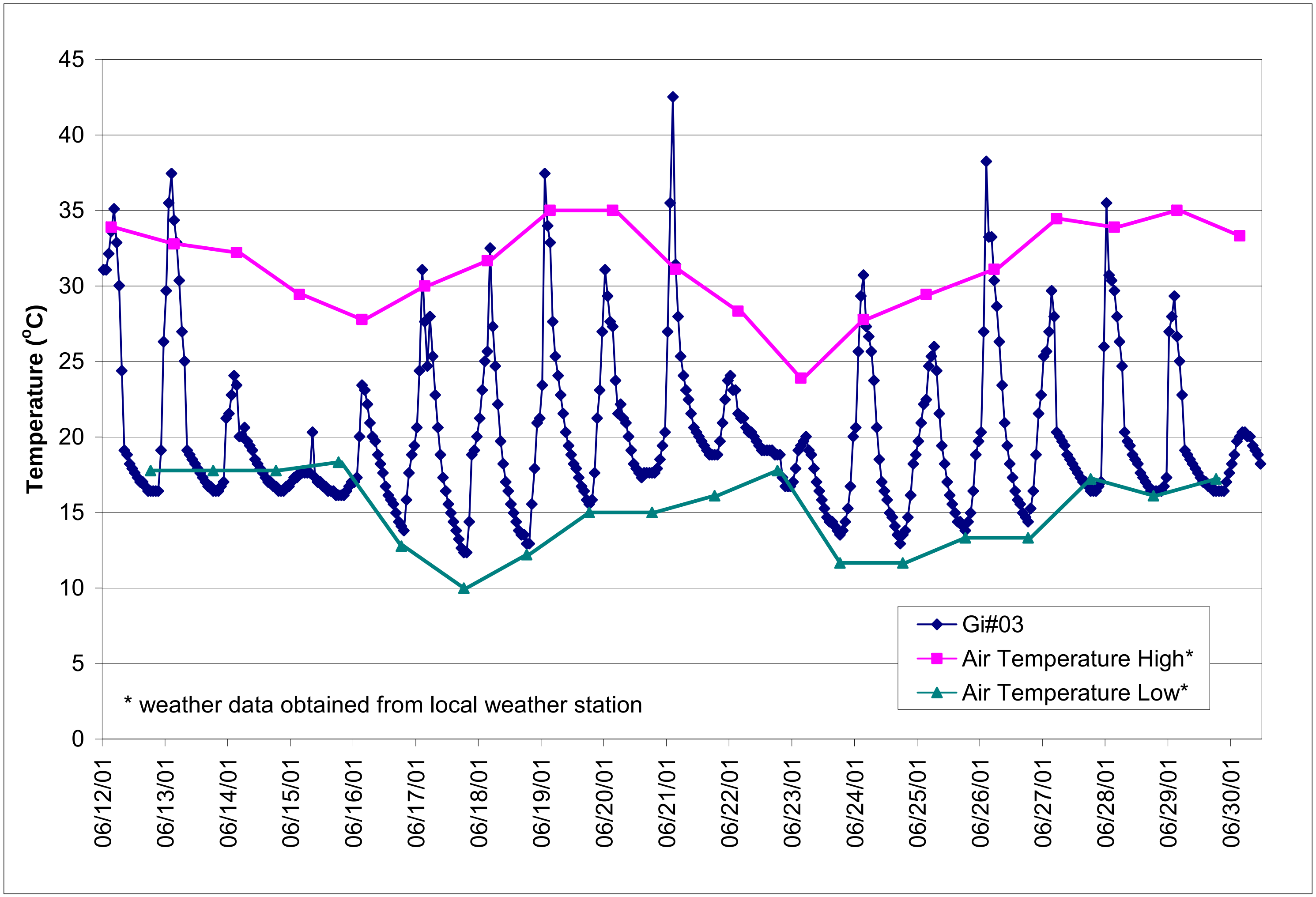
Spotted Turtle and hibernaculum temperatures for February 2002.



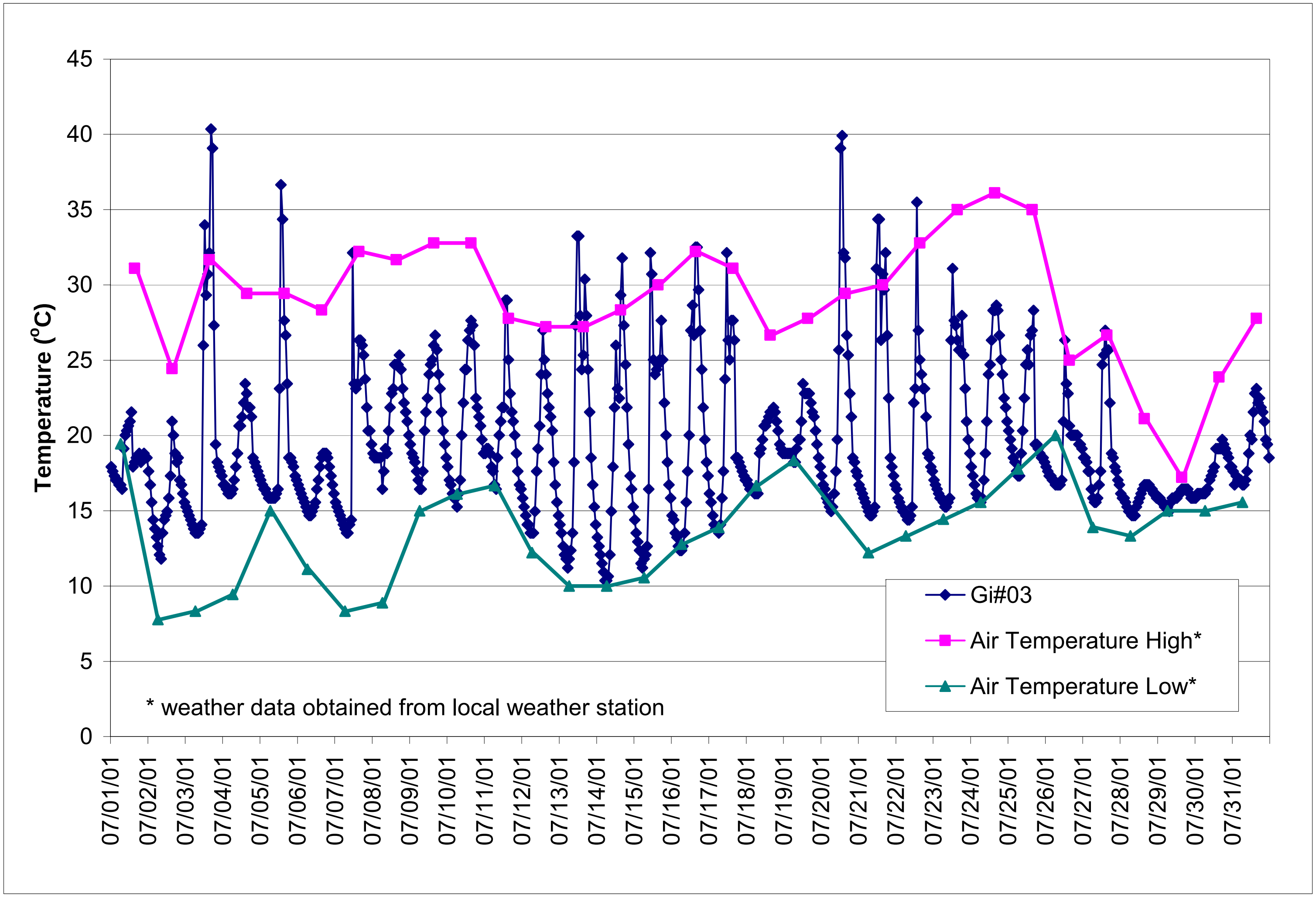
Spotted Turtle and hibernaculum temperatures for March 2002.

APPENDIX VIII

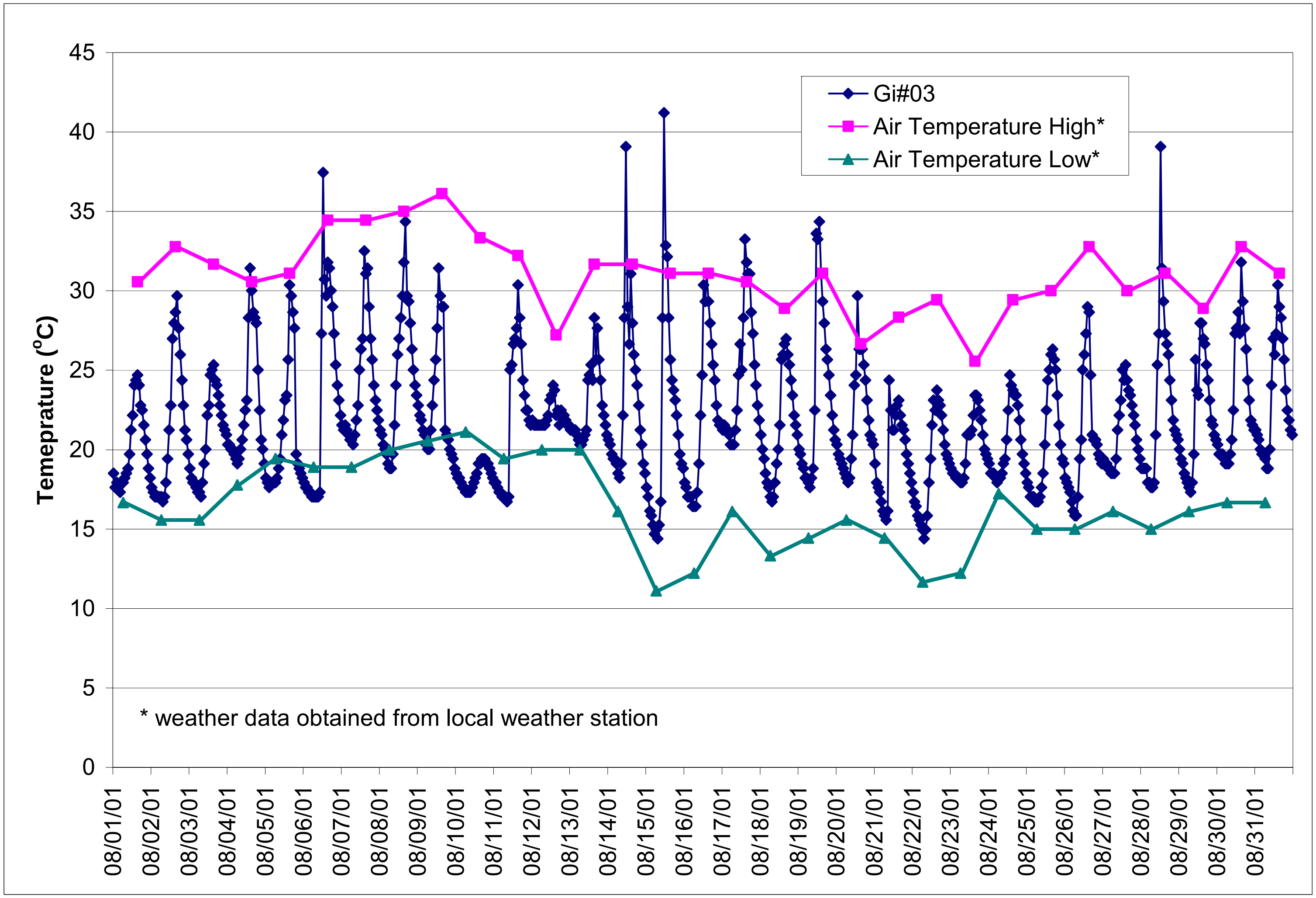
Wood Turtle (*Glyptemys insculpta*) #03 temperatures



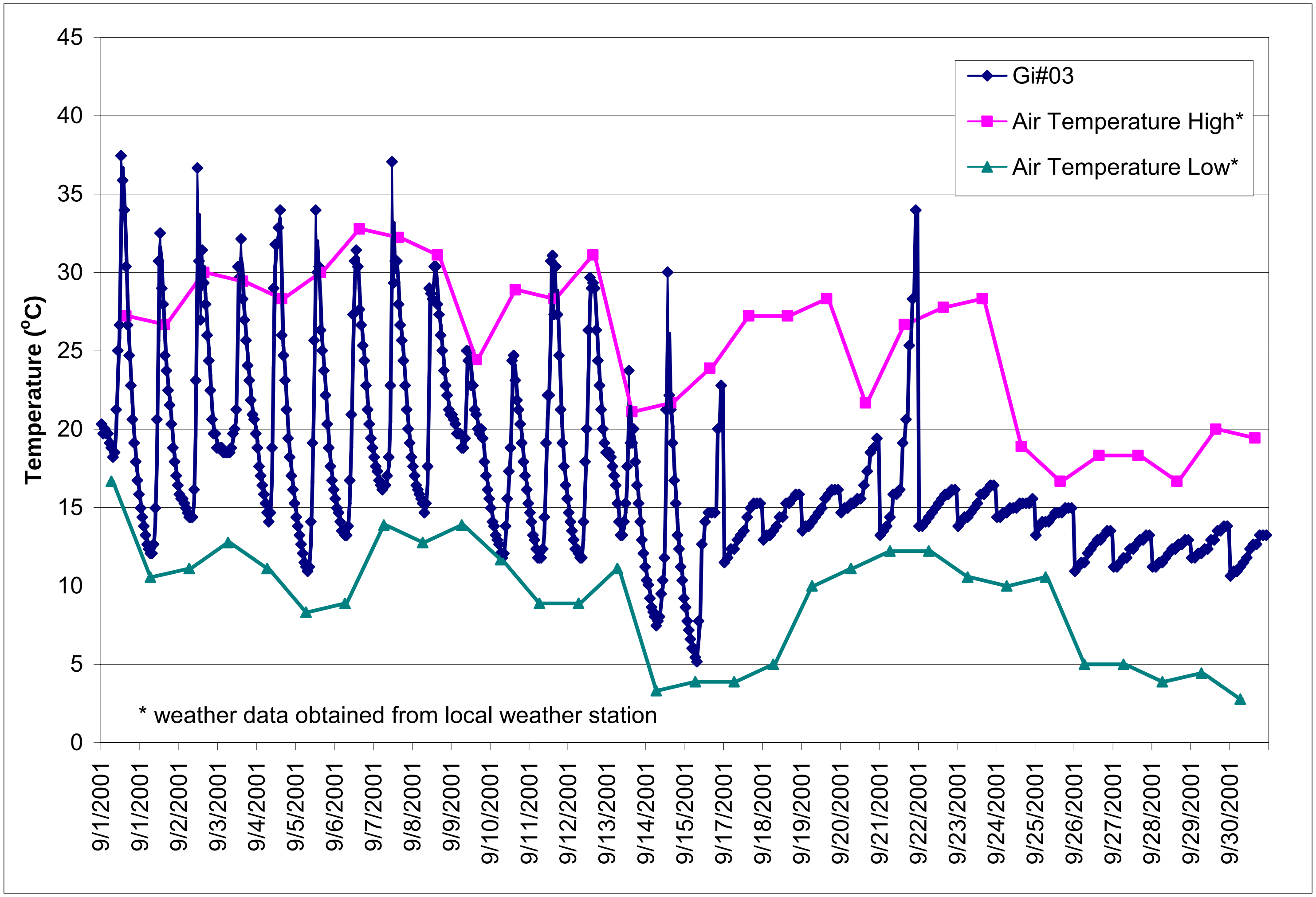
Gi#03 temperatures for June 2001.



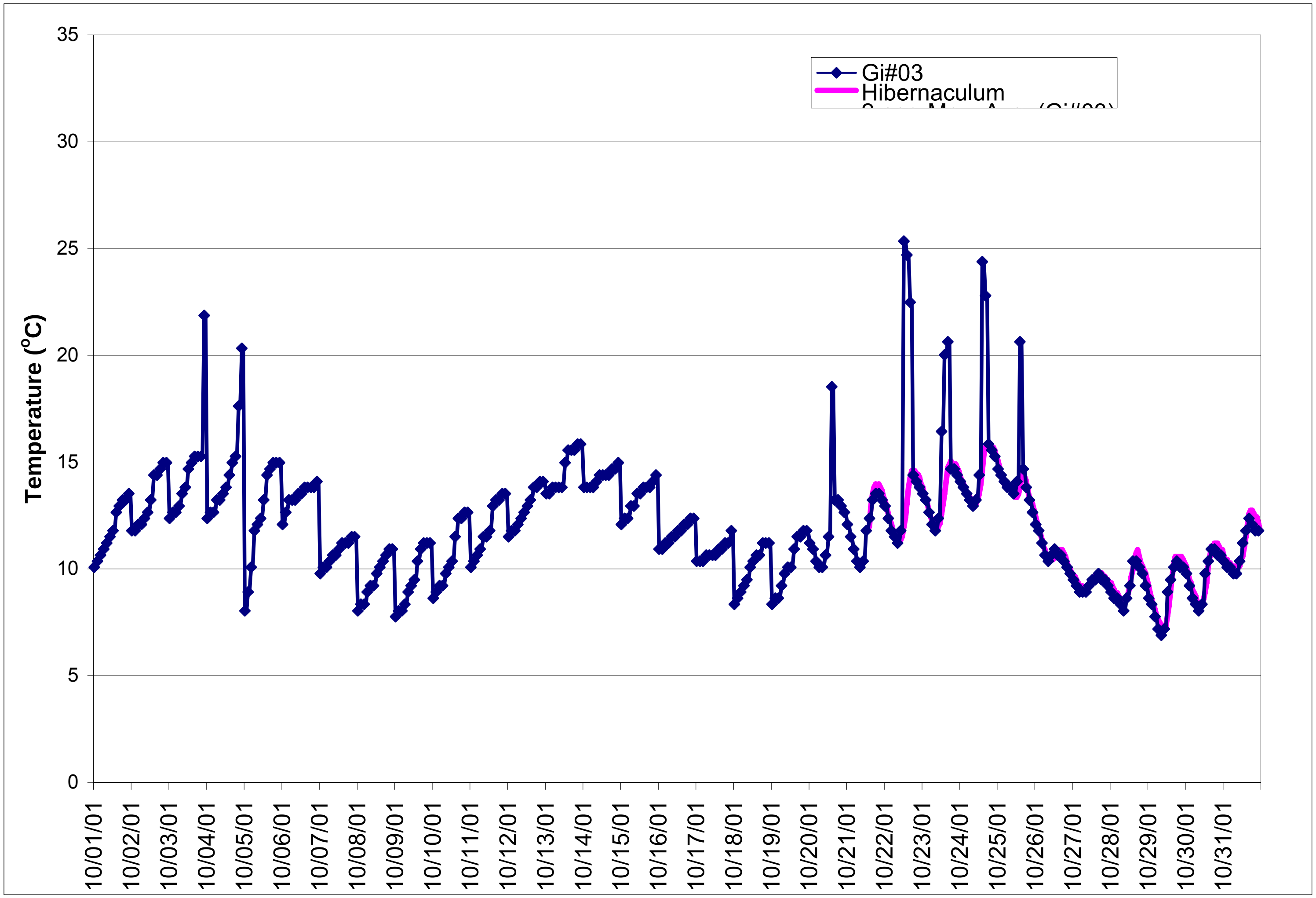
Gi#03 temperatures for July 2001.



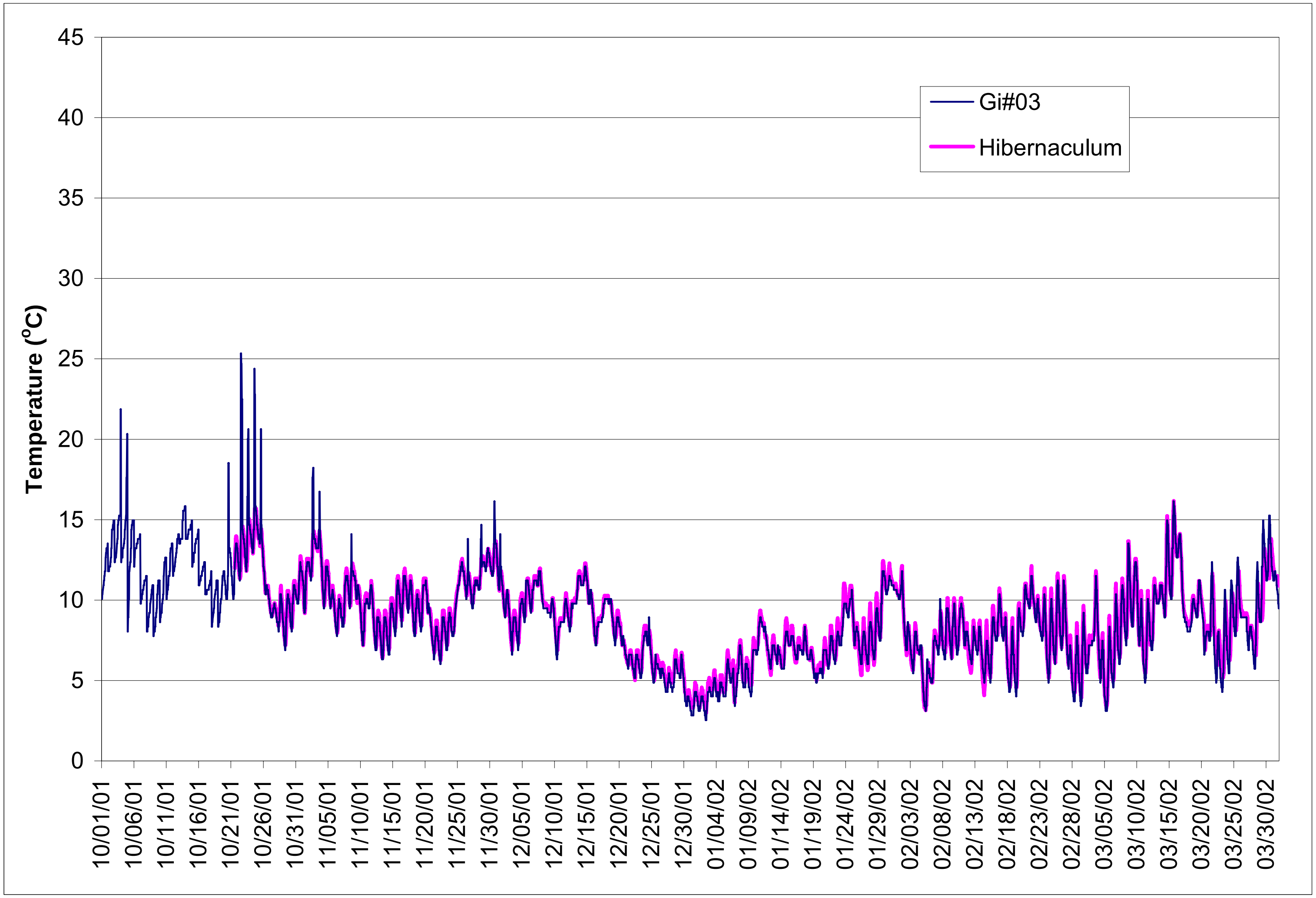
Gi#03 temperatures for August 2001.



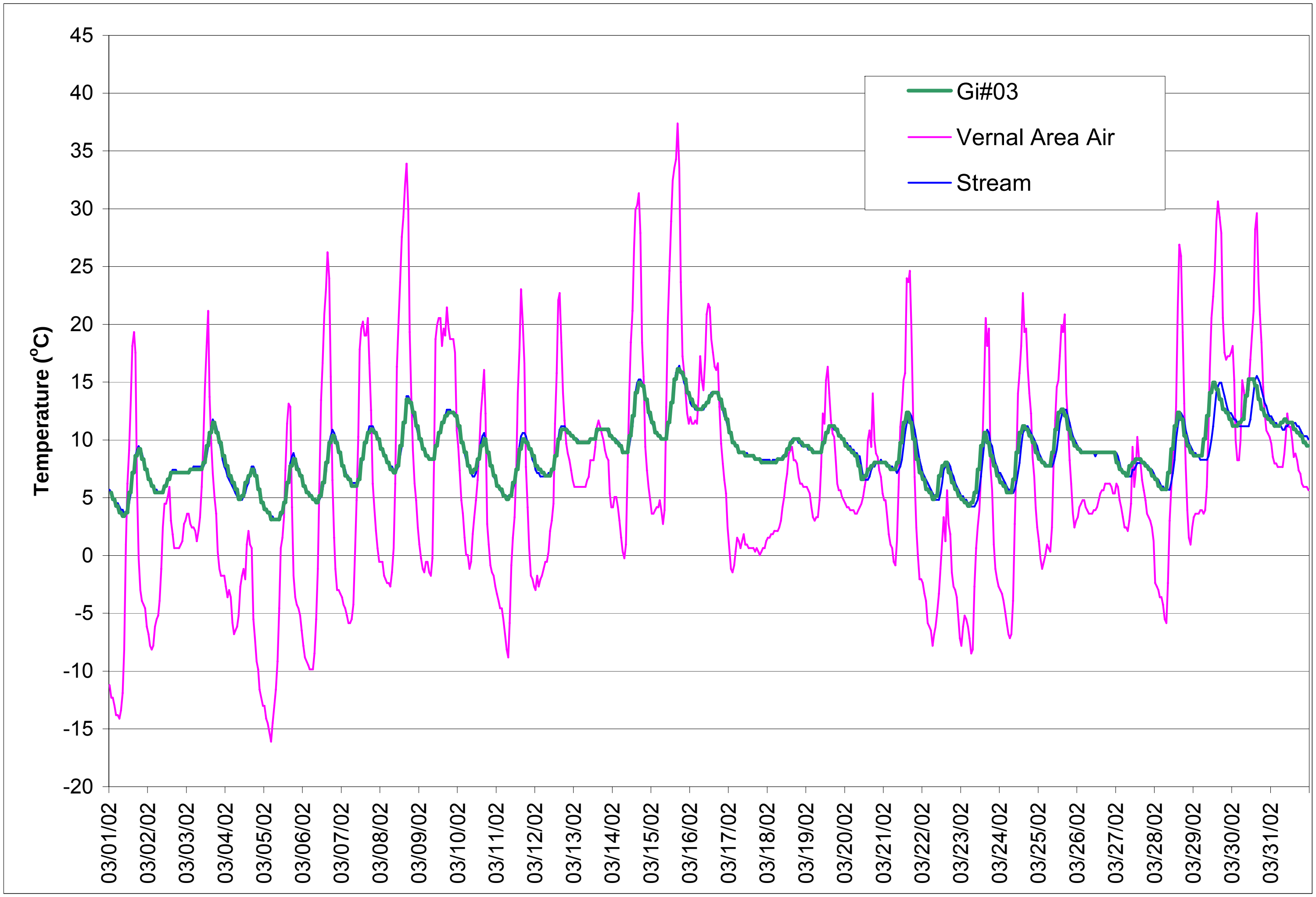
Gi#03 temperatures for September 2001.



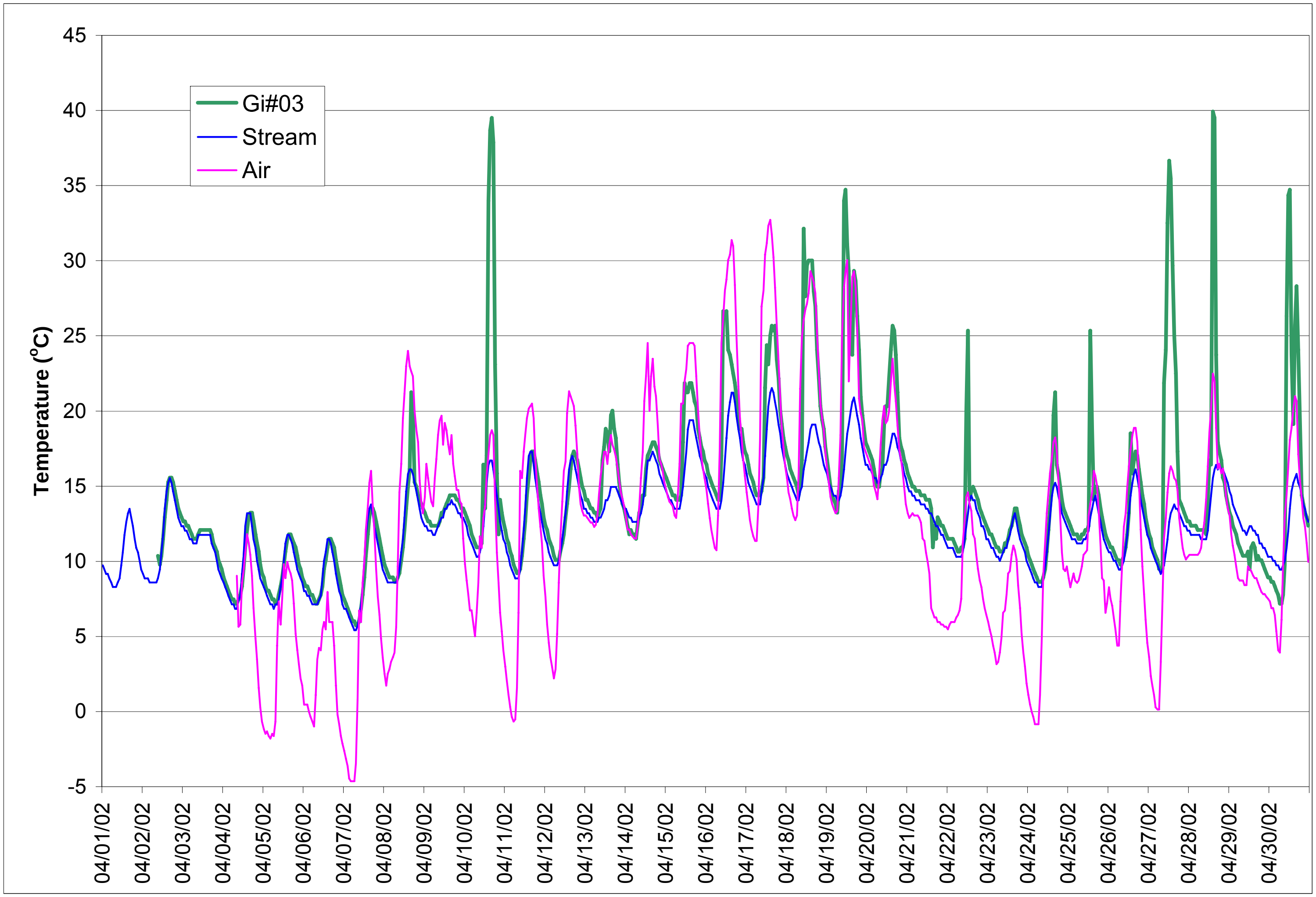
Gi#03 temperatures for October 2001.



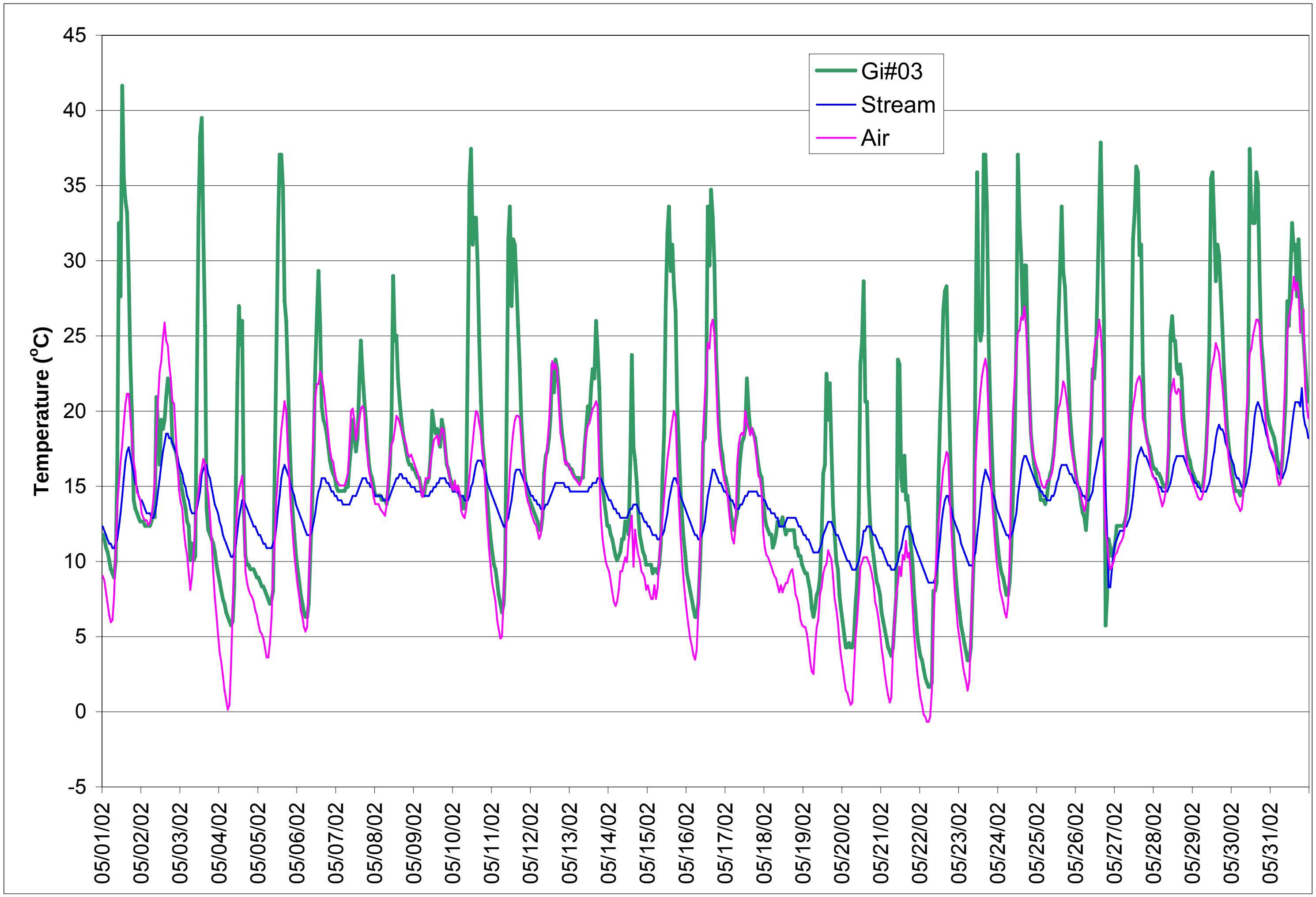
Gi#03 temperatures for October 2001 through March 2002.



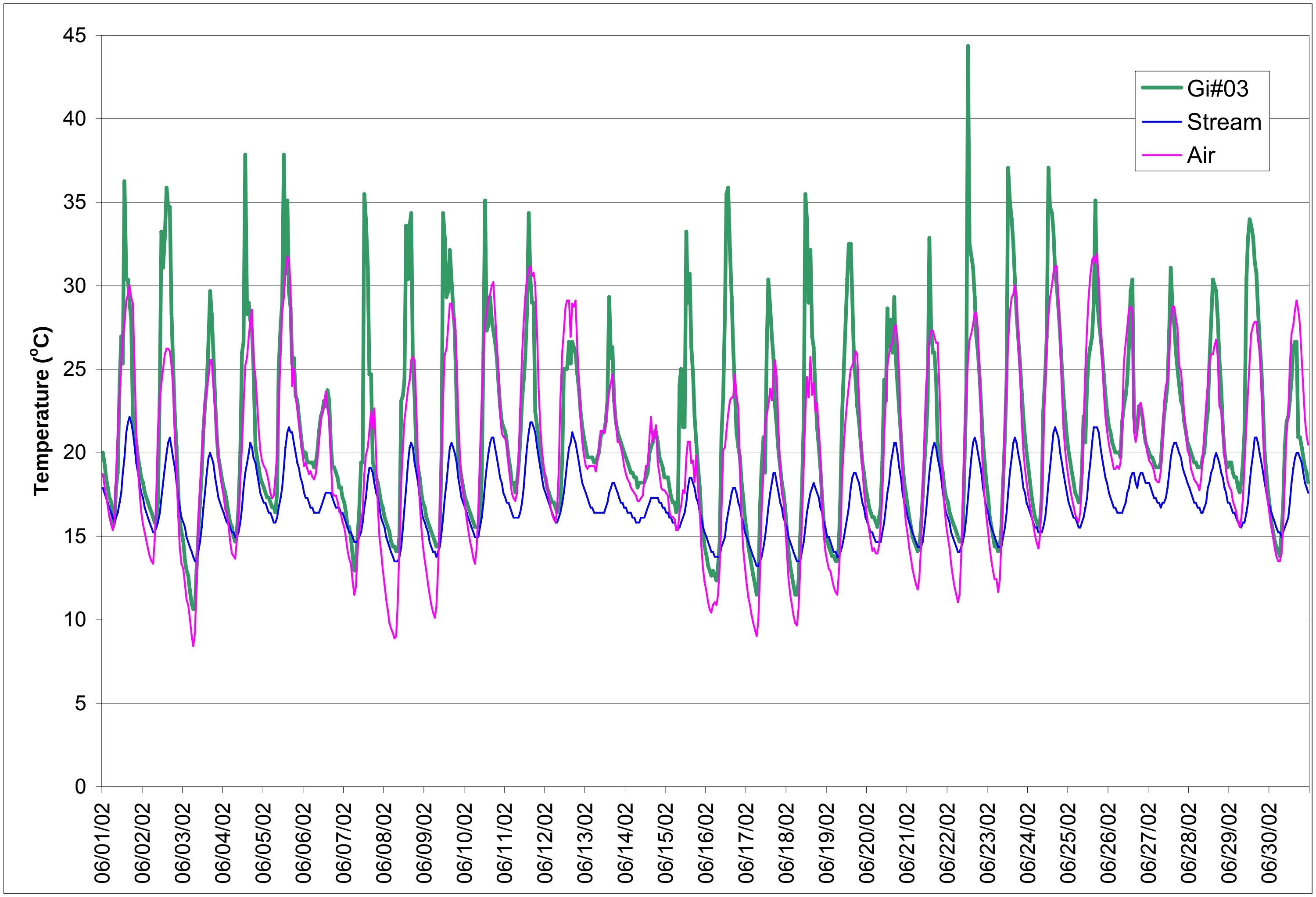
Gi#03 temperatures for March 2002.



Gi#03 temperatures for April 2002.



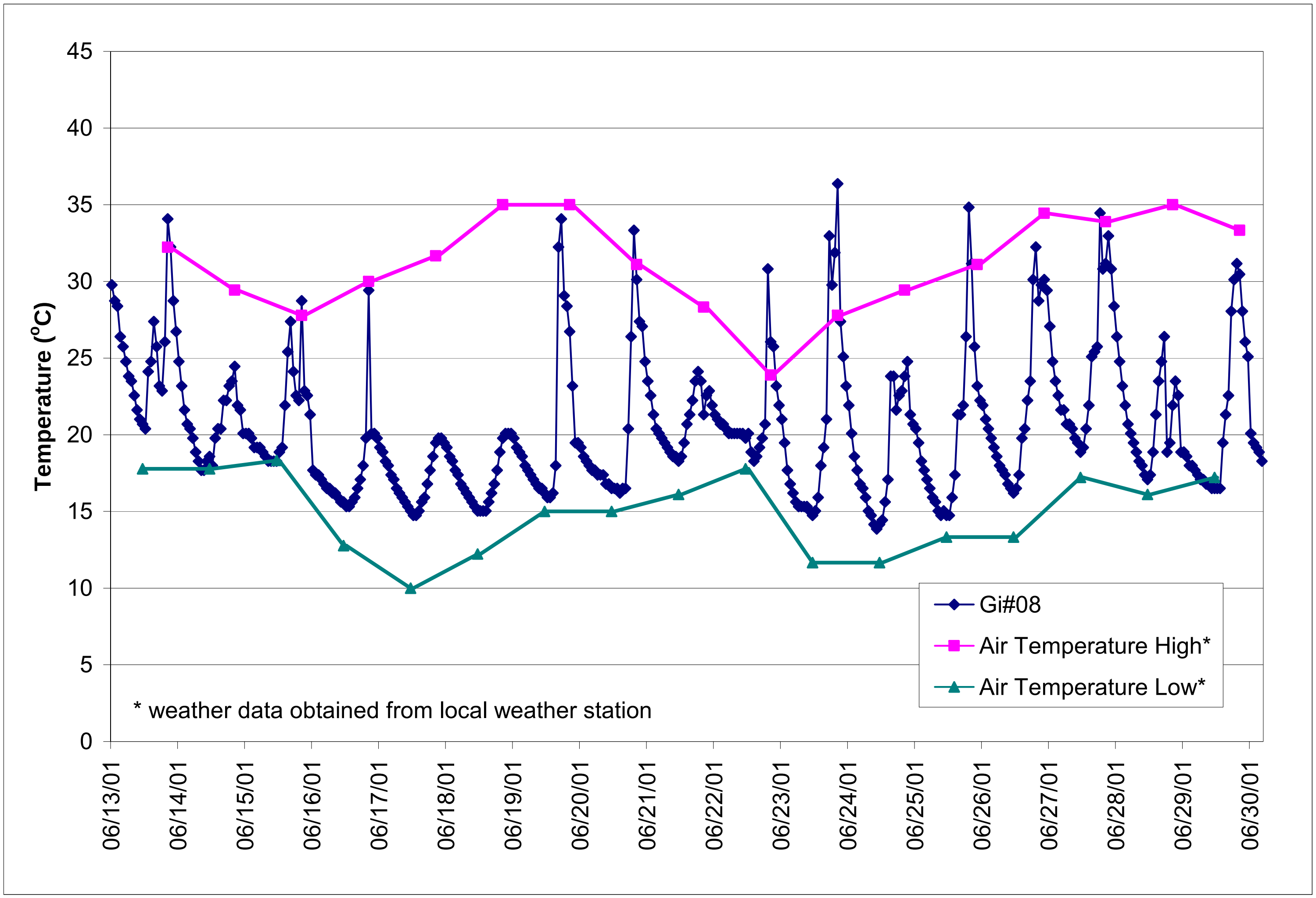
Gi#03 temperatures for May 2002.



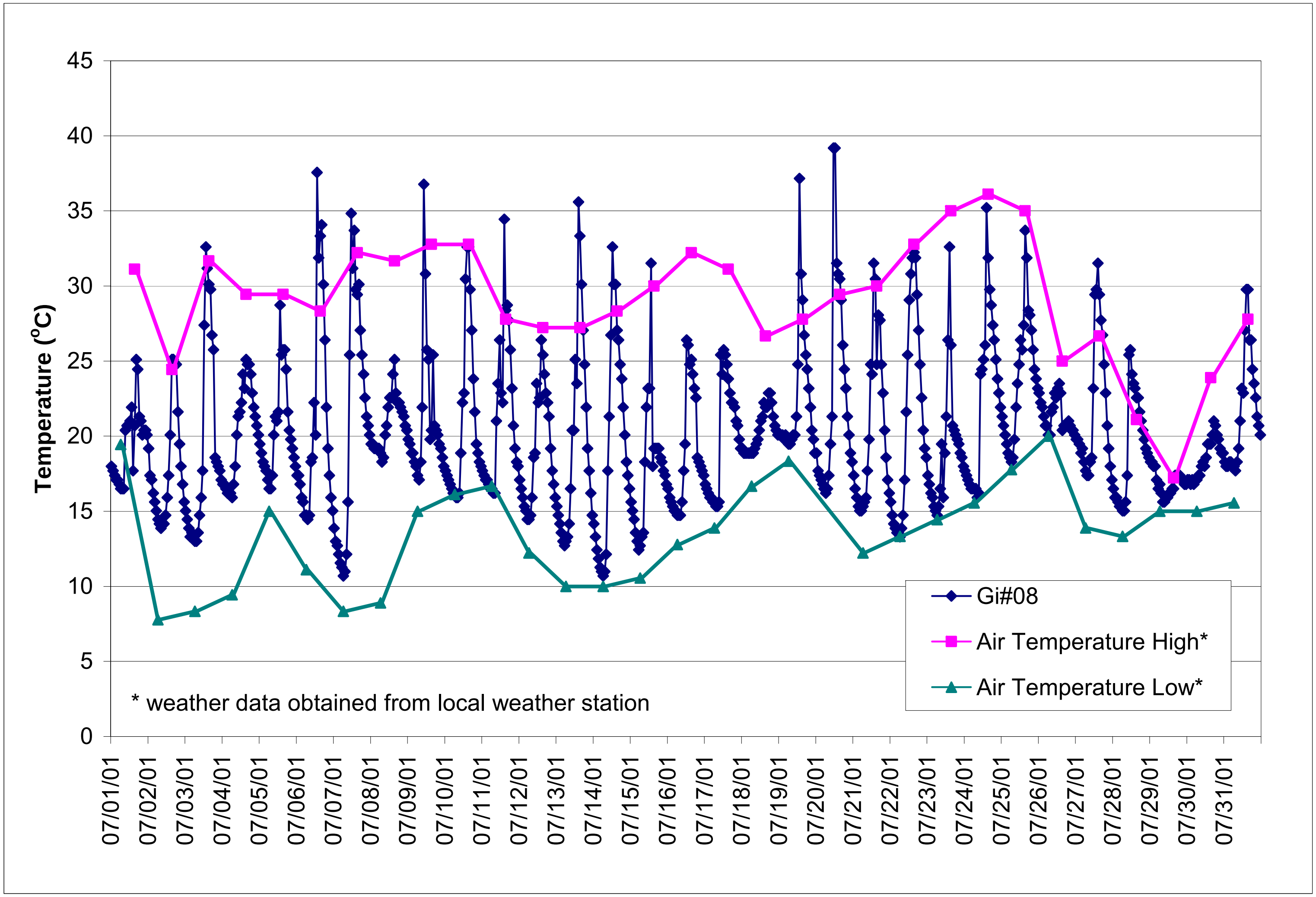
Gi#03 temperatures for June 2002.

APPENDIX IX

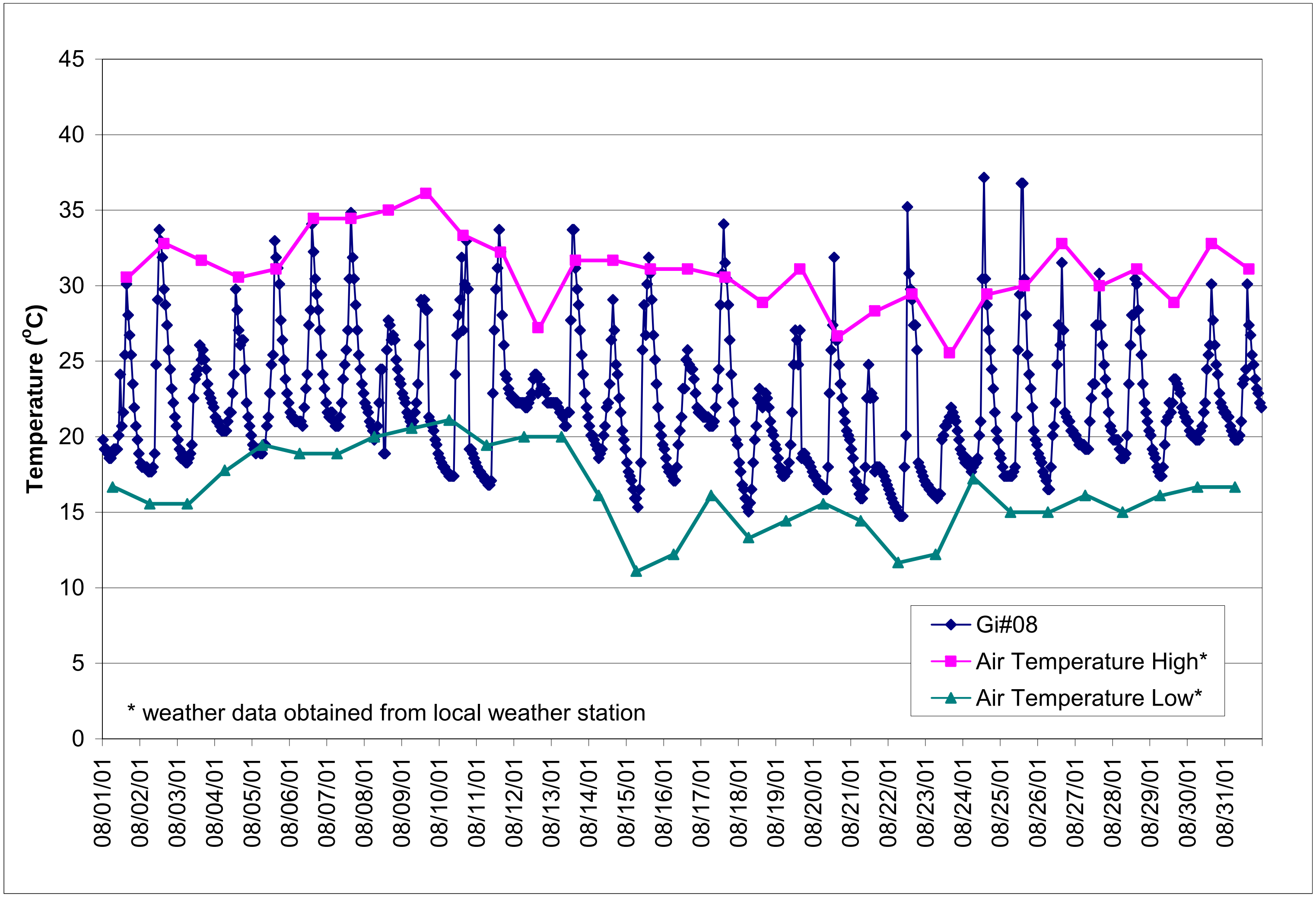
Wood Turtle (*Glyptemys insculpta*) #08 temperatures



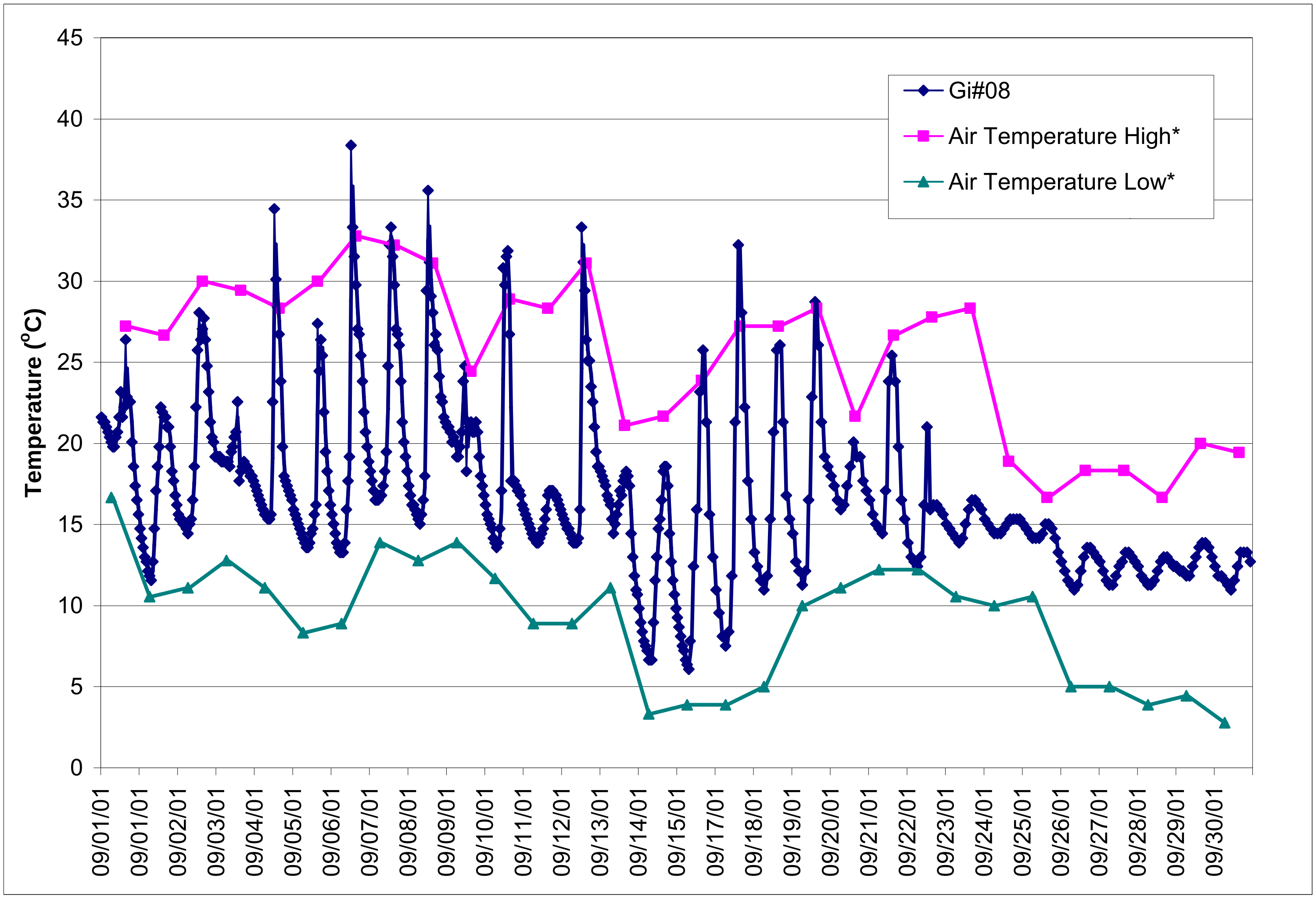
Gi#08 temperatures for June 2001.



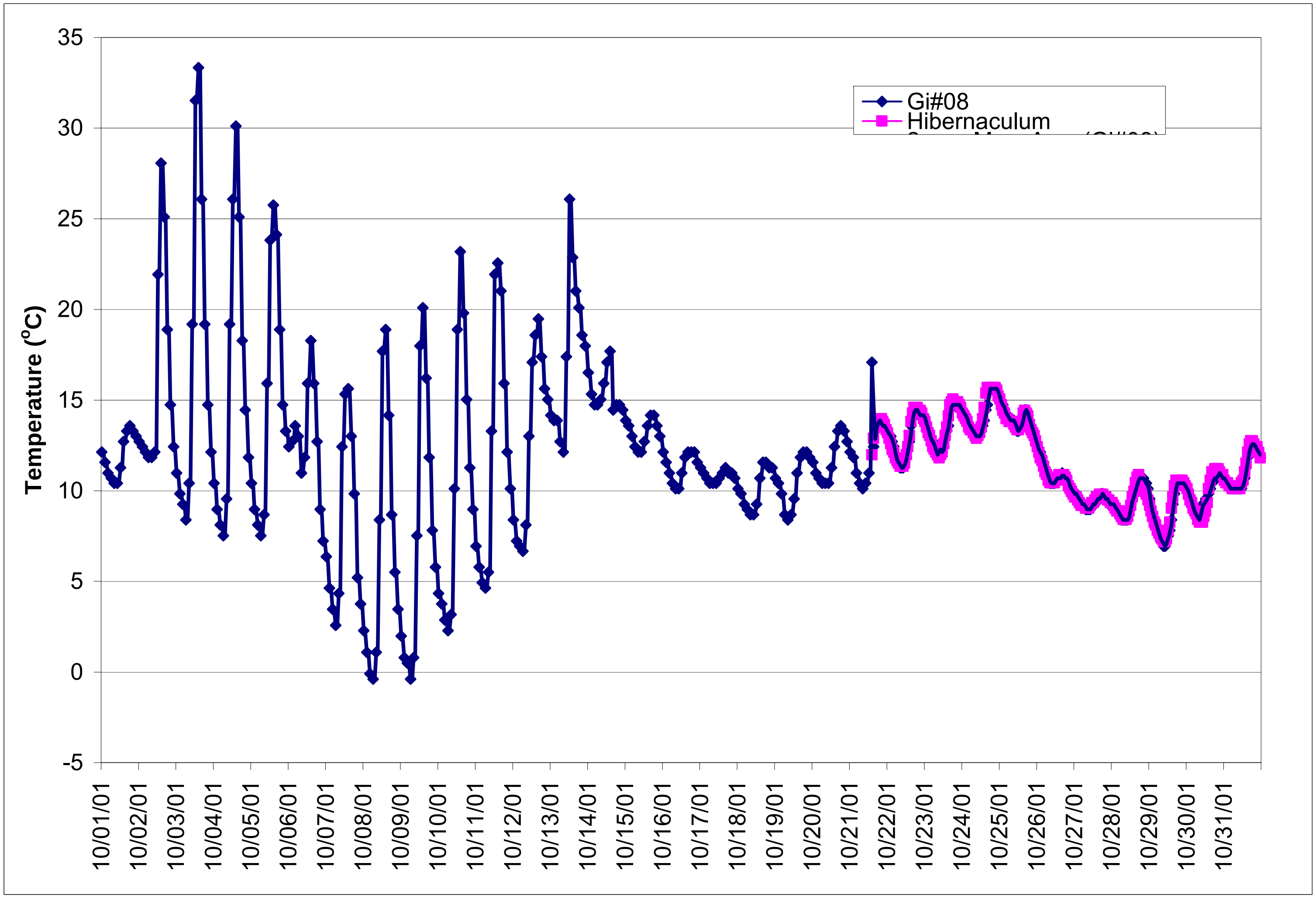
Gi#08 temperatures for July 2001.



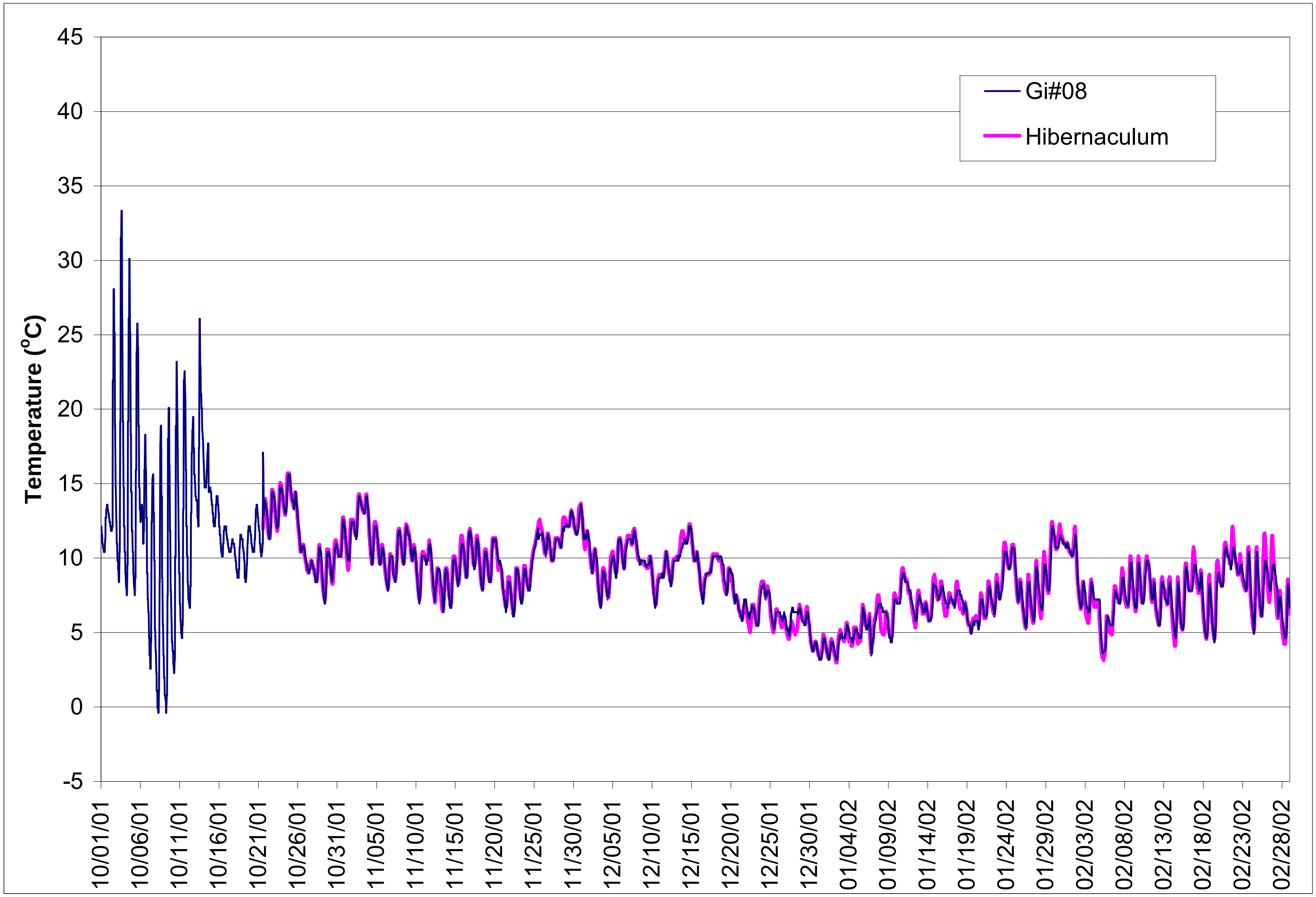
Gi#08 temperatures for August 2001.



Gi#08 temperatures for September 2001.



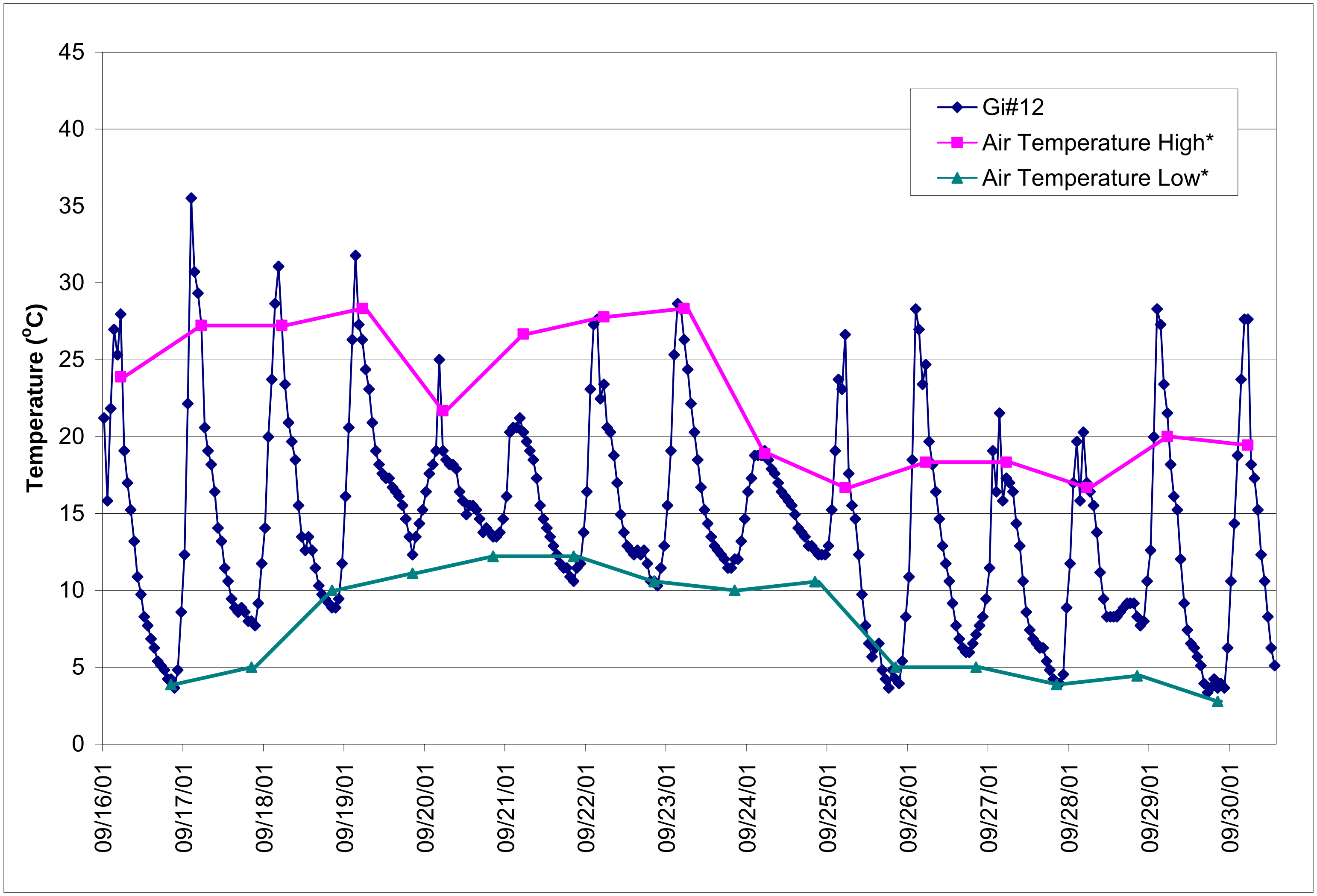
Gi#08 temperatures for October 2001.



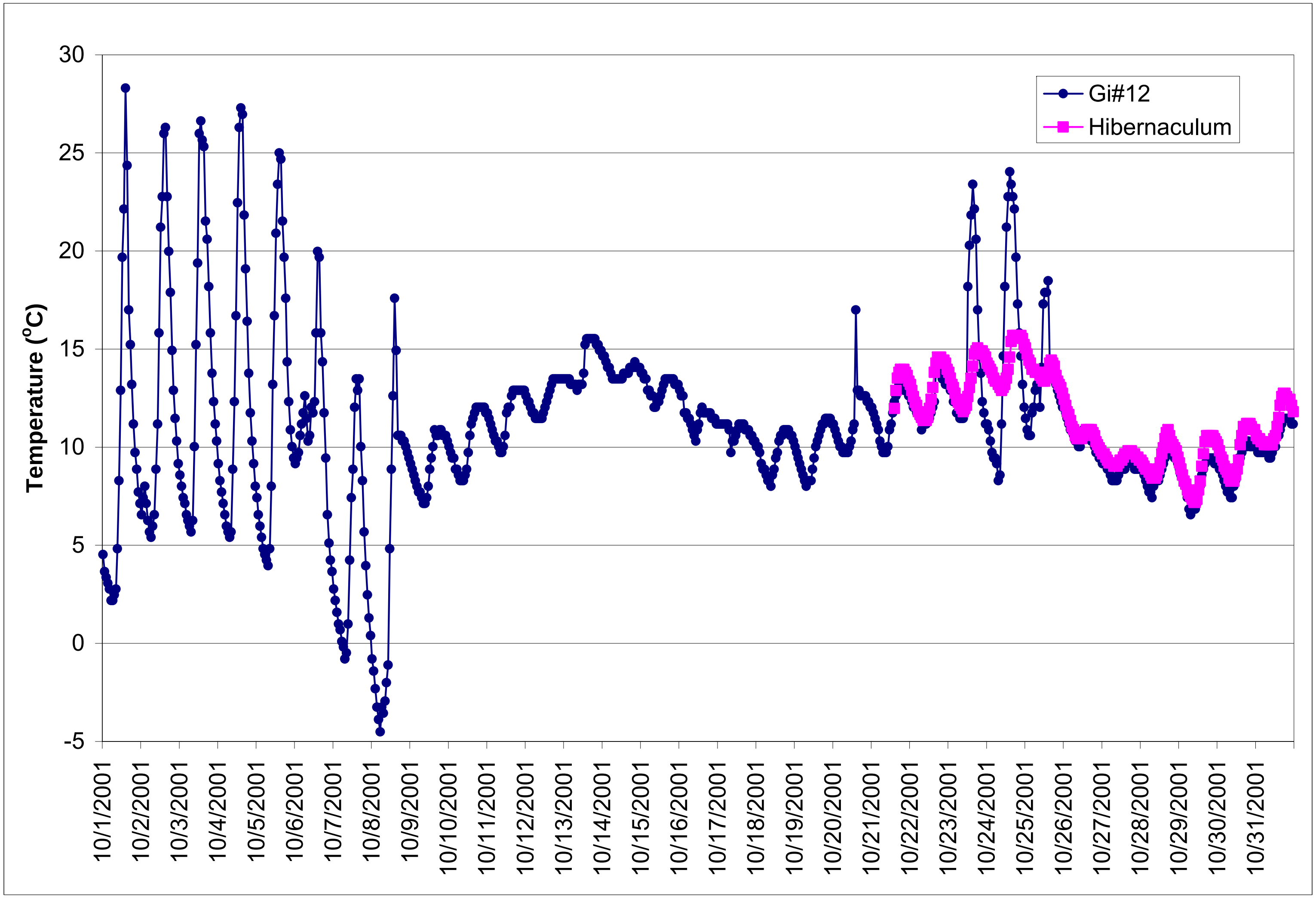
Gi#08 temperatures for October 2001 through February 2002.

APPENDIX X

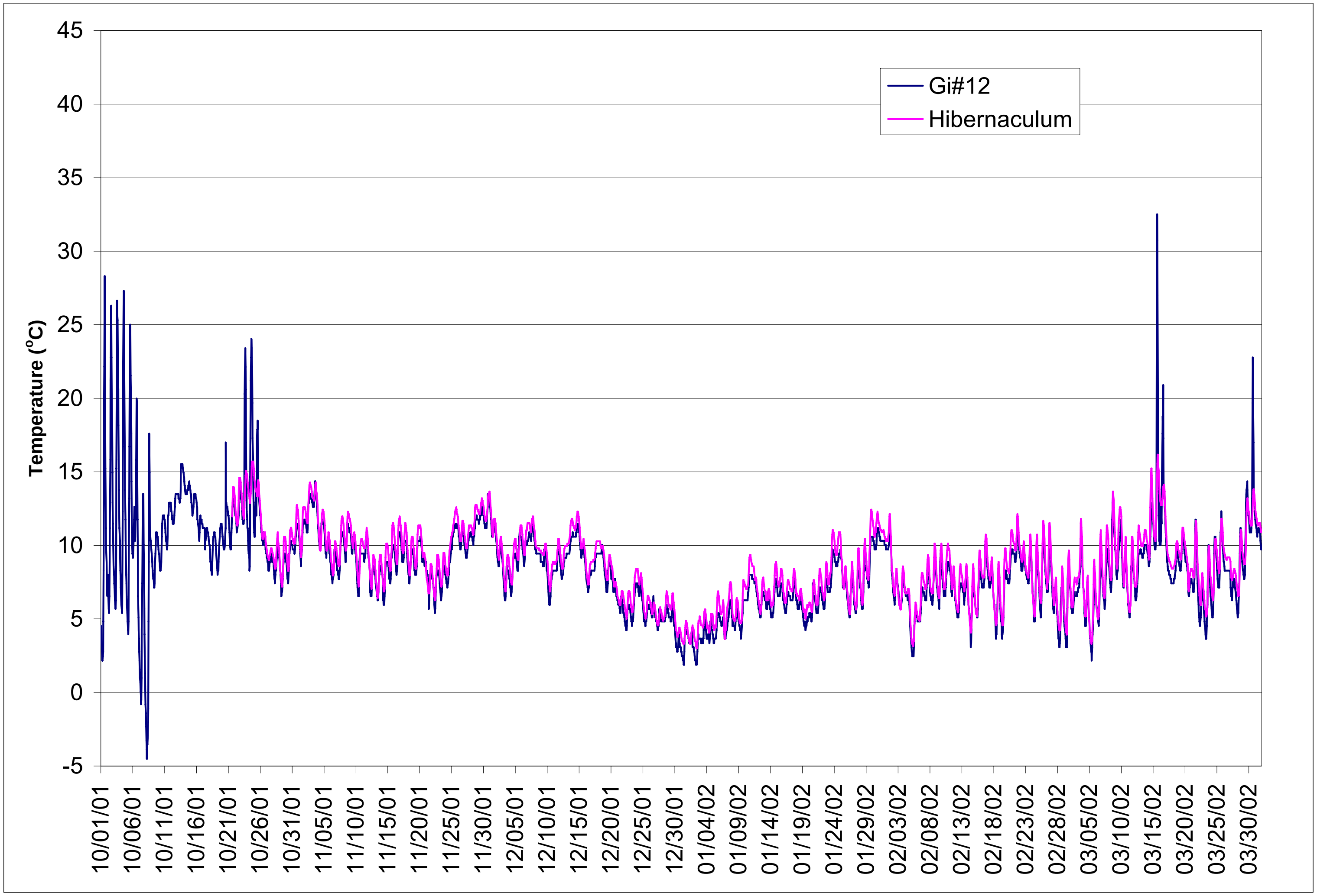
Wood Turtle (*Glyptemys insculpta*) #12 temperatures



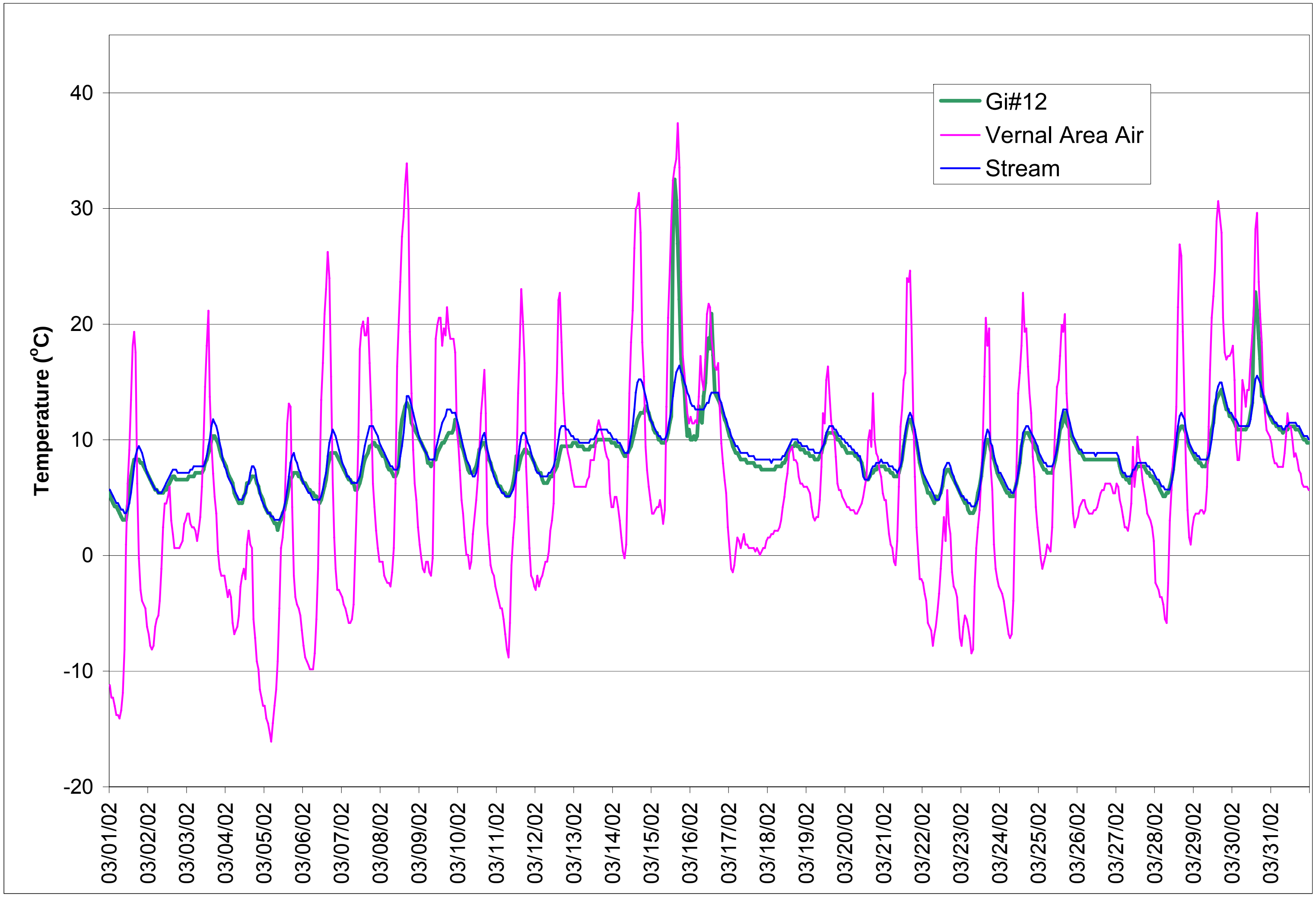
Gi#12 temperatures for September 2001.



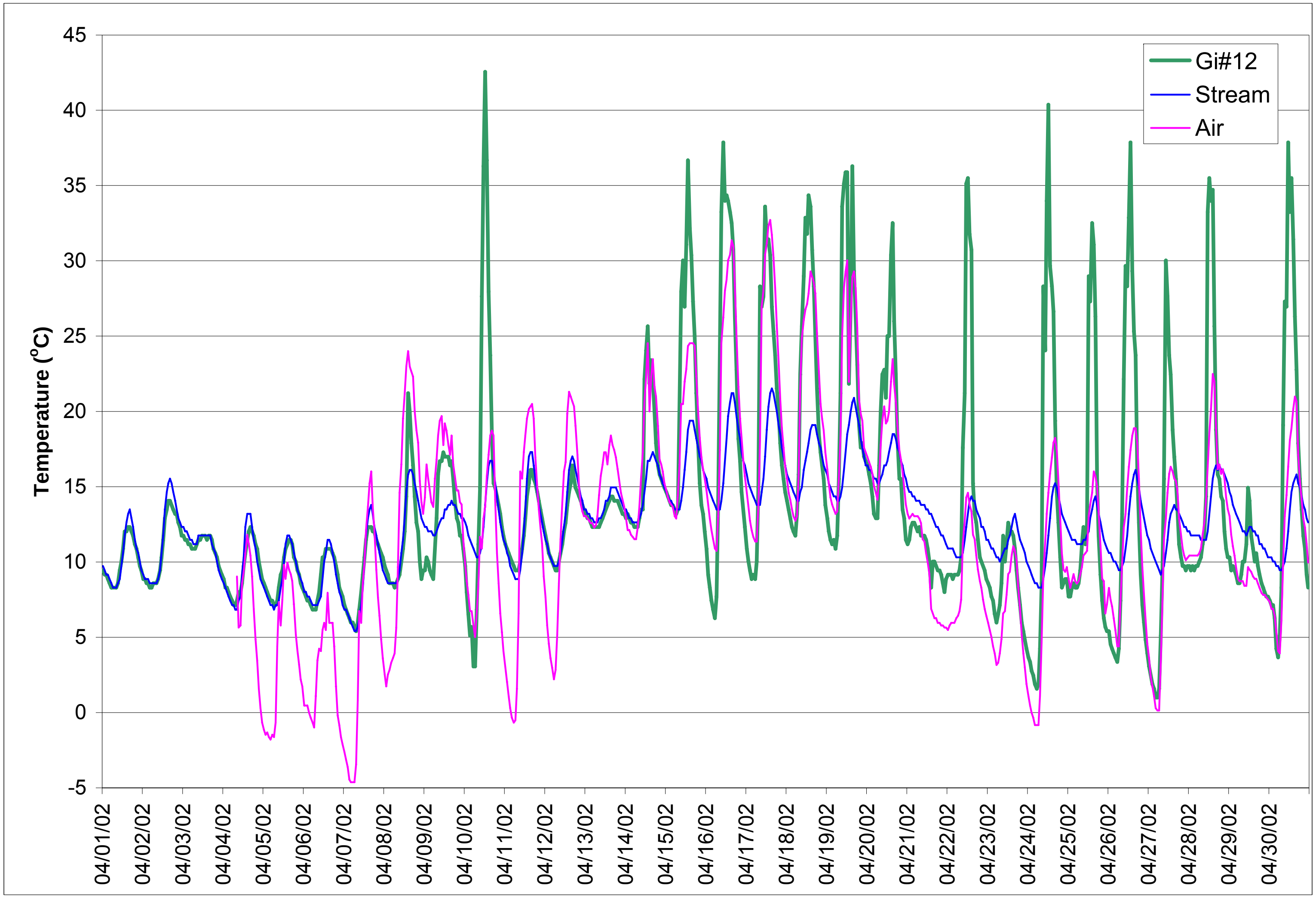
Gi#12 temperatures for October 2001.



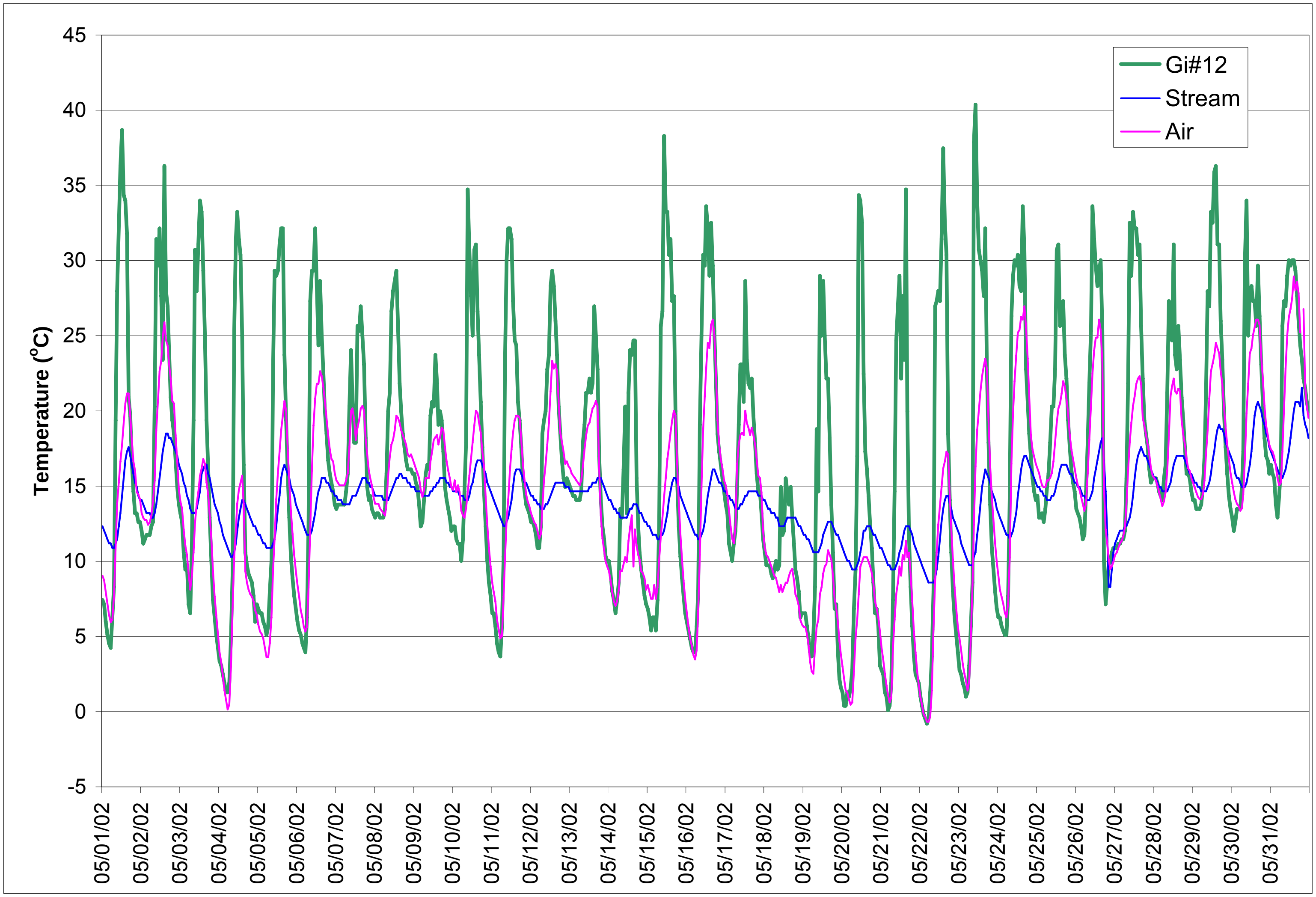
Gi#12 temperatures for October 2001 through March 2002.



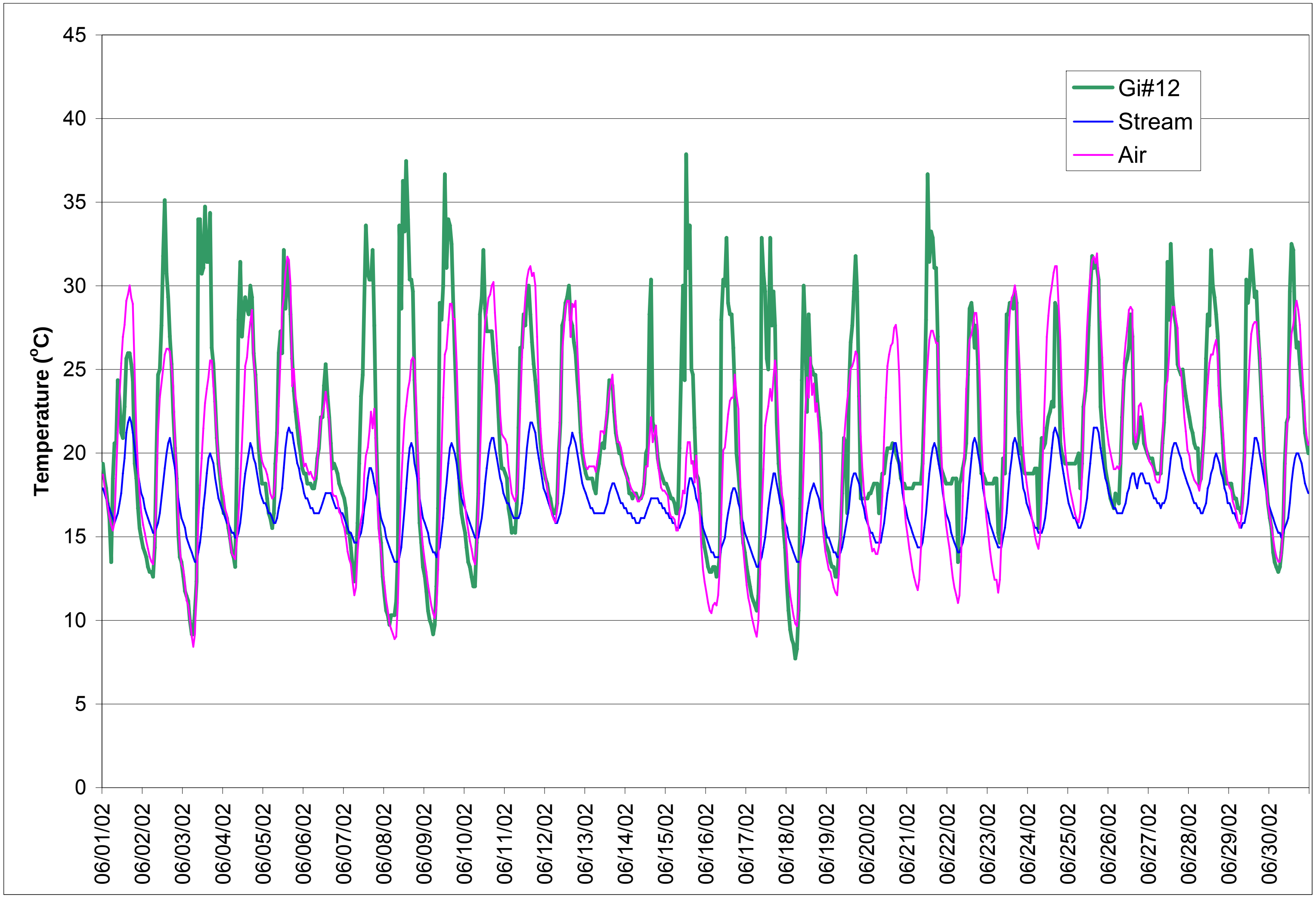
Gi#12 temperatures for March 2002.



Gi#12 temperatures for April 2002.



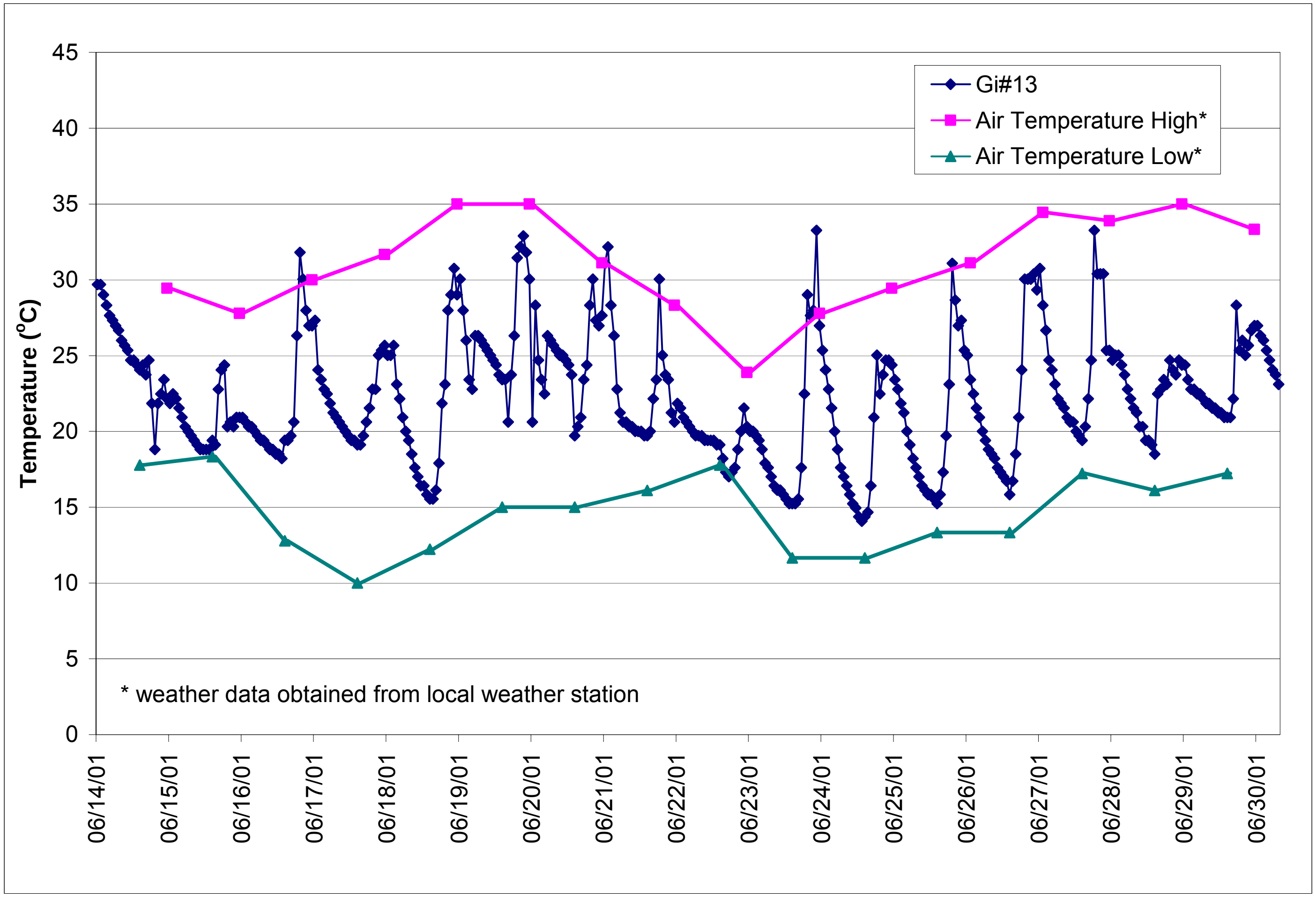
Gi#12 temperatures for May 2002.



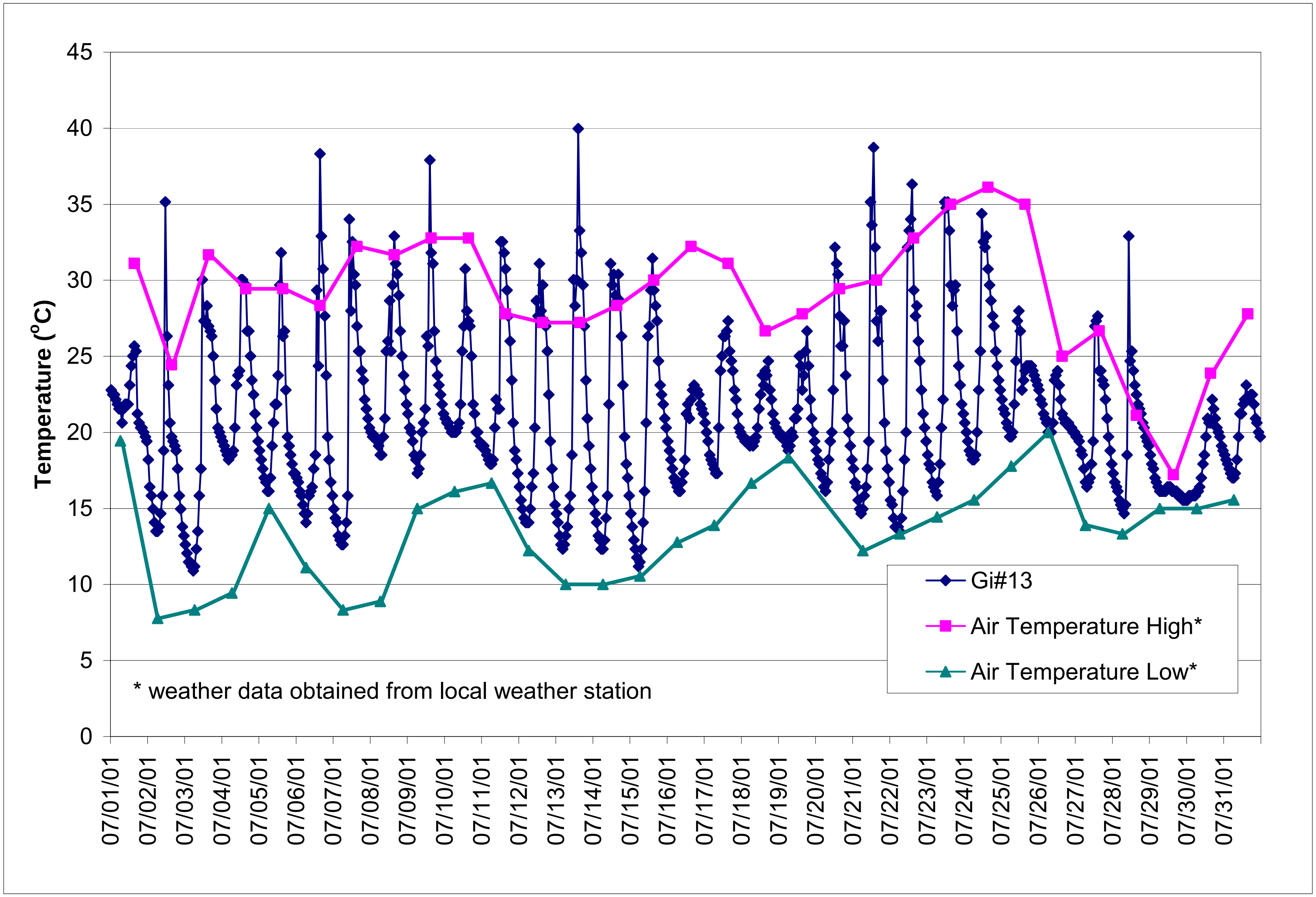
Gi#12 temperatures for June 2002.

APPENDIX XI

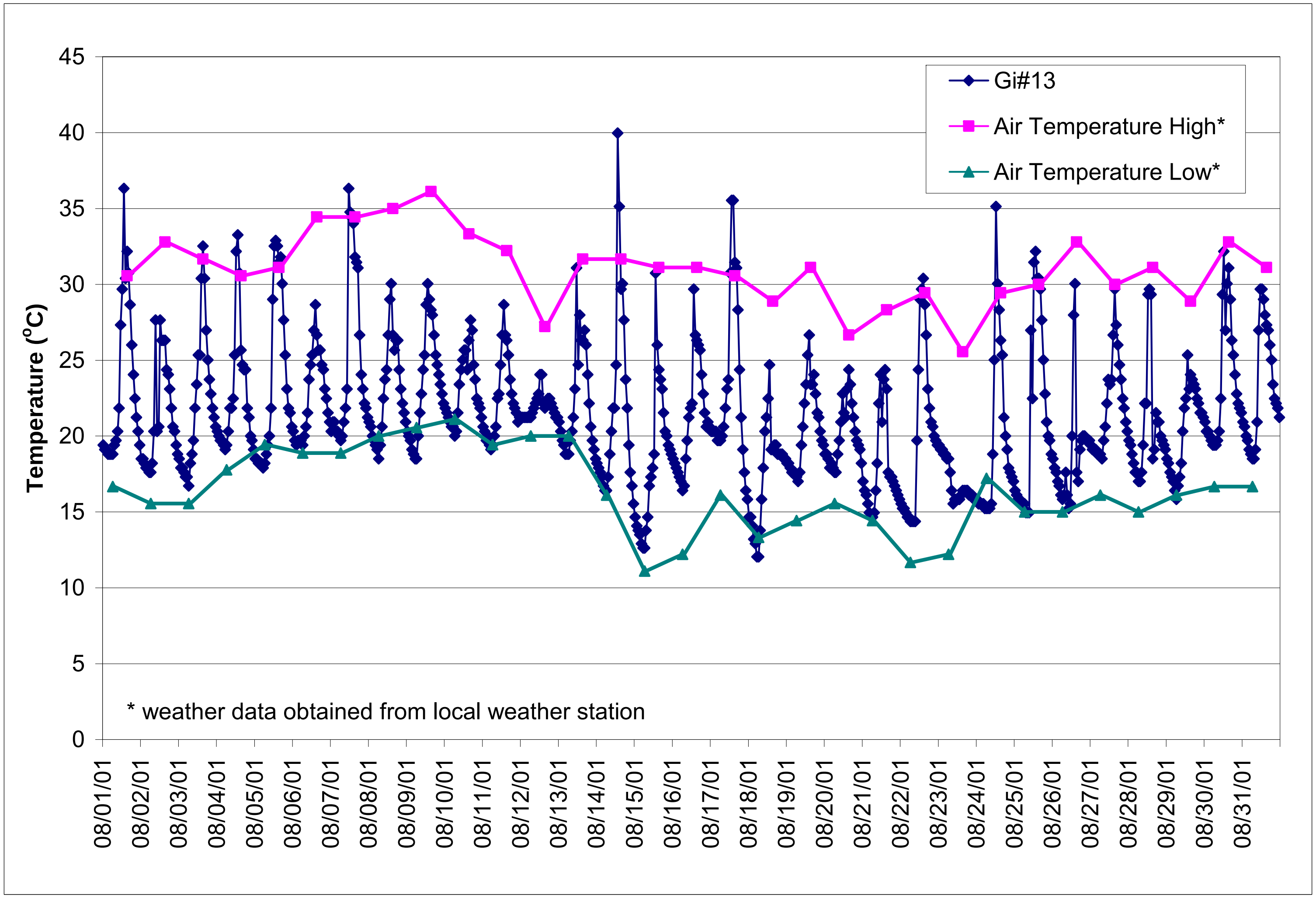
Wood Turtle (*Glyptemys insculpta*) #13 temperatures



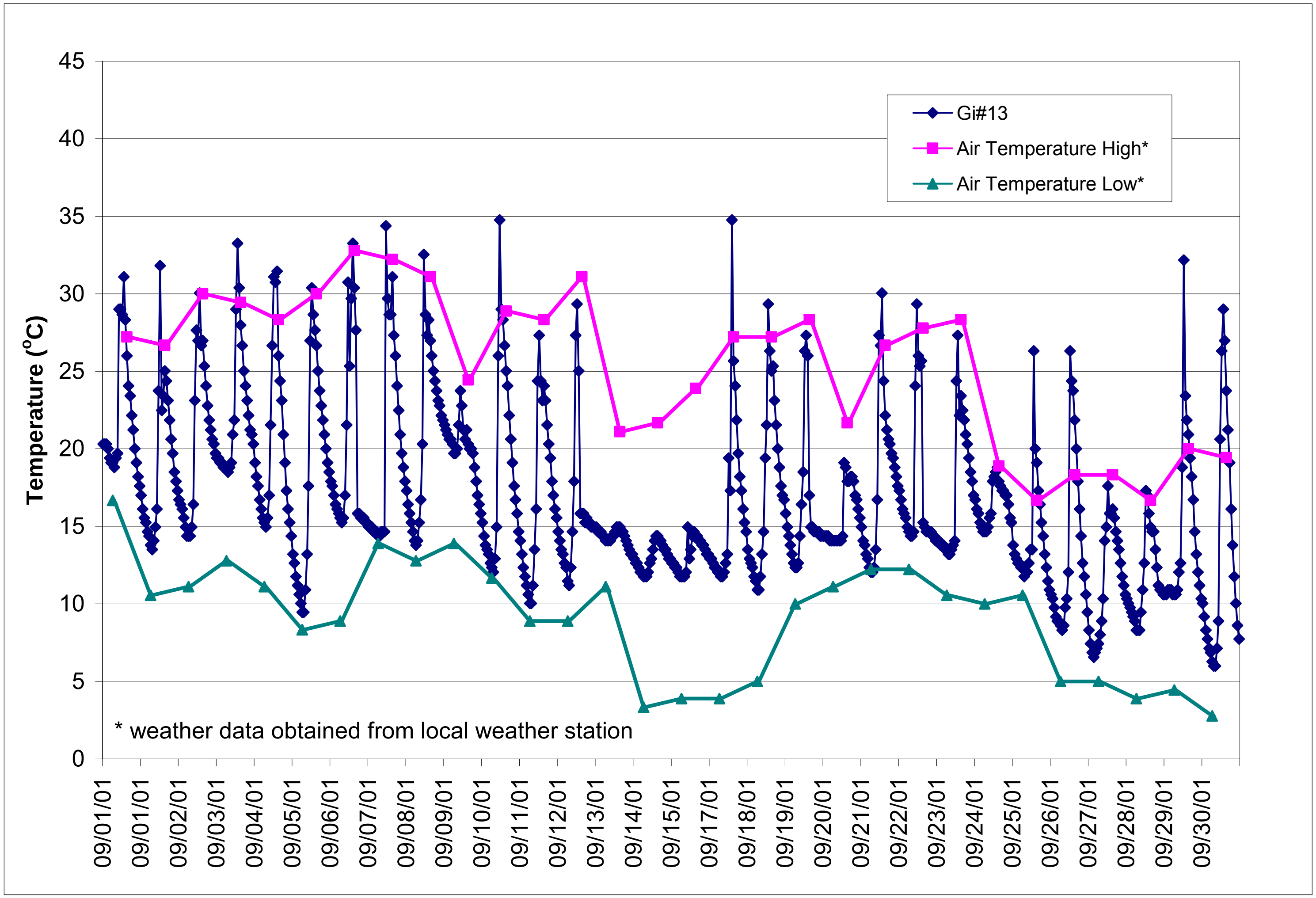
Gi#13 temperatures for June 2001.



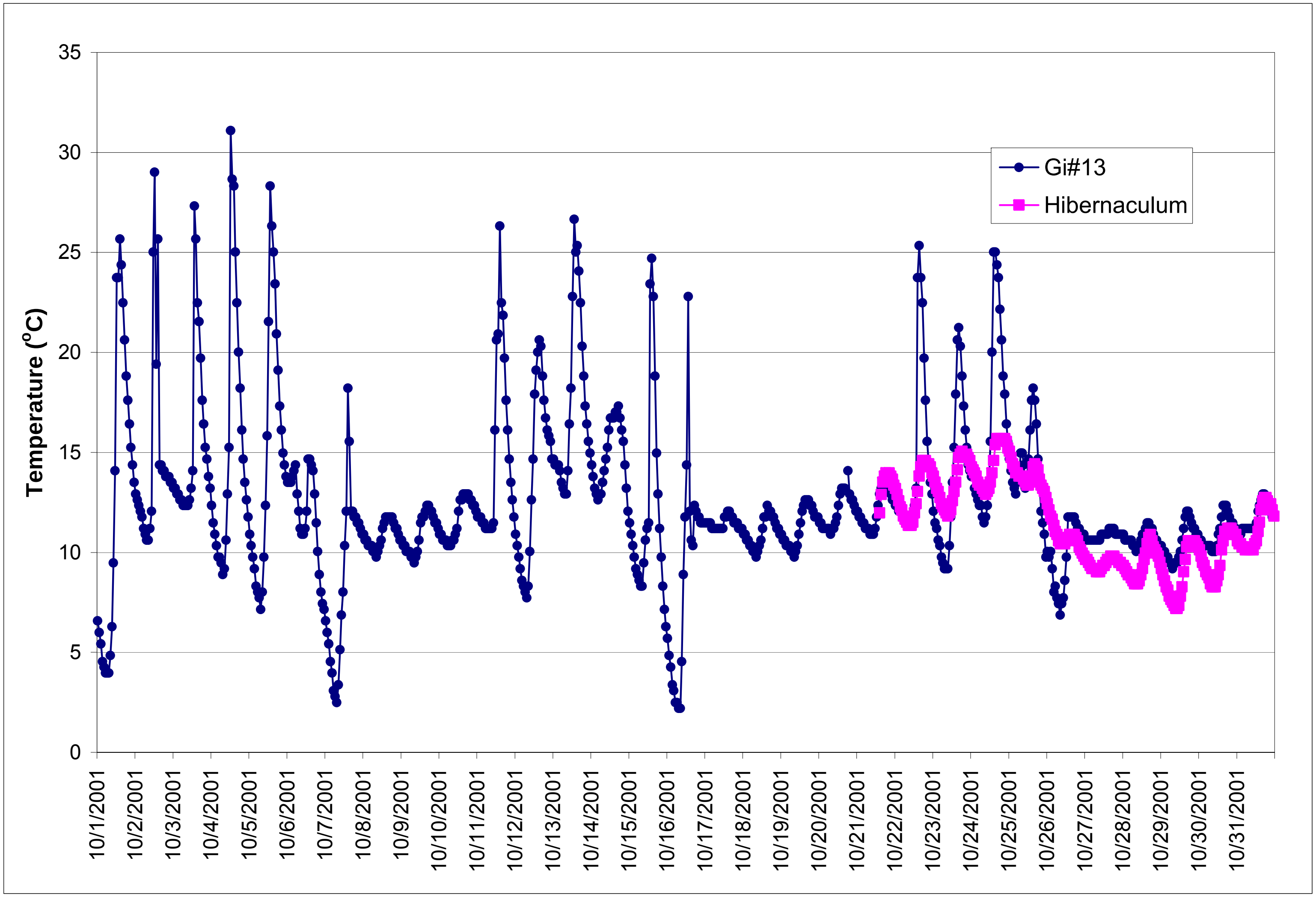
Gi#13 temperatures for July 2001.



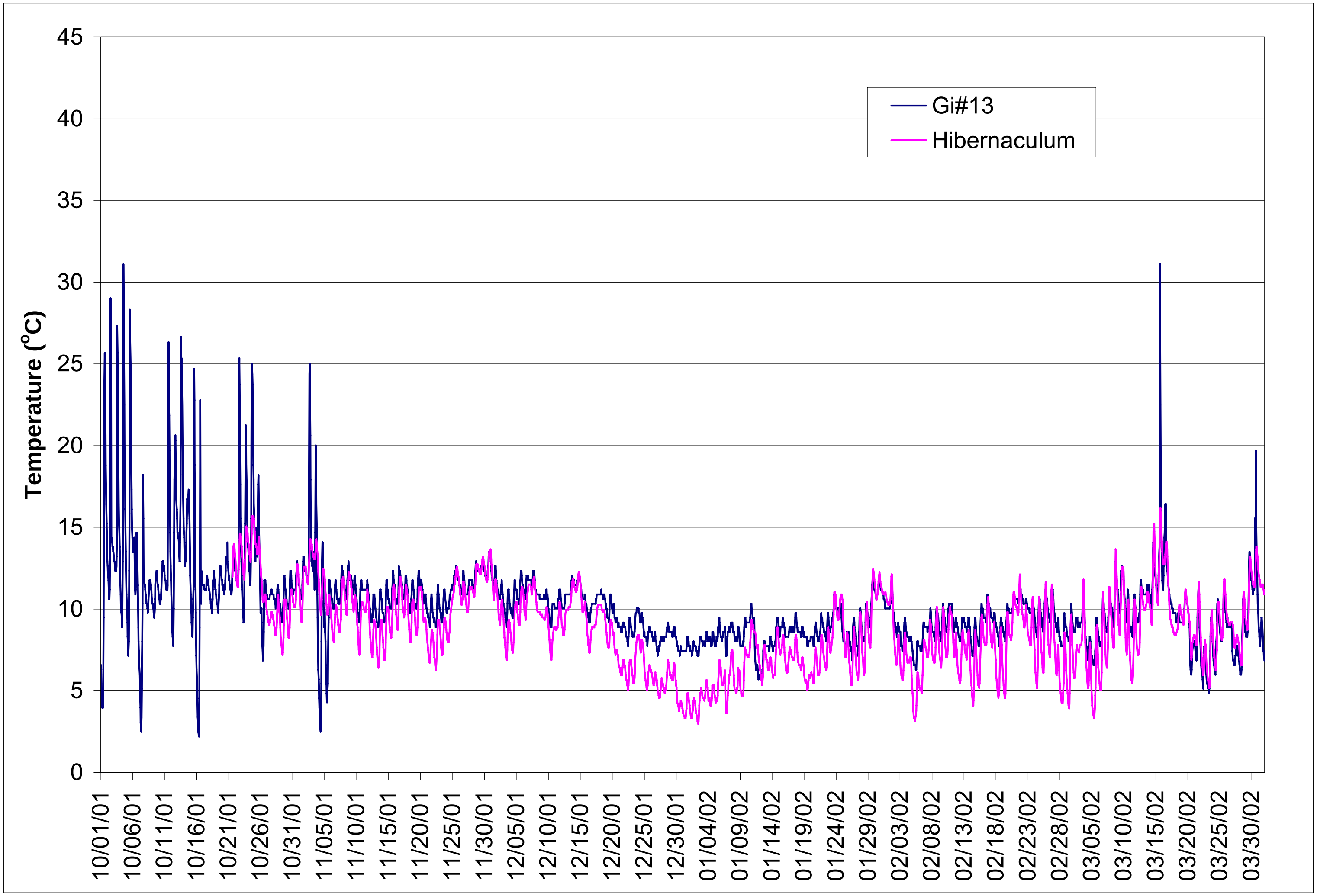
Gi#13 temperatures for August 2001.



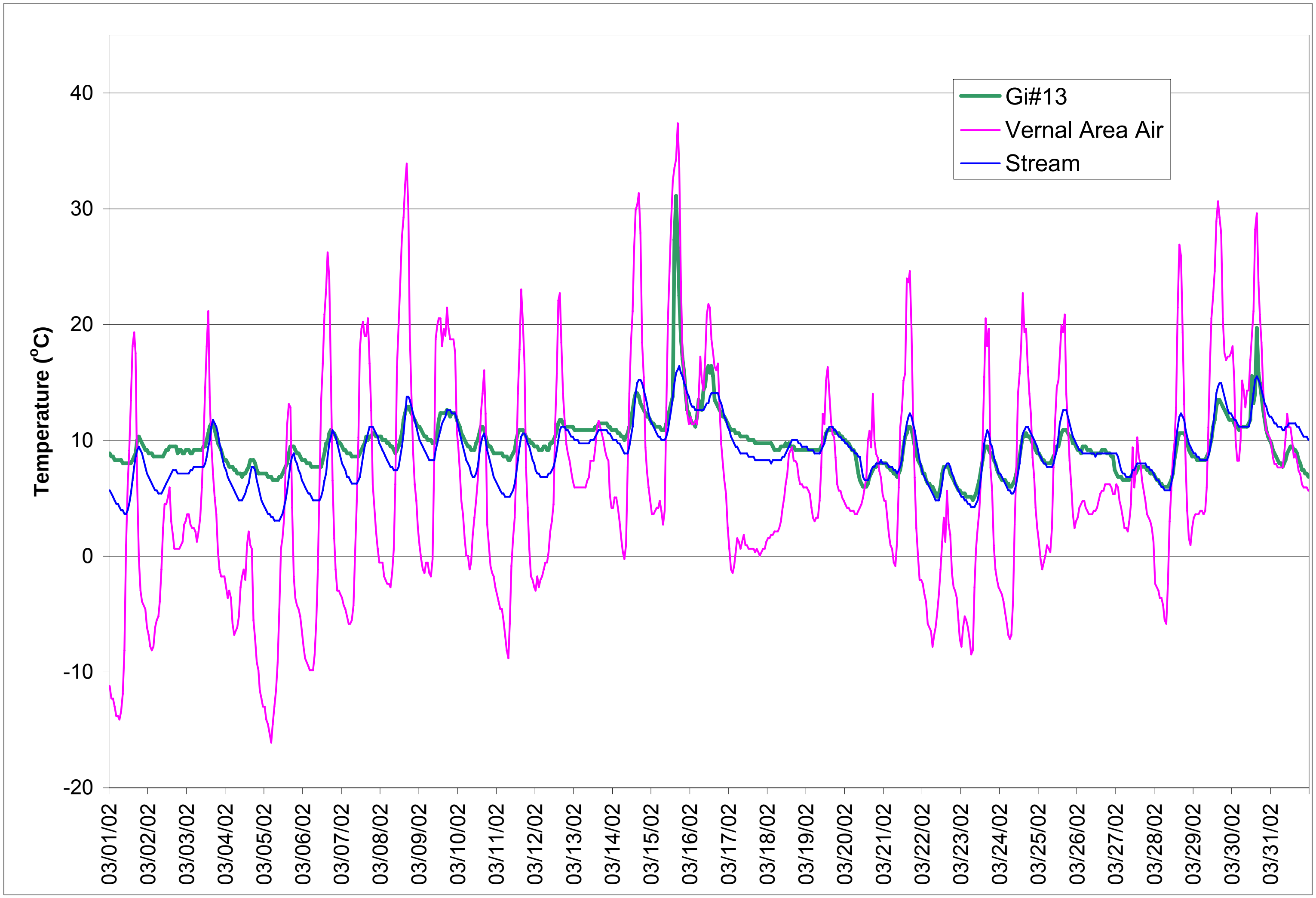
Gi#13 temperatures for September 2001.



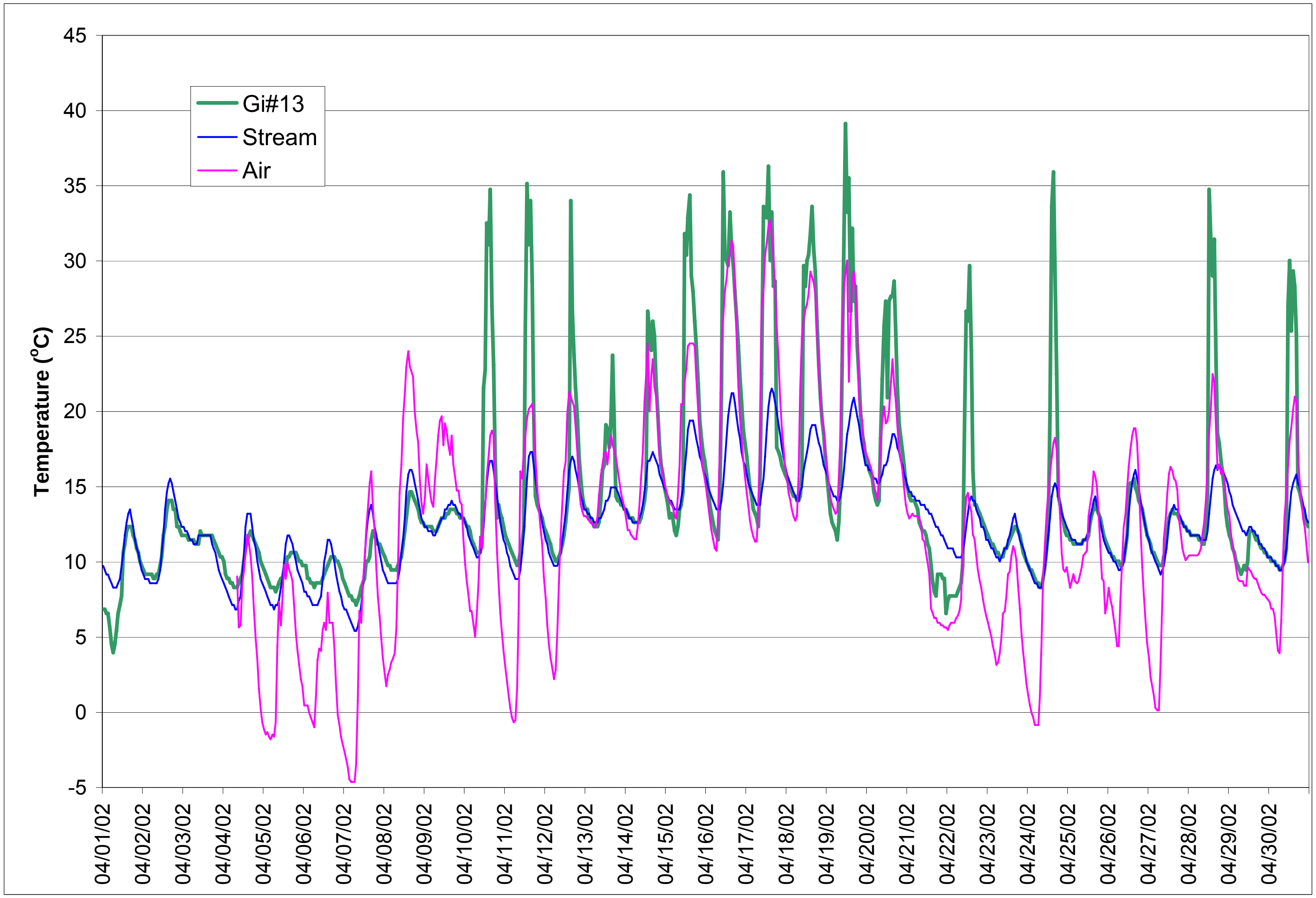
Gi#13 temperatures for October 2001.



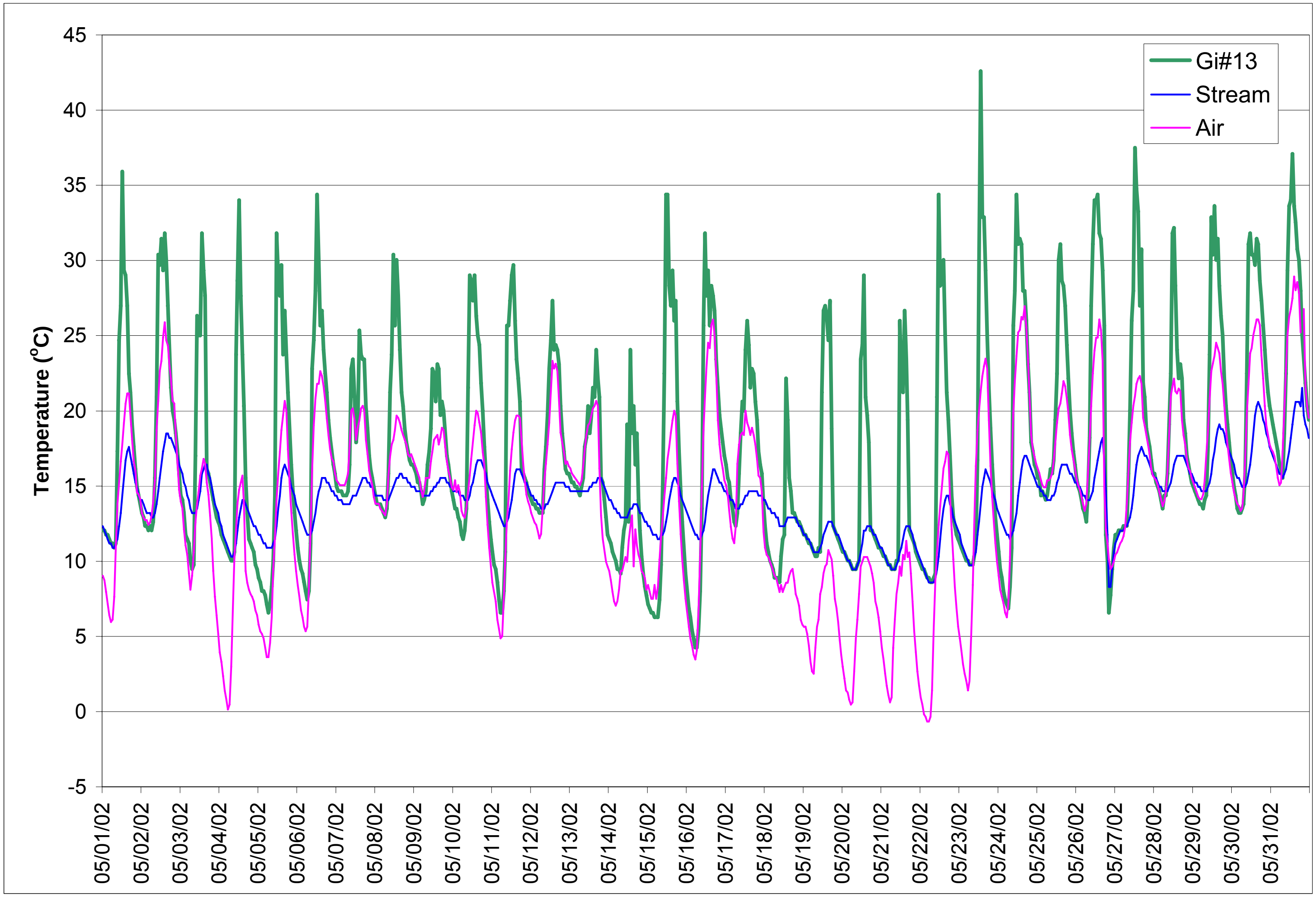
Gi#13 temperatures for October 2001 through March 2002.



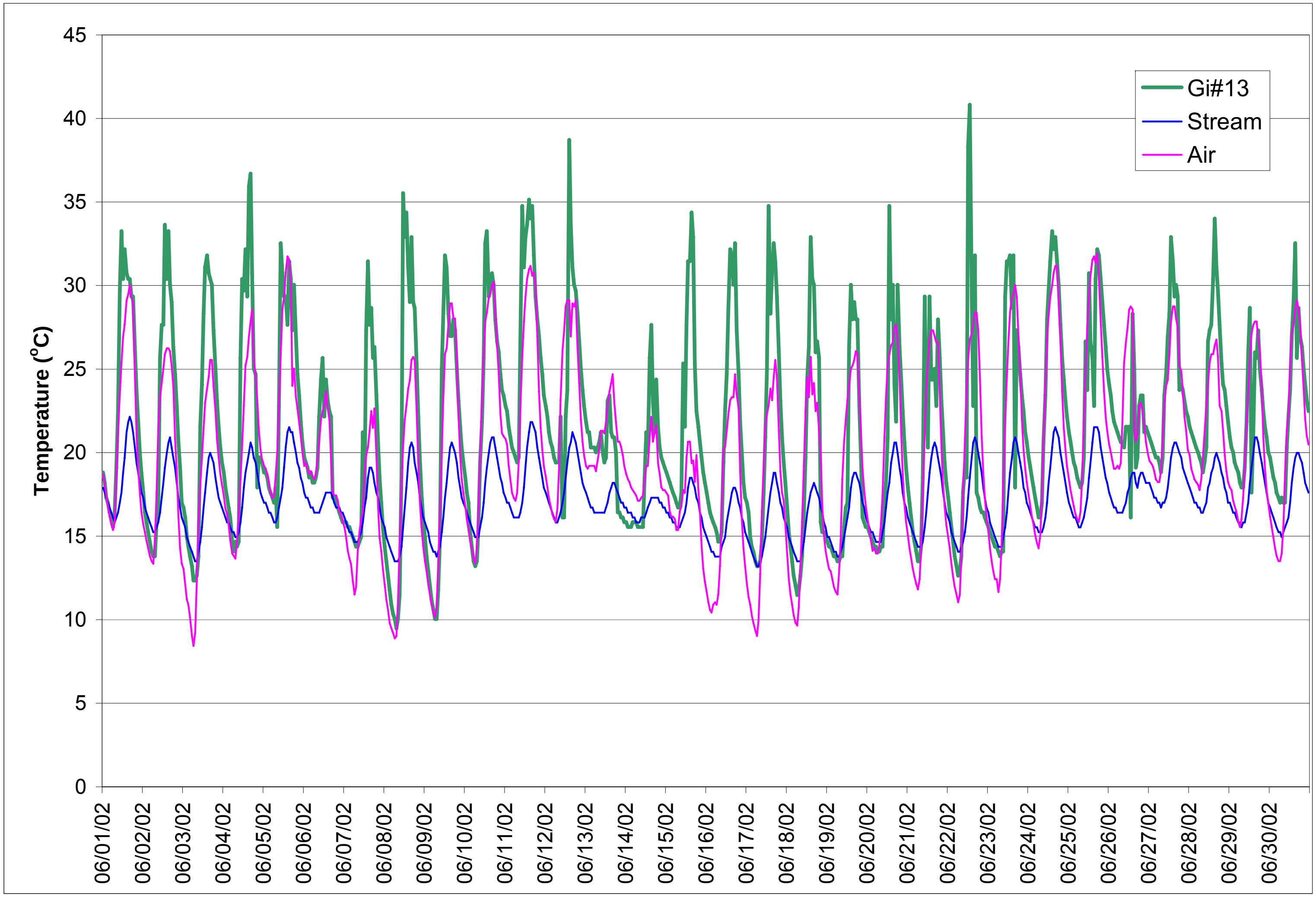
Gi#13 temperatures for March 2002.



Gi#13 temperatures for April 2002.



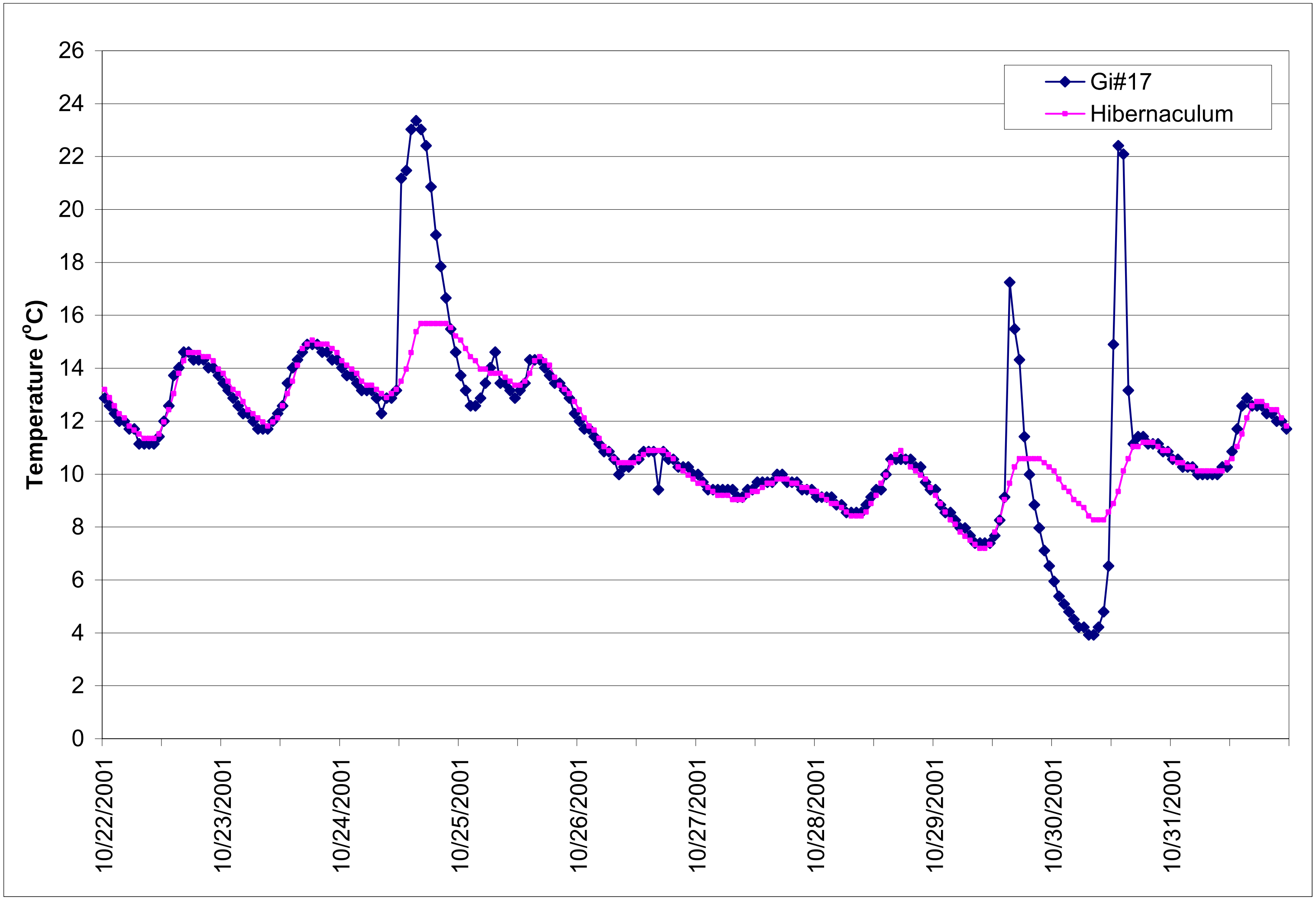
Gi#13 temperatures for May 2002.



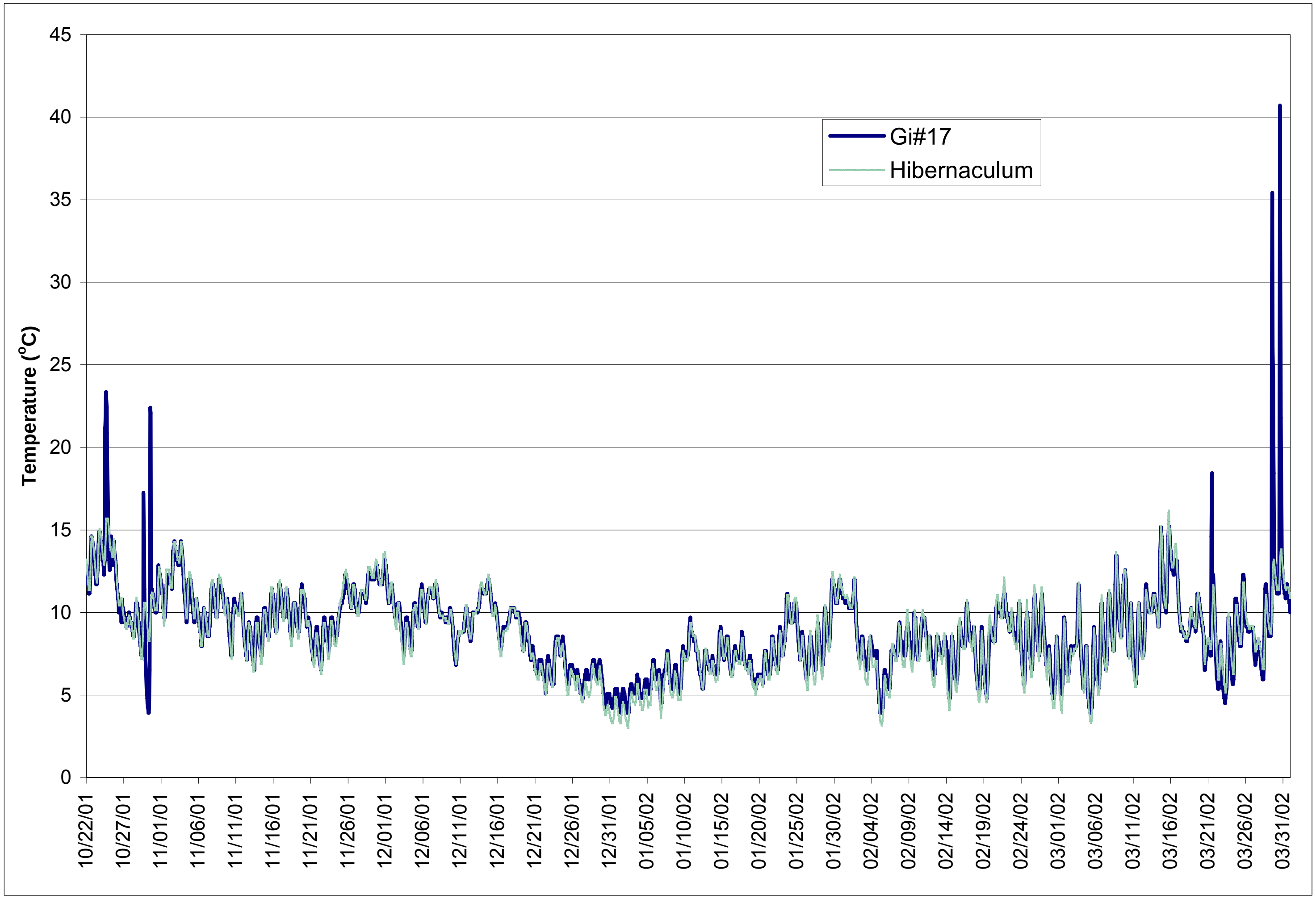
Gi#13 temperatures for June 2002.

APPENDIX XII

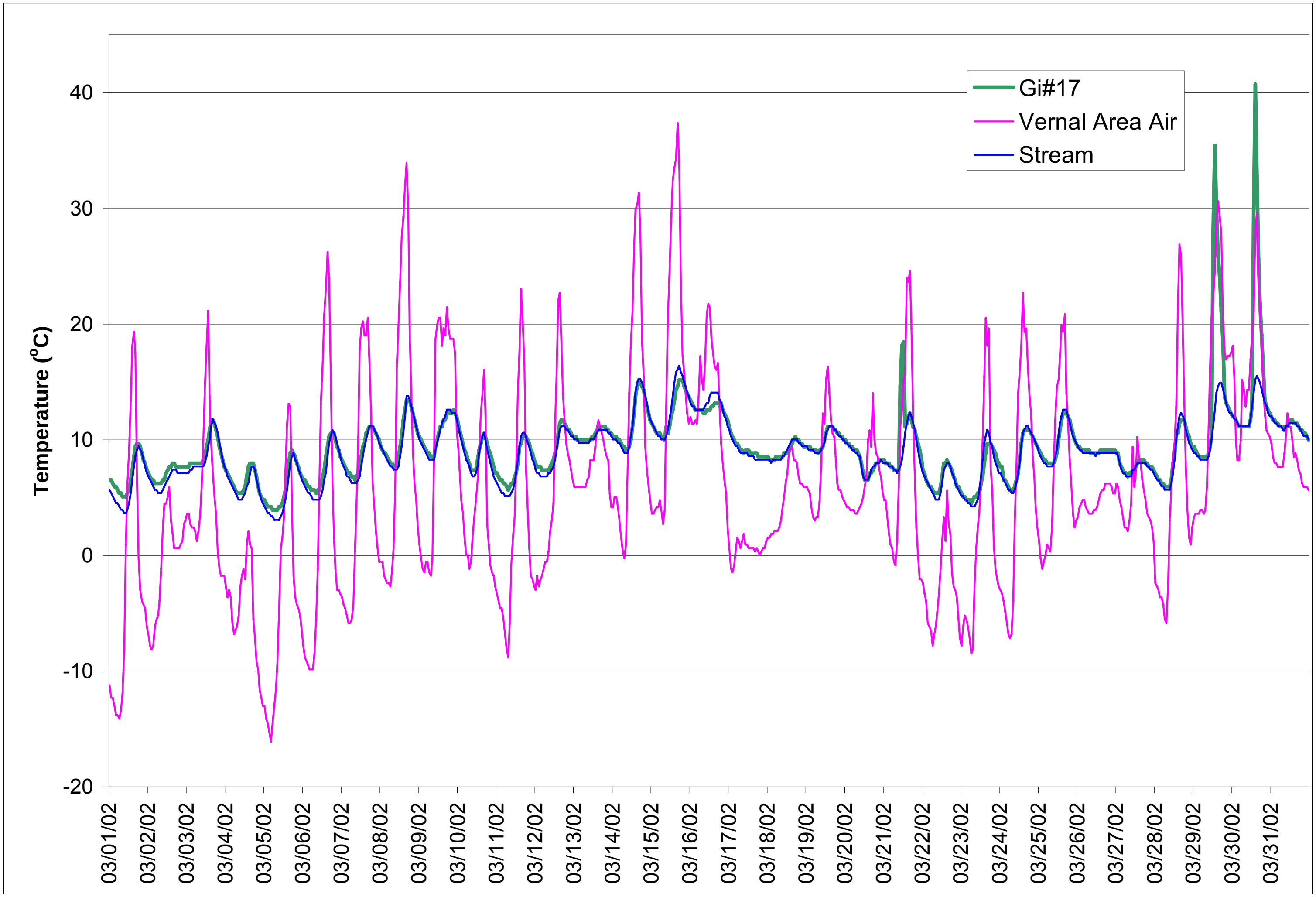
Wood Turtle (*Glyptemys insculpta*) #17 temperatures



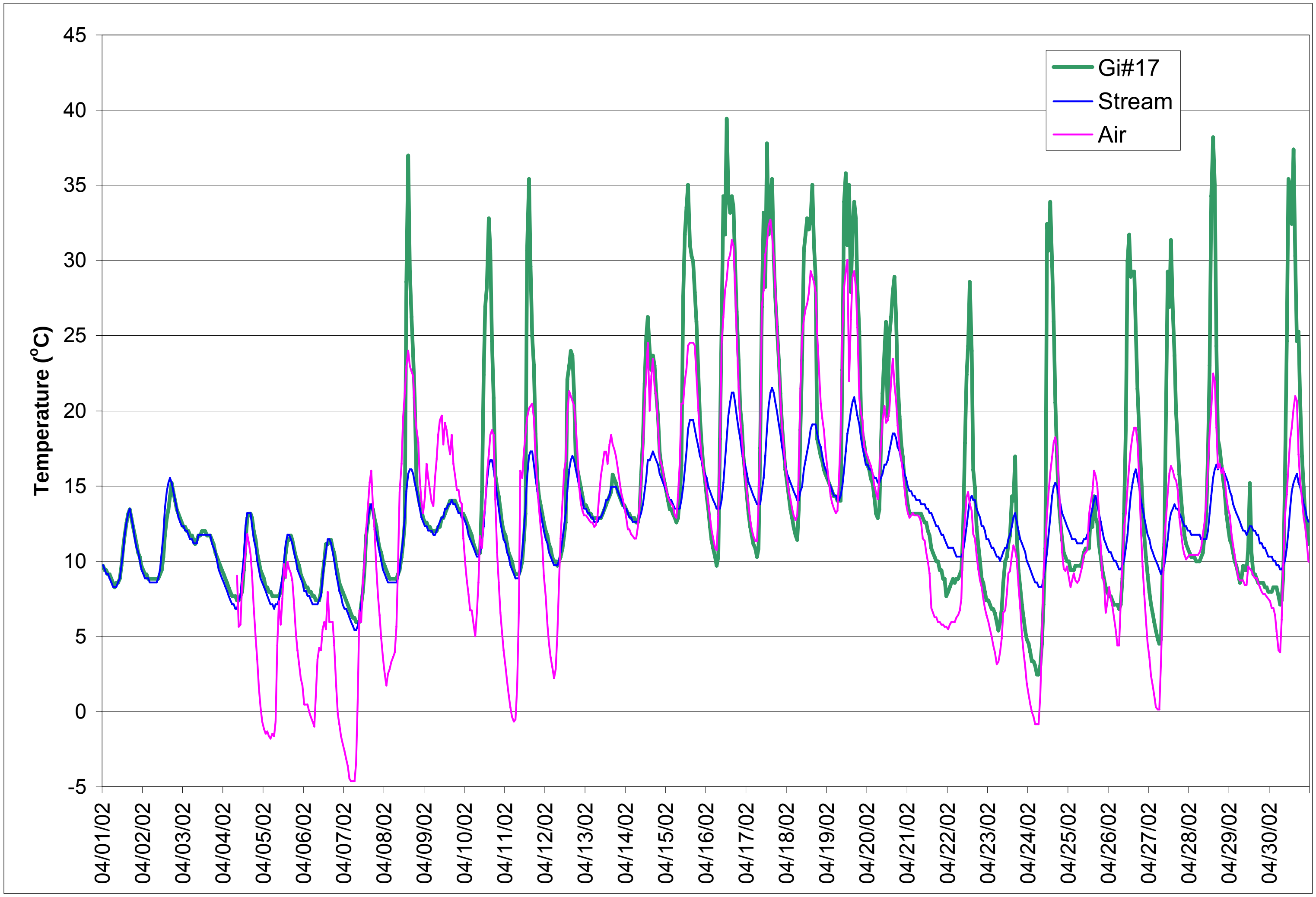
Gi#17 temperatures for October 2001.



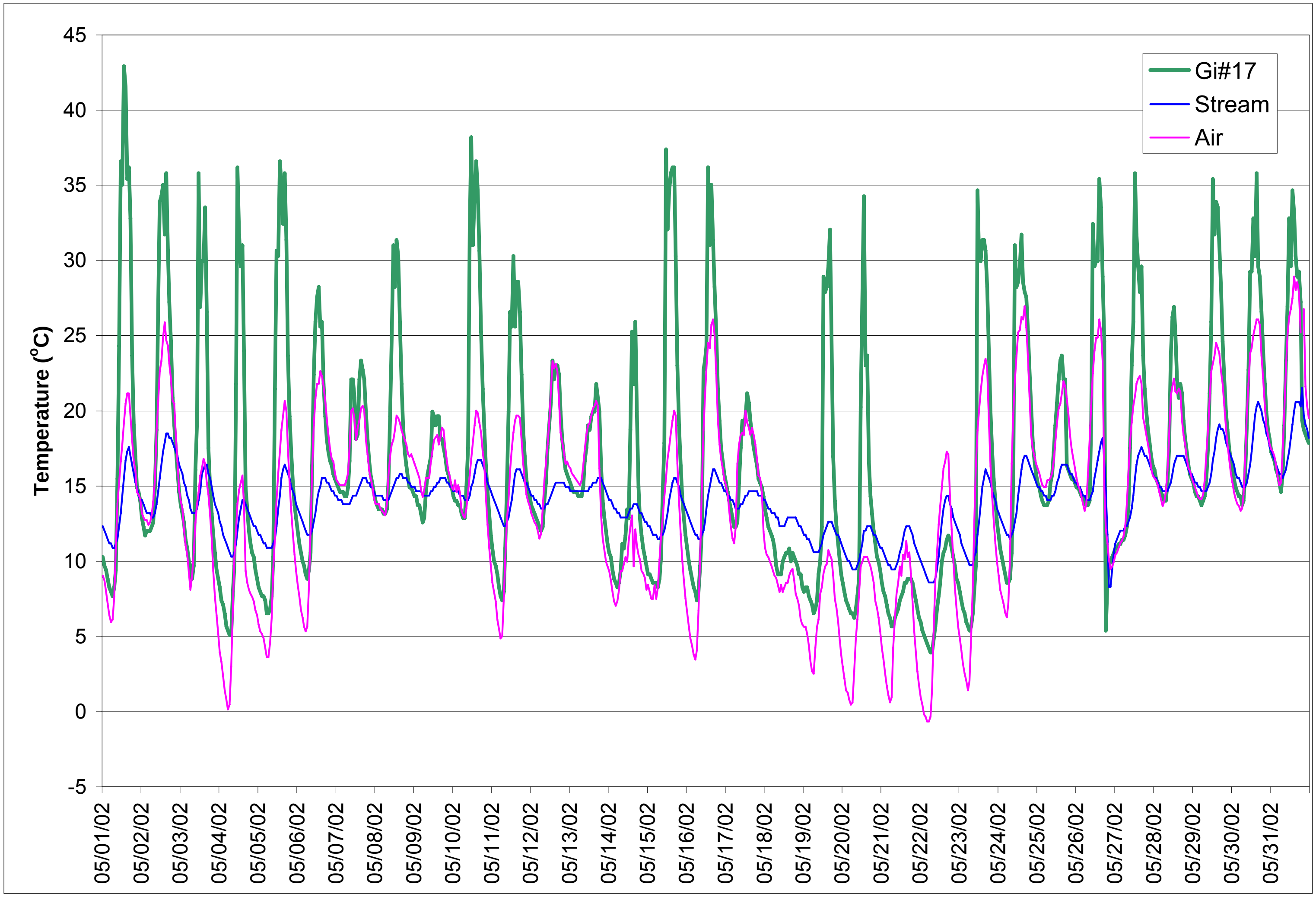
Gi#17 temperatures for October 2001 through March 2002.



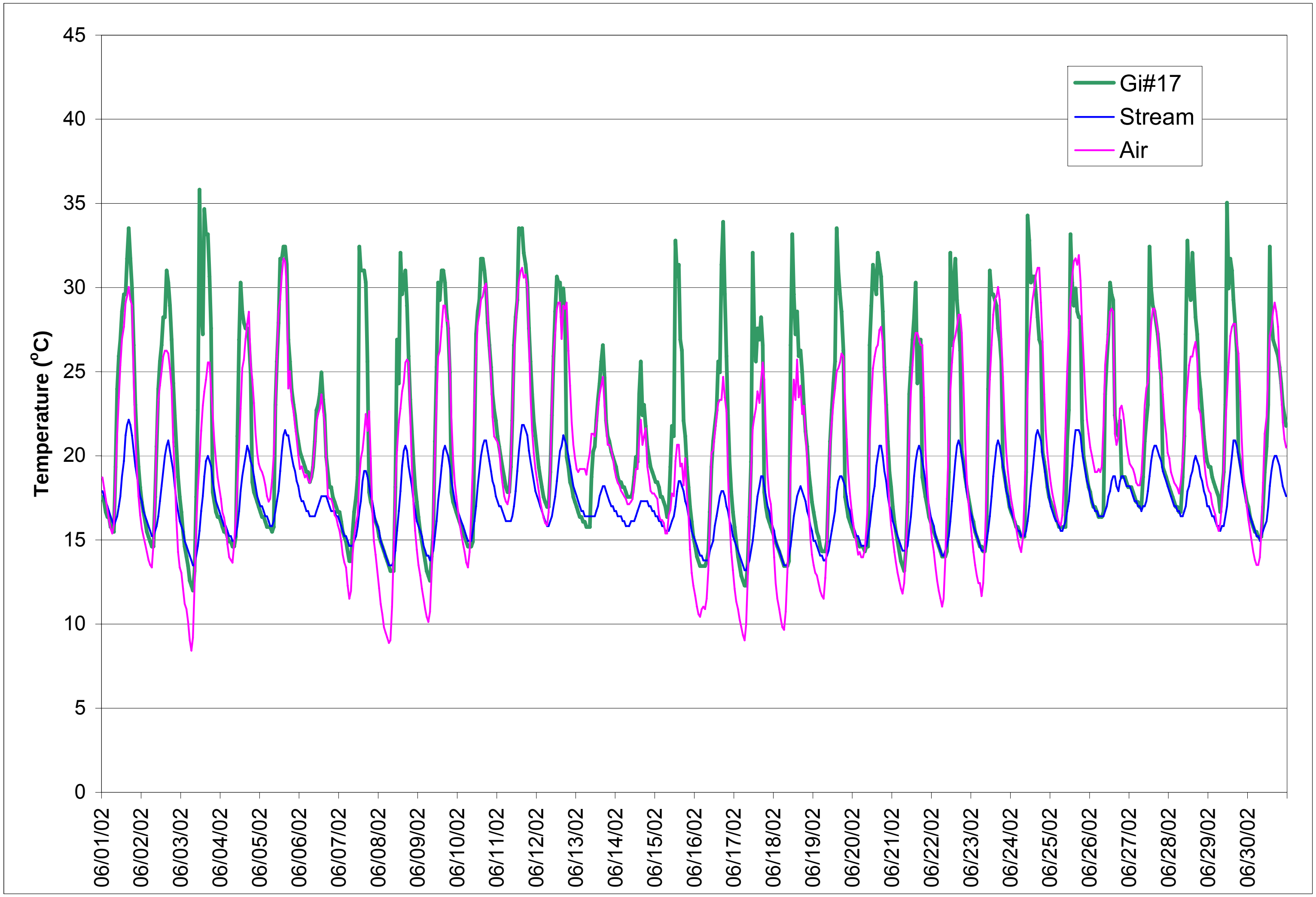
Gi#17 temperatures for March 2002.



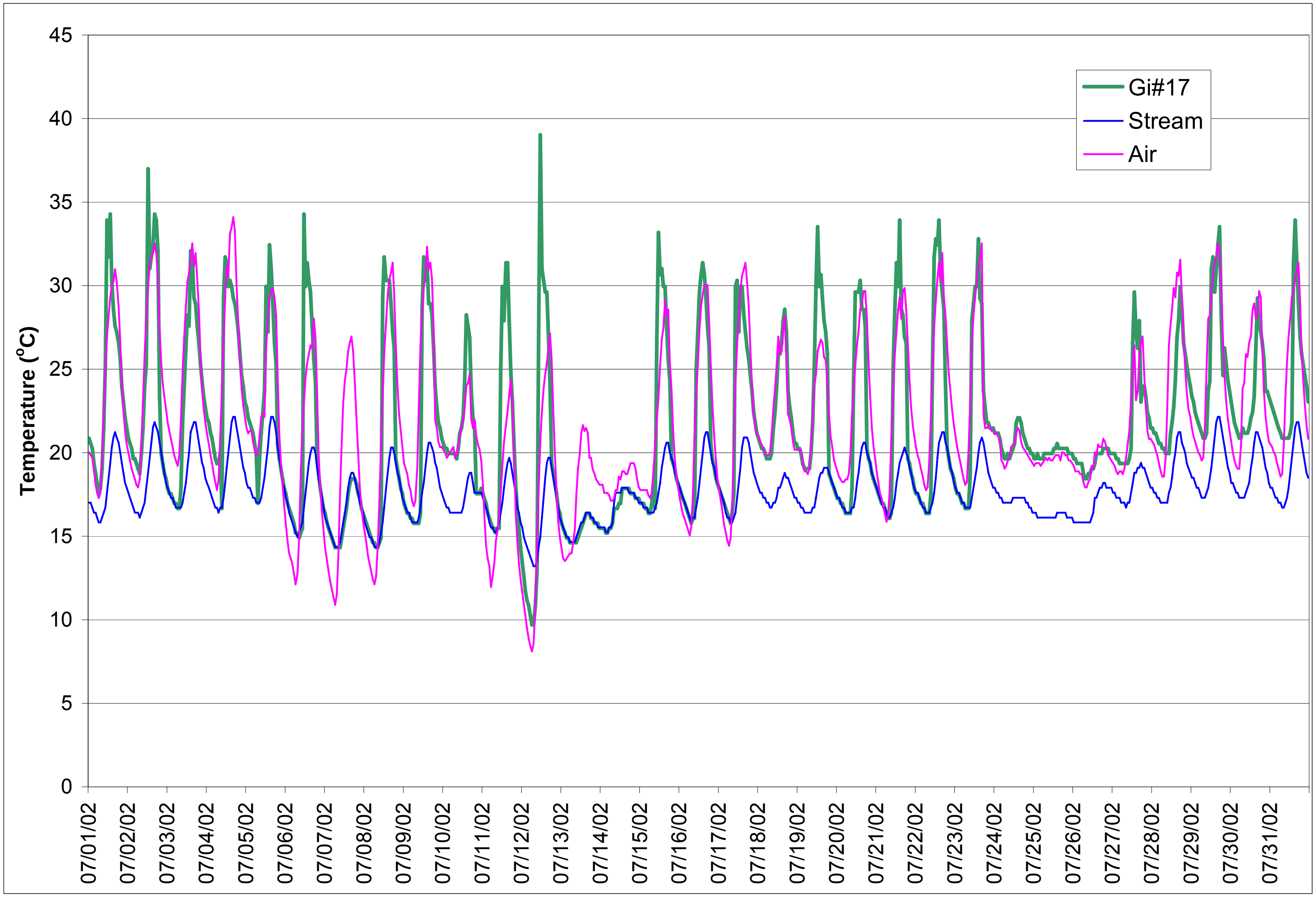
Gi#17 temperatures for April 2002.



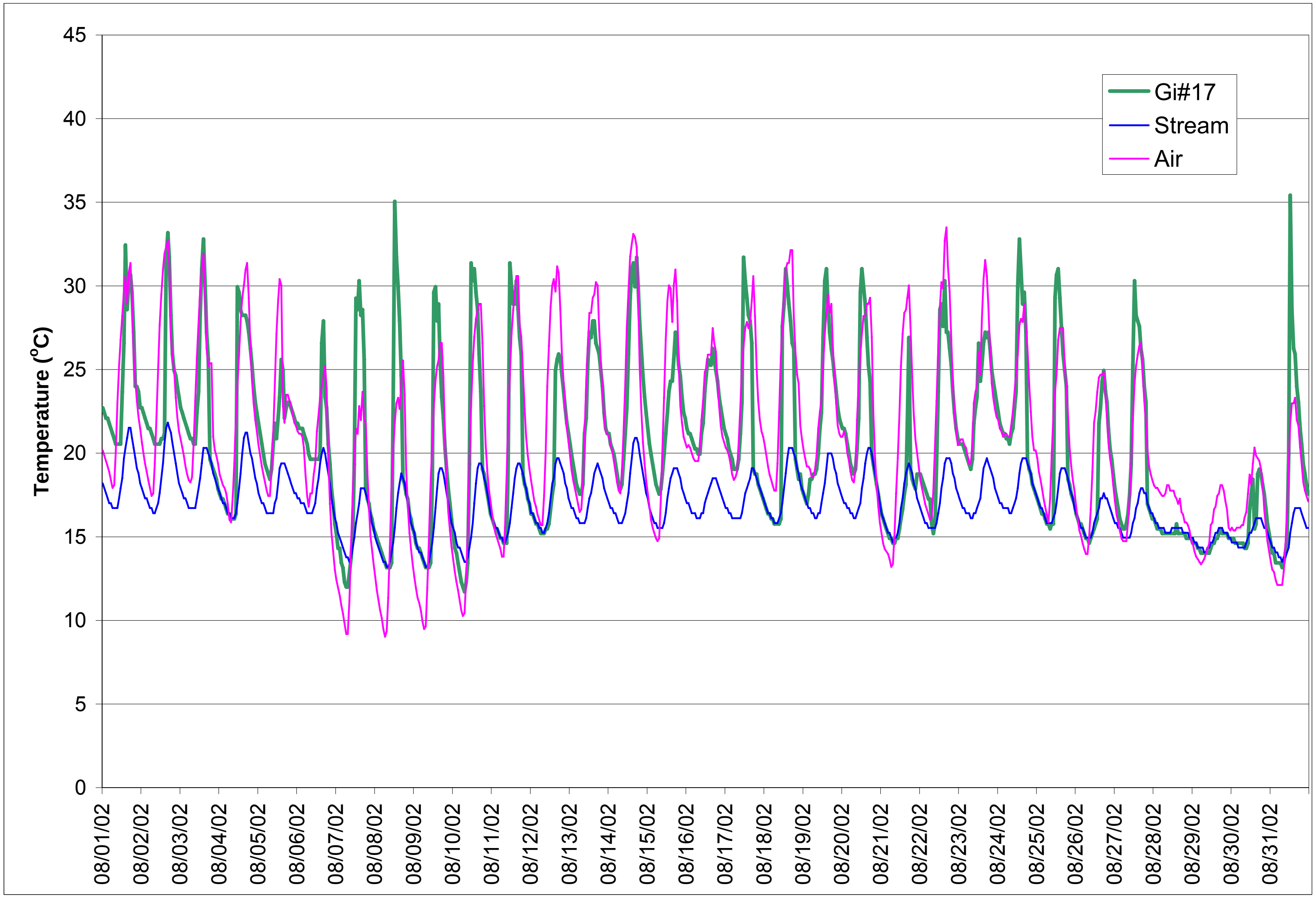
Gi#17 temperatures for May 2002.



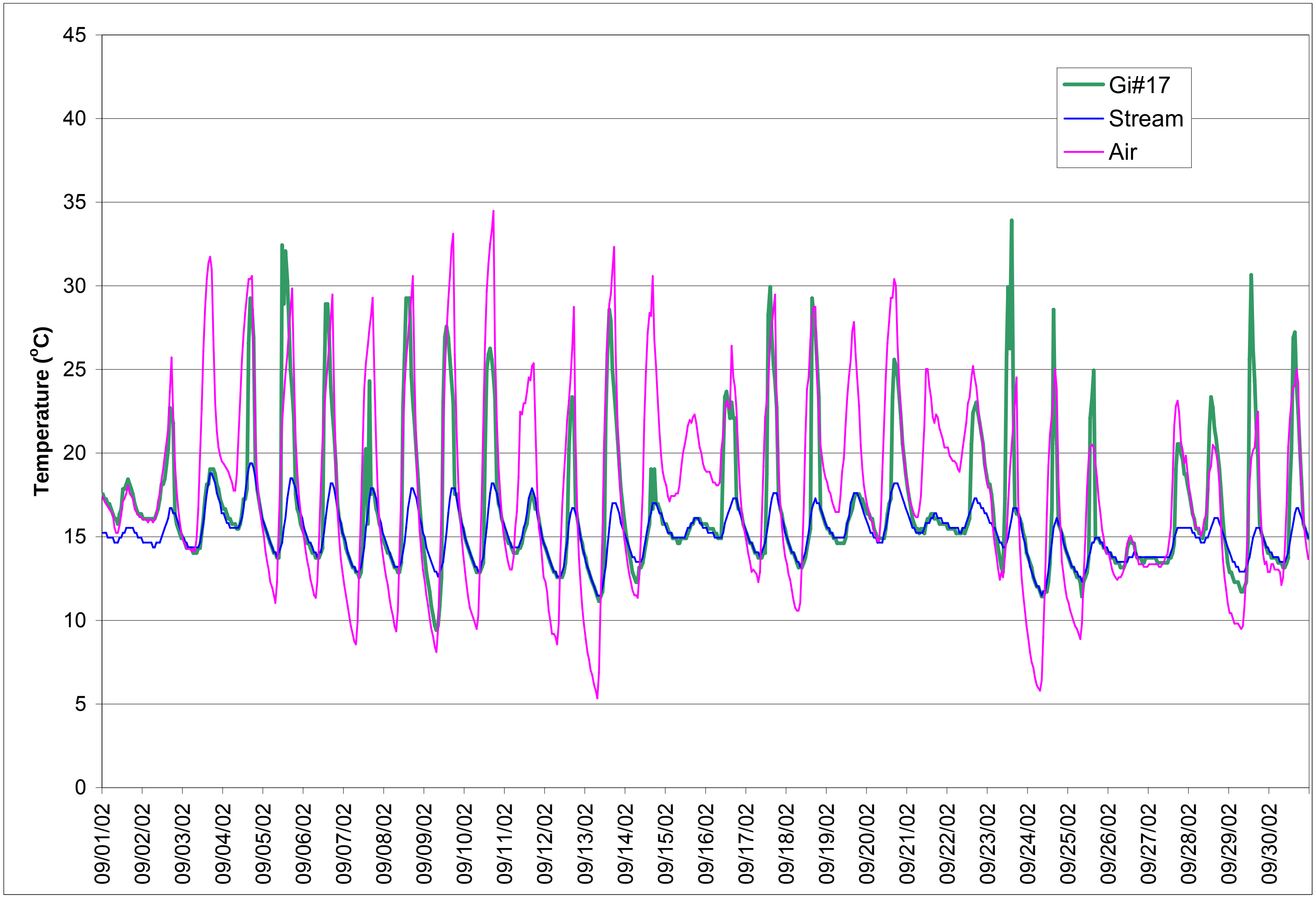
Gi#17 temperatures for June 2002.



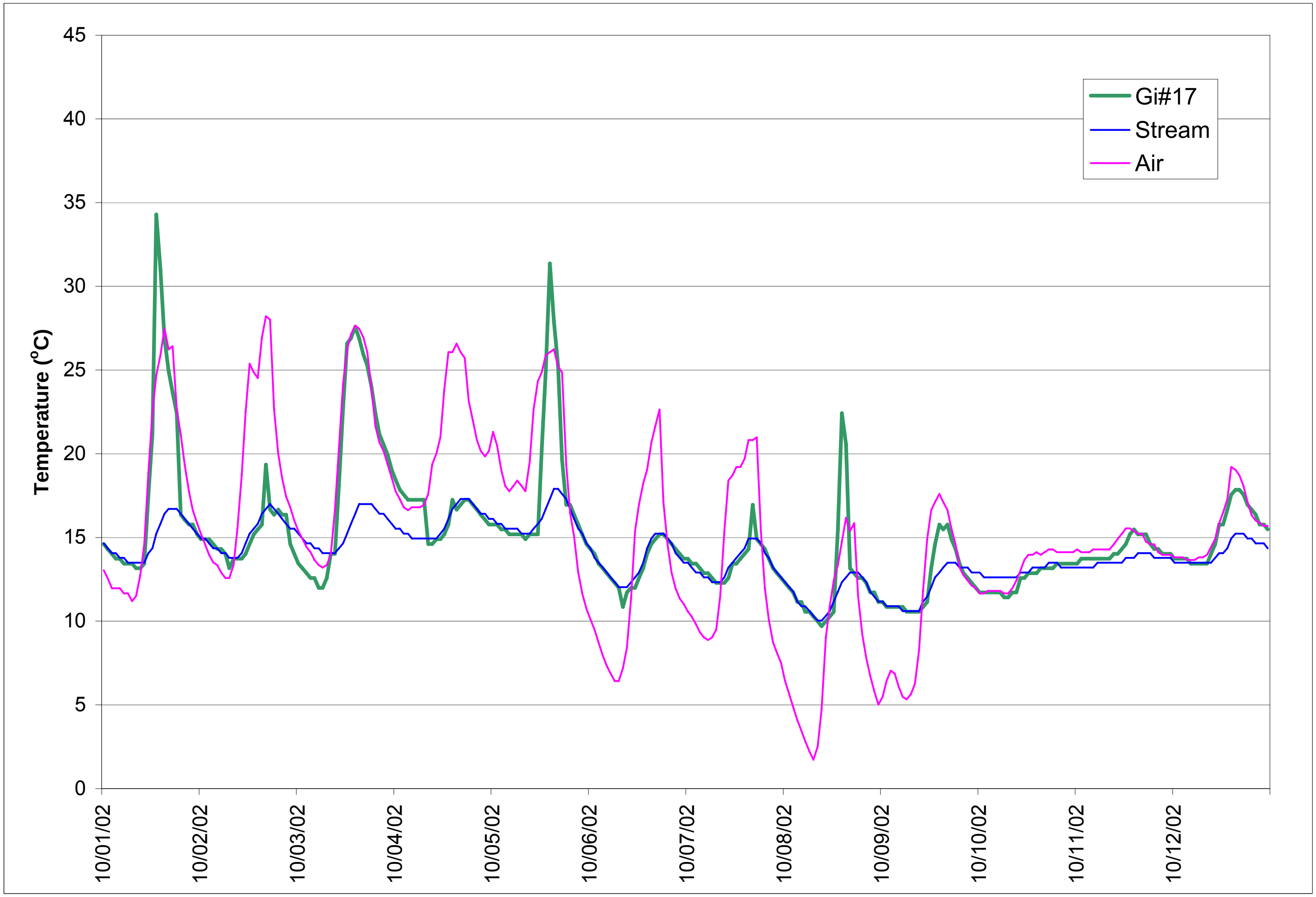
Gi#17 temperatures for July 2002.



Gi#17 temperatures for August 2002.



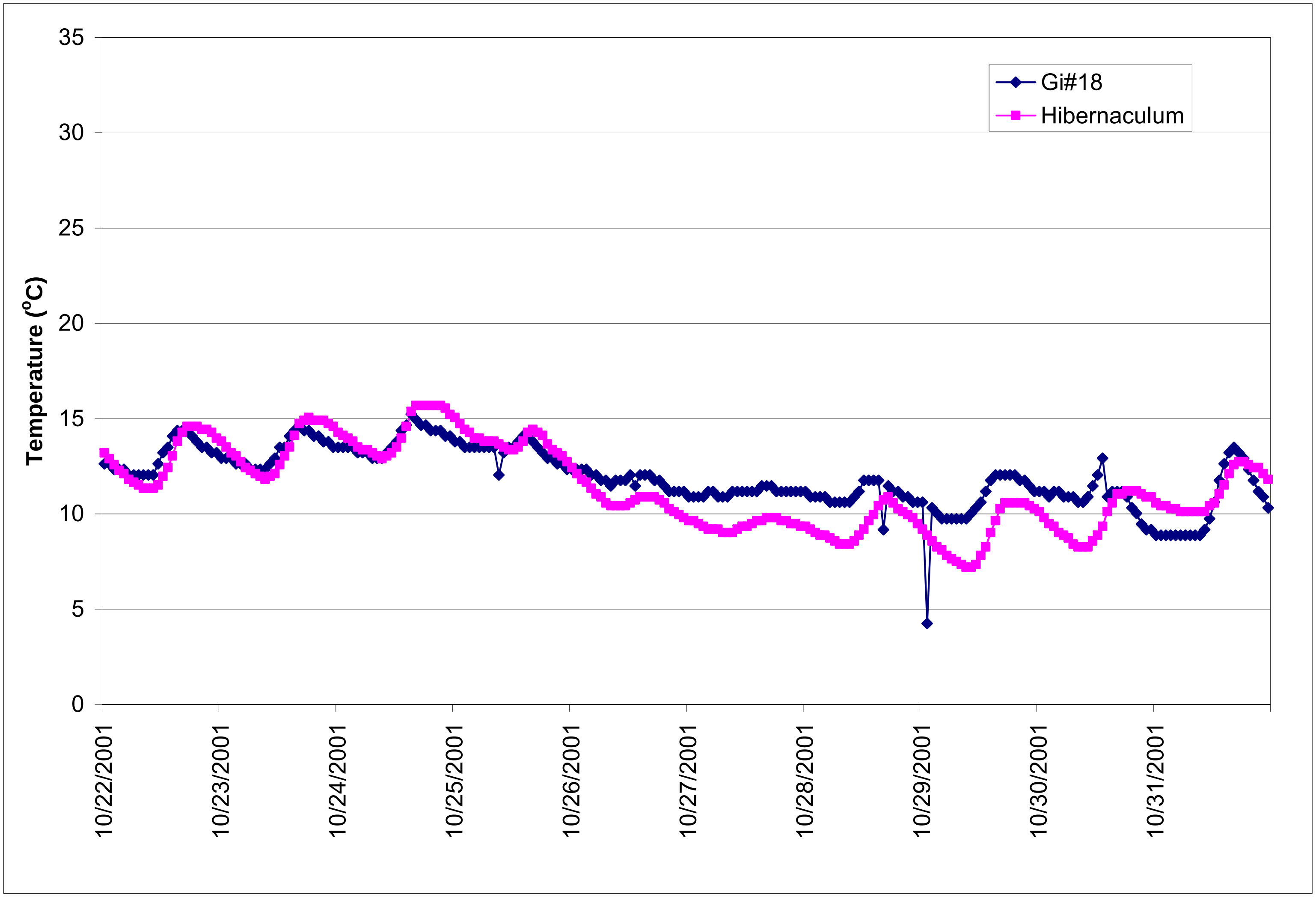
Gi#17 temperatures for September 2002.



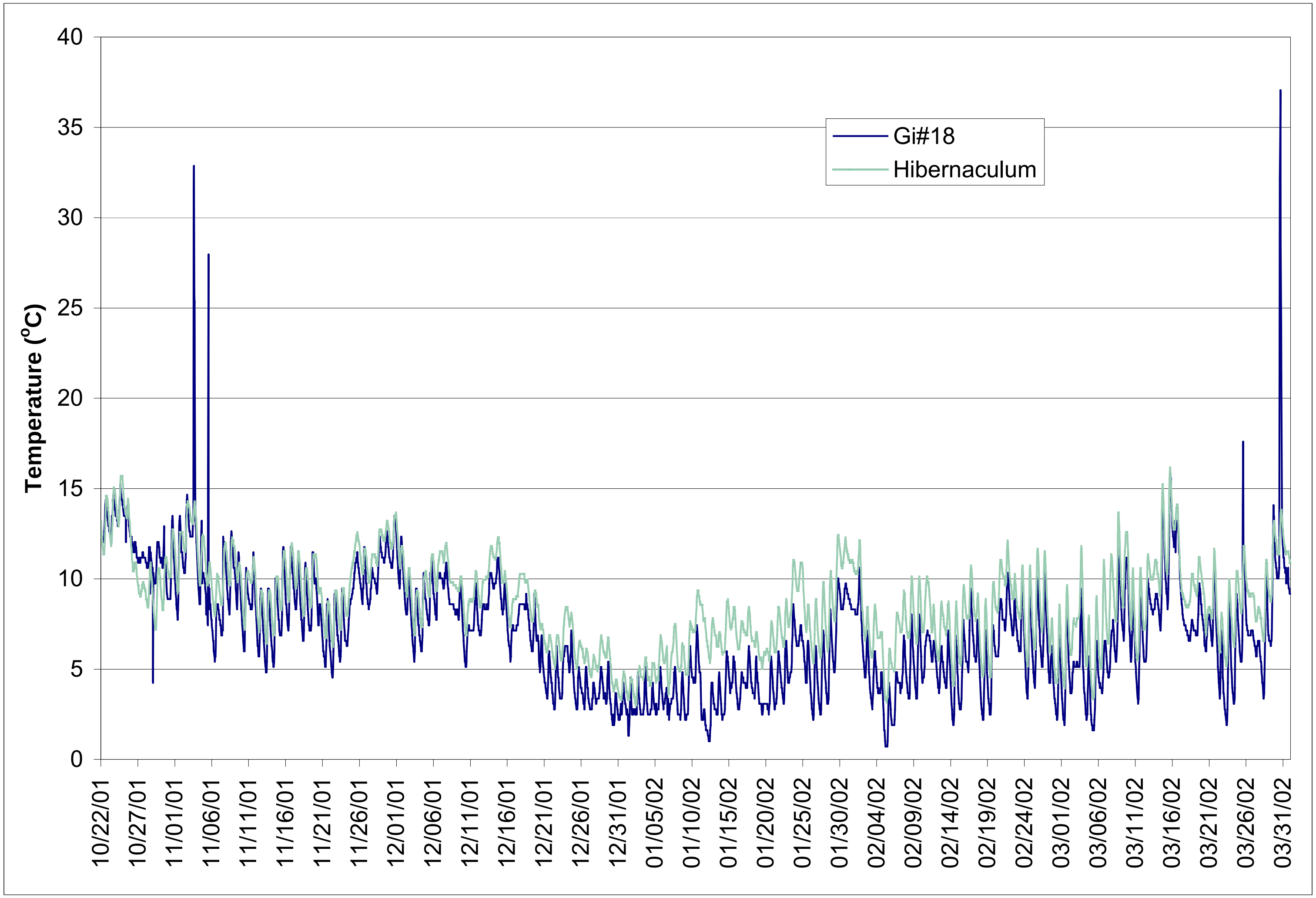
Gi#17 temperatures for October 2002.

APPENDIX XIII

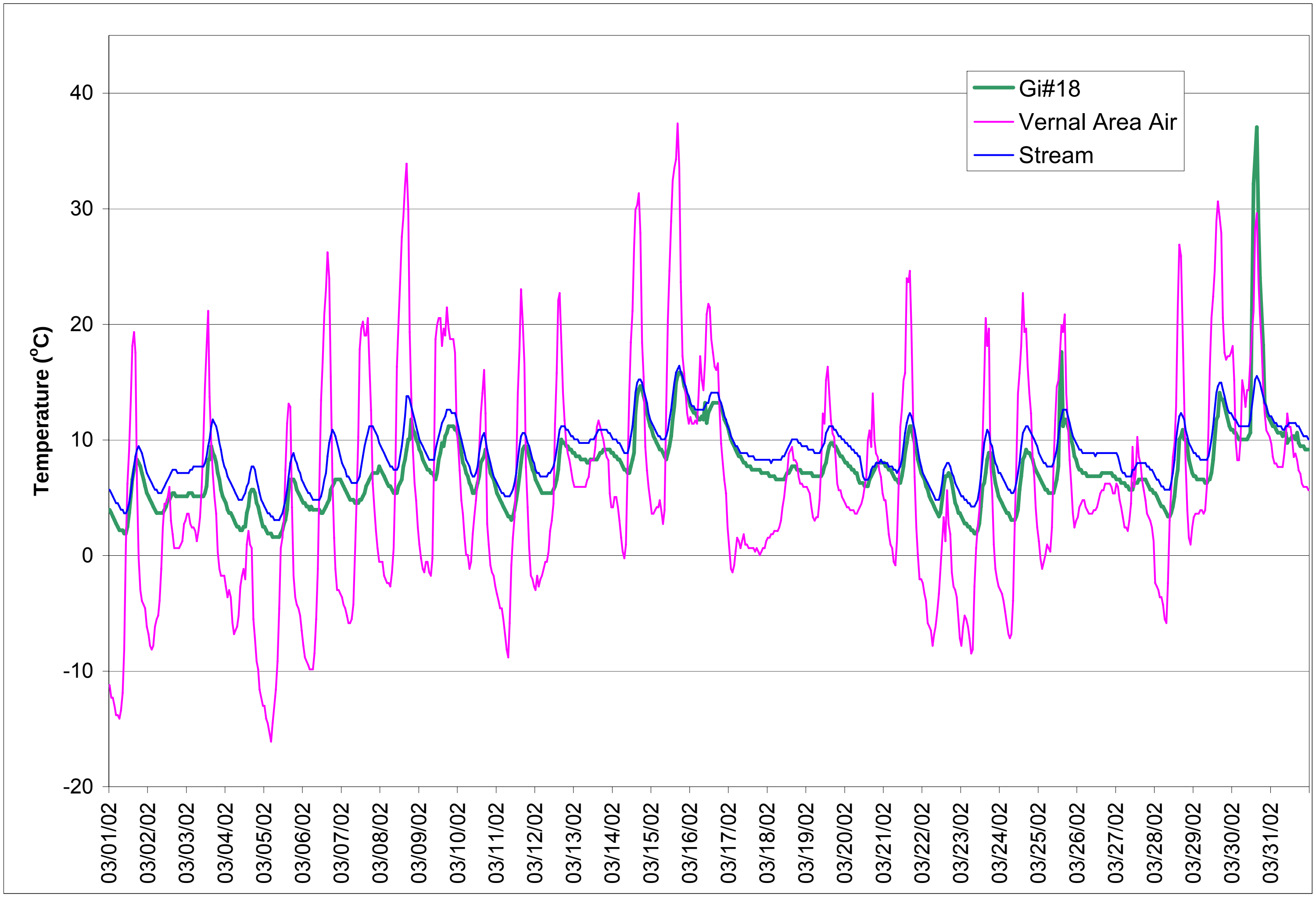
Wood Turtle (*Glyptemys insculpta*) #18 temperatures



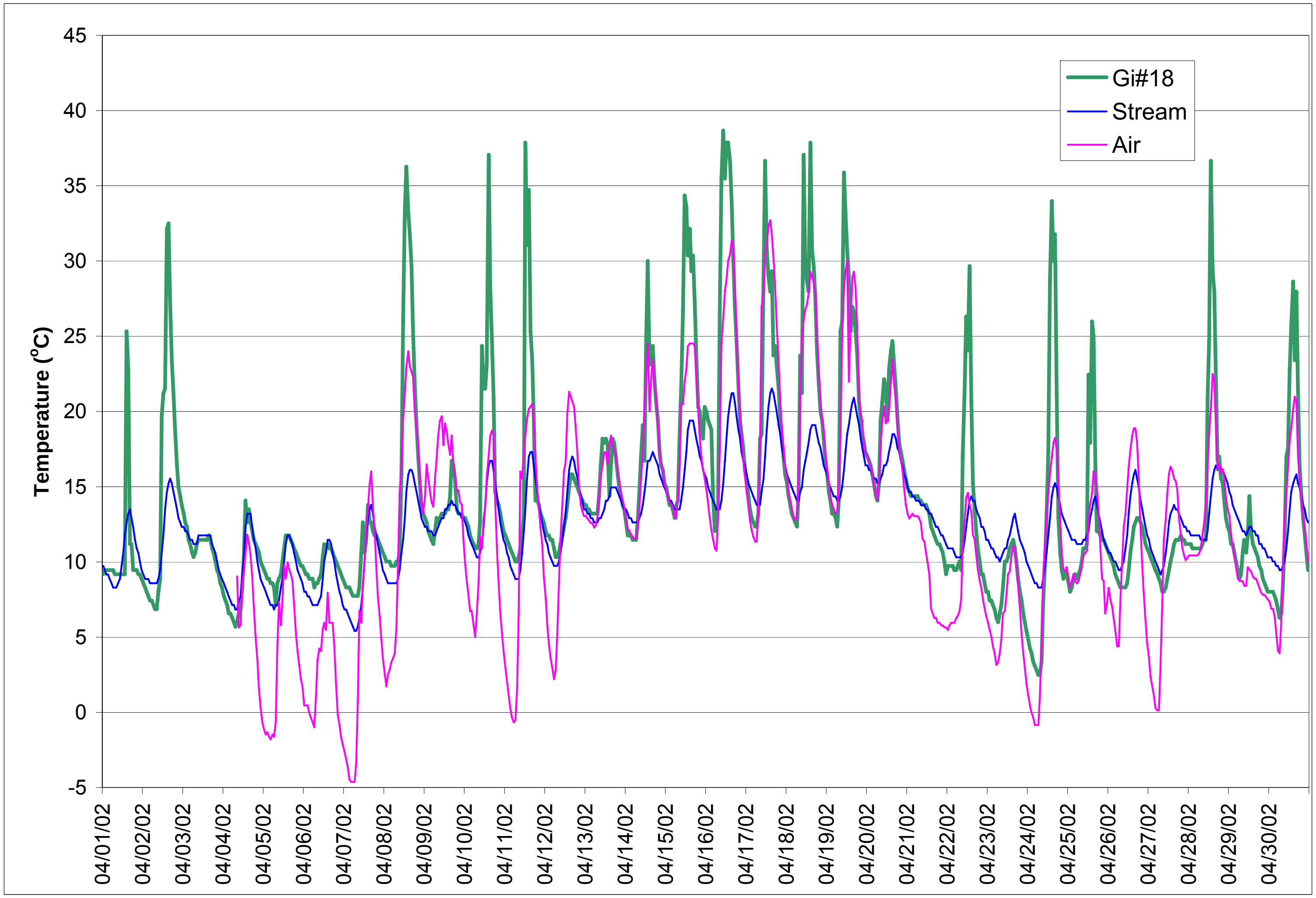
Gi#18 temperatures for October 2001.



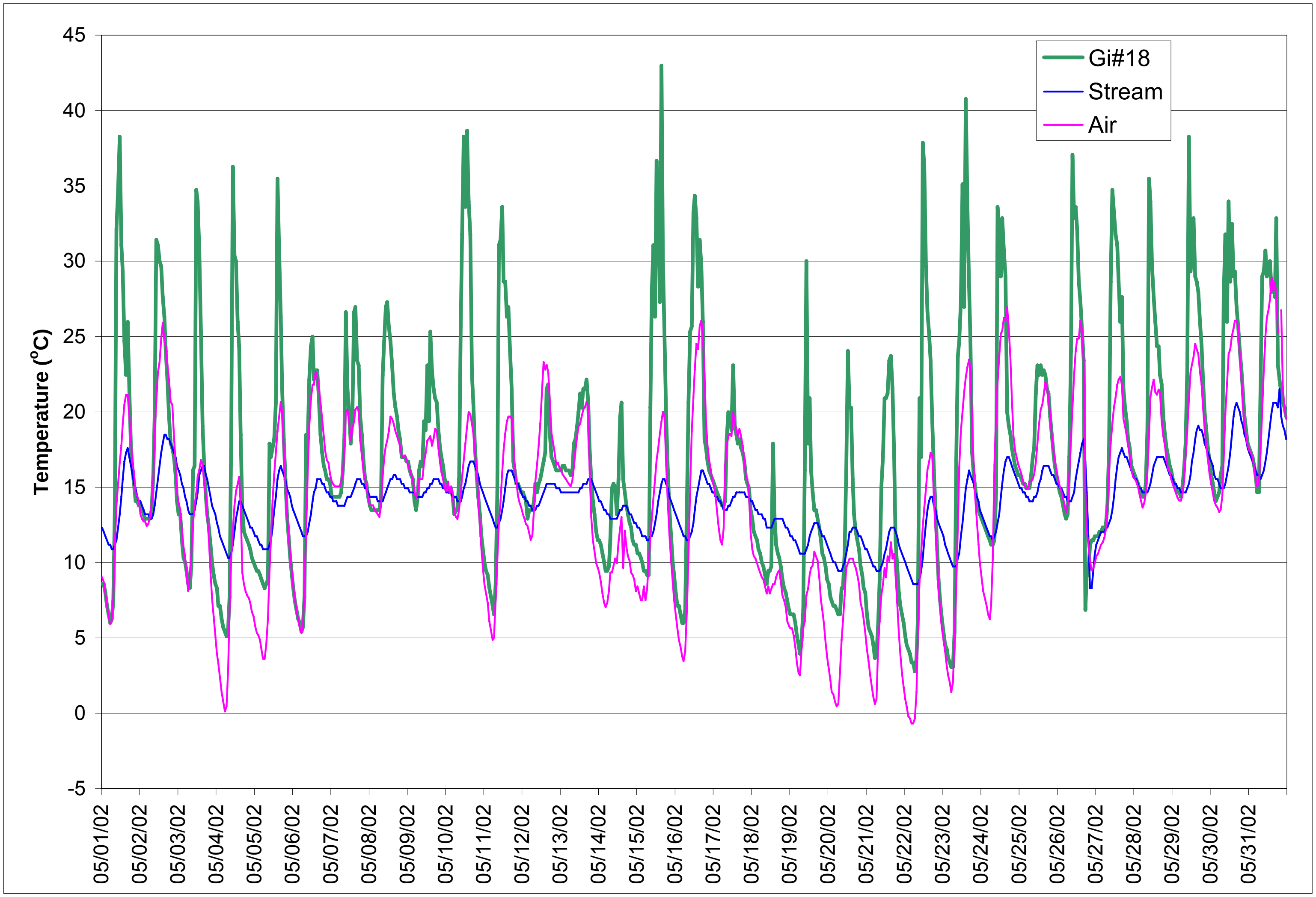
Gi#18 temperatures for October 2001 through March 2002.



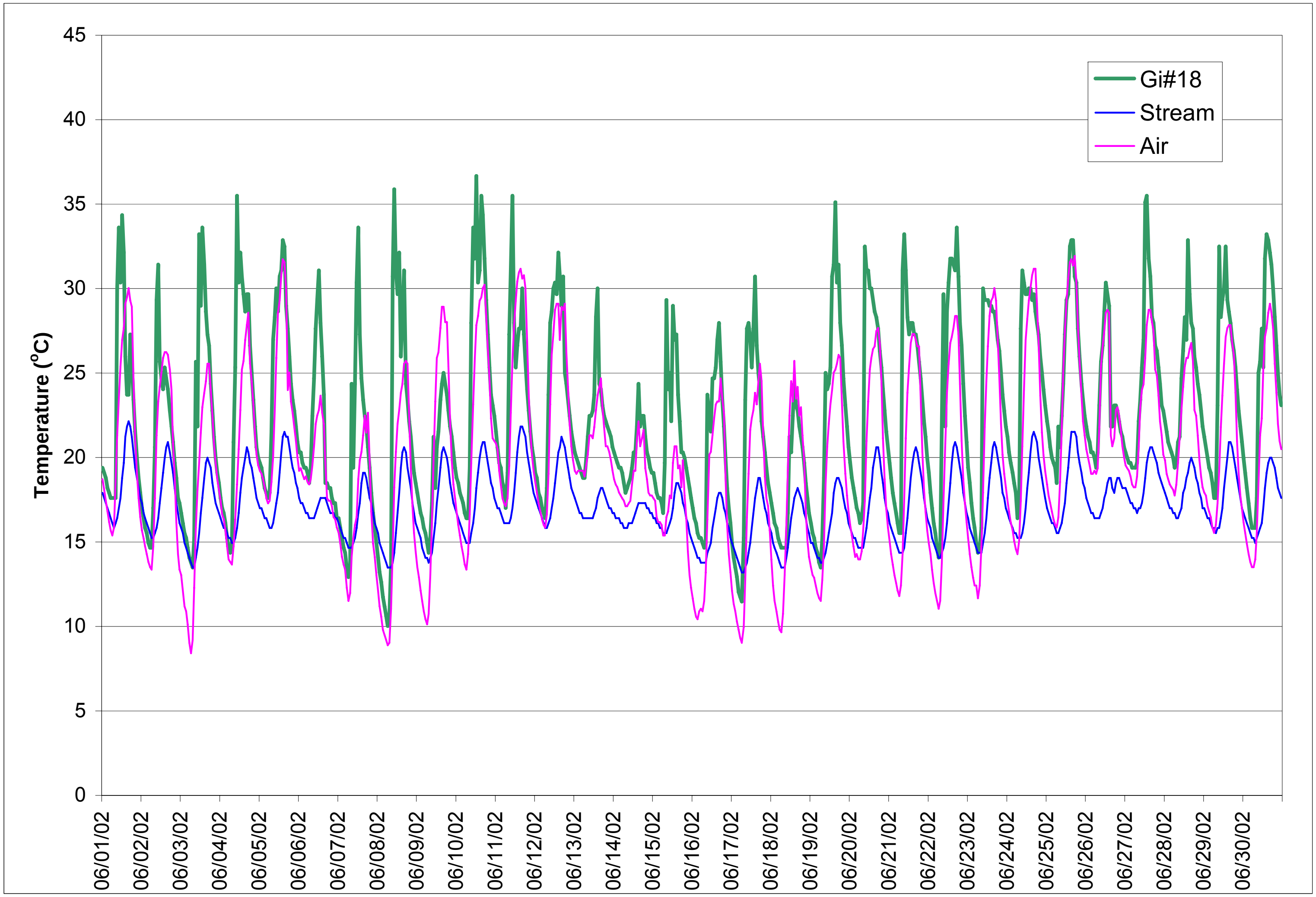
Gi#18 temperatures for March 2002.



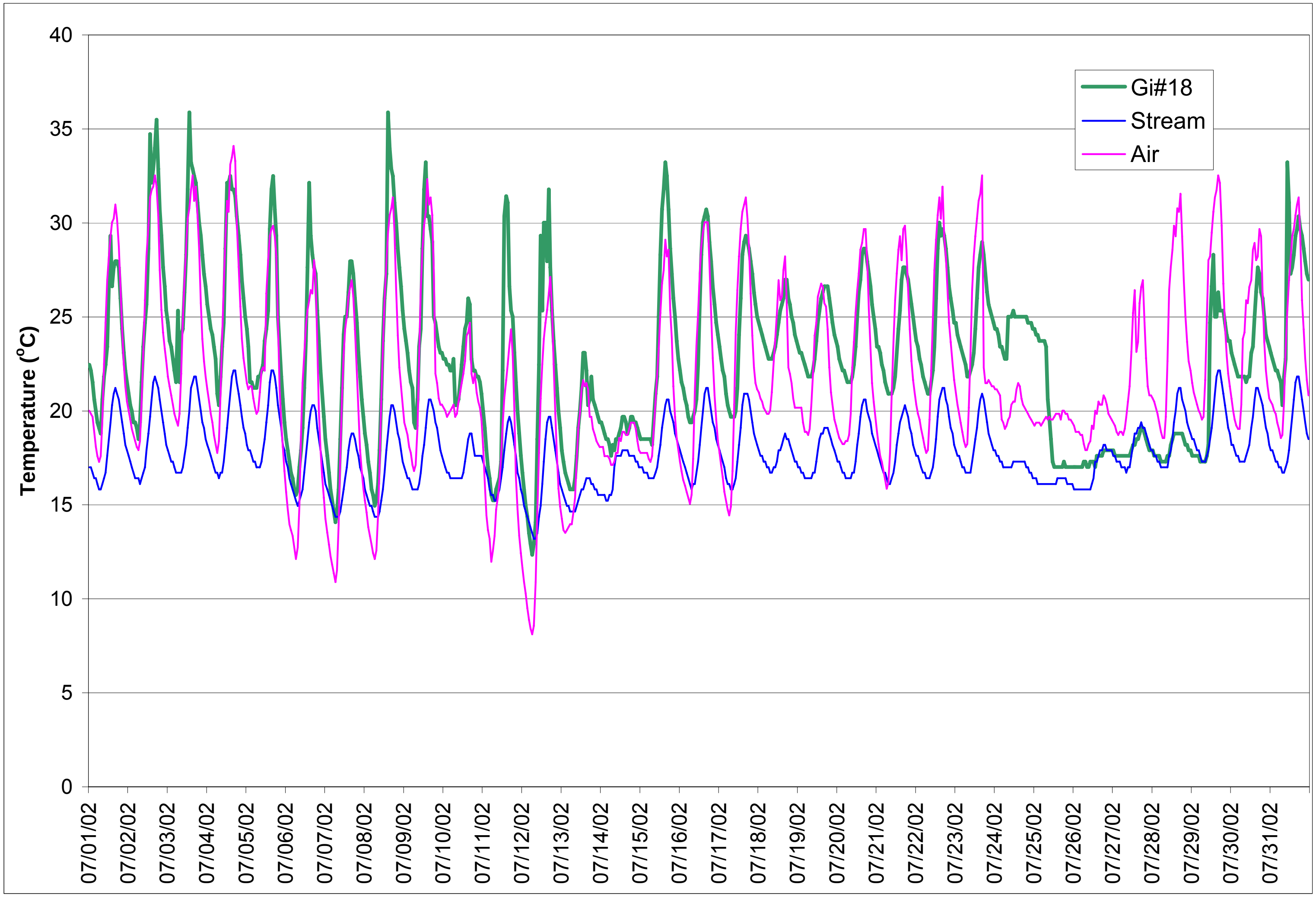
Gi#18 temperatures for April 2002.



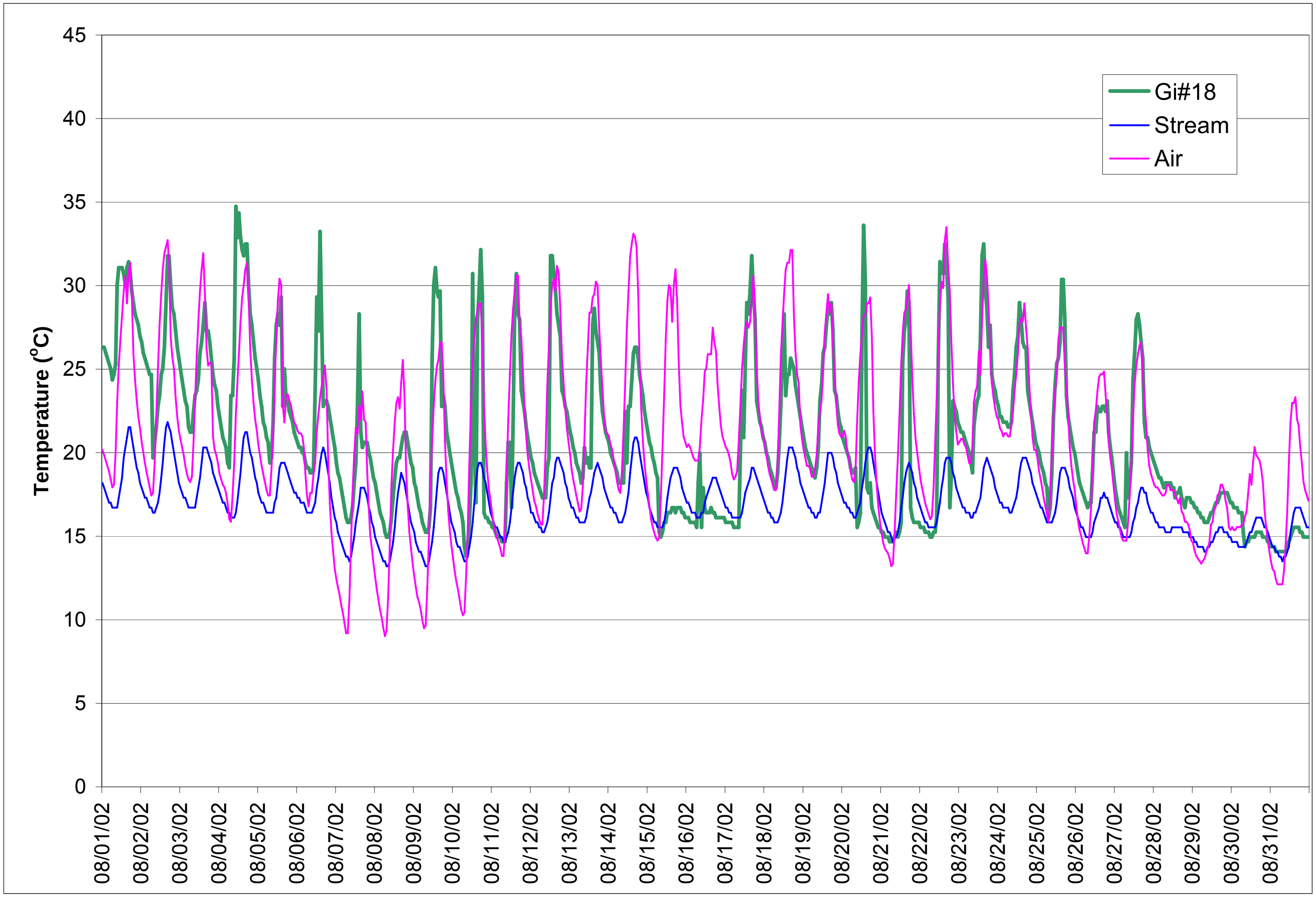
Gi#18 temperatures for May 2002.



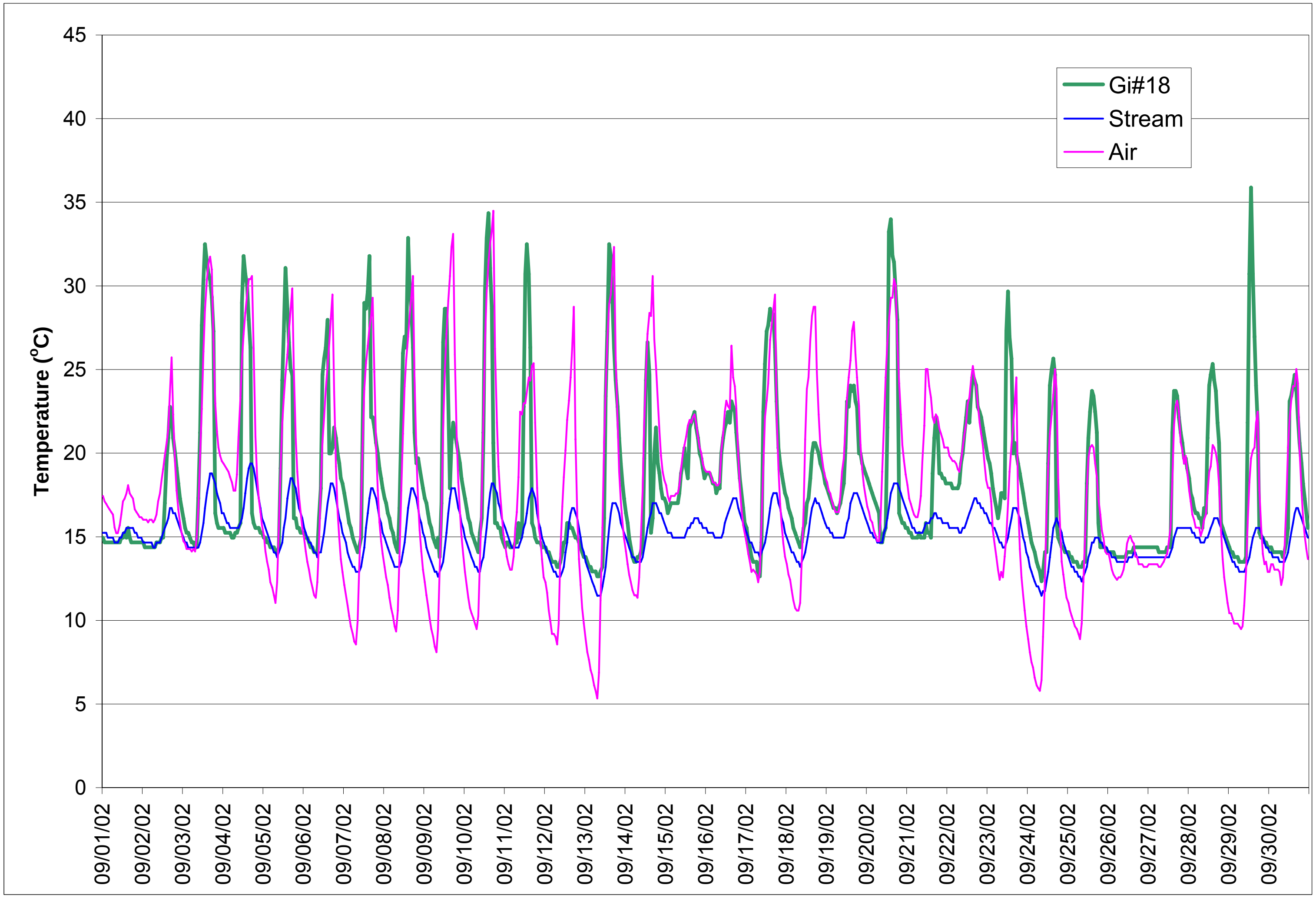
Gi#18 temperatures for June 2002.



Gi#18 temperatures for July 2002.



Gi#18 temperatures for August 2002.



Gi#18 temperatures for September 2002.

Gi#18 temperatures for October 2002.

CURRICULUM VITAE

Ariana N. Breisch

Education:

August 2000–present. Marshall University, Huntington, WV.

Master of Science in Biological Sciences.
Advisor: Dr. Thomas K. Pauley.
Expected date of graduation: May 2006.

May–June 2000. Highlands Biological Station, Highlands, NC.
Two graduate classes “Biology of Plethodontid Salamanders” and “Conservation Biology of Amphibians.”
Six credits from the University of North Carolina at Chapel Hill.

January–May 2000. Siena College, Loudonville, NY.
Three credits from undergraduate class “Conservation Biology.”

January 1998–May 2000. State University of New York at Cobleskill.
Bachelor of Technology, Wildlife Management.

August 1995–May 1997. State University of New York at Delhi.
Associate in Applied Sciences, Veterinary Science Technology.

Experience:

February 2003 – present. Wildlife technician, Cornell University, Ithaca, NY.
Duties included data entry for the NYS Amphibian and Reptile Atlas Project, radio-tracking *Terrapene carolina*, *Clemmys guttata* and *Glyptemys insculpta*, assist in field surveys and trapping of herps, including *Glyptemys muhlenbergii* and *Emydoidea blandingii*.

May – December 2002. Volunteer, Dept. of Environmental Conservation, Delmar, NY. Assisted in field surveys of various herpetofauna in New York, including *C. guttata* and *G. muhlenbergii*, radio-tracking *T. c. carolina* and juvenile *G. insculpta*.

August 2000-May 2002. Research assistant, Marshall University, Huntington, WV. Atlas of Reptiles and Amphibians in West Virginia – A WVDNR Non-game Project.
Identified and collected county records, directed and coordinated activities of 12 atlasers.

August 2000-May 2002. Assistant amphibian and reptile museum curator, Marshall University, Huntington, WV. West Virginia

Biological Survey of Reptiles and Amphibians in West Virginia. Maintained and updated state herpetological collection, directed and coordinated activities of other museum personnel/volunteers.

July 2001. Research assistant, North American Amphibian Monitoring Program. WV.
Conducted calling frog surveys.

August 2000-December 2000. Research assistant, Marshall University, Huntington, WV. Non-target Impacts from Regional Insecticide Applications and Gypsy Moth Defoliation – National Center of Forest Health Management and Forest Service.
Monitored salamanders and environmental conditions.

August 2000. Research assistant, Marshall University, Huntington, WV. Status of the Cheat Mountain Salamander in Timberline Ski Area in Monongahela National Forest.
Monitored salamanders and environmental conditions.

July-August 2000. Wildlife technician, Cornell University, NY. Duties included data entry for the NYS Amphibian and Reptile Atlas Project.

May–August 1999. Research assistant, Warrensburg, New York. Duties included radio-telemetry study of the Wood Turtle, *Clemmys insculpta*; turtle and small mammal trapping; Peregrine Falcon and Timber Rattlesnake observations.

May-August 1999. Wildlife technician, NYSDEC, Warrensburg, NY. Duties included work on the NYS Amphibian and Reptile Atlas project; waterfowl trapping; banding; and nest box observation; nuisance wildlife calls; herp team volunteer for first annual BioBlitz.

1996-1998. Field assistant, Dome Island, Nature Conservancy Preserve, Lake George, NY.
Duties included note taking, data entry, and assisting with identification and inventory of woody plant species.

June 1997-January 1998. Licensed veterinary technician, Shaker Veterinary Hospital, Latham, NY.
Duties included office visits, blood work, laboratory analysis, radiography, anesthesia, surgical assisting, administering meds.

1992-2000. Volunteer, NYS Department of Environmental Conservation, Delmar, NY.

Duties included searching for and identification of amphibian and reptiles throughout New York State for the Amphibian and Reptile Atlas Project and assisting with monitoring amphibian tunnels.

1993-1994. Animal caretaker, Griffin Laboratory, NYS Department of Health, Guilderland, NY.
Cared for dogs with bleeding disorders, assisted veterinarian.

Posters:

Breisch, A. N., A. R. Breisch, and T. K. Pauley. 20 April 2002. *Using temperature loggers to supplement Wood Turtle telemetry data.* 77th Annual Meeting of the West Virginia Academy of Science, Morgantown, WV.

Pauley, T. K., A. N. Breisch, and S. J. Myers. 20 April 2002. *Status of the West Virginia state collection of amphibians and reptiles.* 77th Annual Meeting of the West Virginia Academy of Science, Morgantown, WV.

Breisch, A. N., A. R. Breisch, and T. K. Pauley. 7 March 2002. *Using temperature loggers to supplement Wood Turtle telemetry data.* West Virginia Chapter of the Wildlife Society 2002 Annual Spring Meeting, Stonewall Jackson Lake State Park, WV.

Pauley, T. K., A. N. Breisch, and S. J. Myers. 7 March 2002. *Status of the West Virginia state collection of amphibians and reptiles.* West Virginia Chapter of the Wildlife Society 2002 Annual Spring Meeting, Stonewall Jackson Lake State Park, WV.

Wooten J., A. Breisch, and T. K. Pauley. 22-25 April 2001. *SEM analysis of tooth morphology in some species of the family Plethodontidae.* 57th Annual Northeast Fish and Wildlife Conference, Saratoga Springs, NY.

Wooten J., A. Breisch, and T. K. Pauley. 5 April 2001. SEM analysis of tooth morphology in some species of the family Plethodontidae. Association of Southeastern Biologists 62nd Annual Meeting, New Orleans, LA.

Felix, Z., J. Wooten, N. J. Dickson, R. Fiorentino, A. Breisch, M. Takahashi, and T. K. Pauley. 5 April 2001. *Nontarget impacts on terrestrial and aquatic salamanders from insecticide applications and gypsy moth defoliation.* Association of Southeastern Biologists 62nd Annual Meeting, New Orleans, LA.

Breisch, A. N. and A. R. Breisch. 27 April 2000. *Predicting biomass of salamanders by measuring lengths.* New York State Natural History Conference VI, Albany, NY

Breisch, A. R., K. L. Breisch, and A. N. Breisch. 27 April 2000. *Long-term changes in an old-growth hemlock-hardwood forest.* New York State Natural History Conference VI, Albany, NY.

Presentations:

Breisch, A. N., A. R. Breisch, and T. K. Pauley. 11 April 2002. *Thermal Regime of Clemmys in West Virginia.* 77th Annual Meeting of the West Virginia Academy of Science, Morgantown, WV.

Breisch, A. N., A. R. Breisch, and T. K. Pauley. 11 April 2002. *Thermal Regime of Clemmys in West Virginia.* Association of Southeastern Biologists Annual Meeting, Boone, NC.

Miscellaneous:

July 2002. Research assistant on Coahuila Box Turtle (*Terrapene coahuila*), Cuatro Cienegas, Mexico.

2000 - present. Northeastern Partners in Amphibian and Reptile Conservation. Member of the Risk Assessment Working Group.

19-21 February 2001. Southeastern Partners in Amphibian and Reptile Conservation. Recorded minutes of annual meeting.

September 1999. Member of the SUNY Cobleskill Quiz Bowl team, competed at the Annual Wildlife Society Meeting, Austin, Texas.

1997. Licensed veterinary technician (now inactive).

References:

Dr. Thomas K. Pauley. Graduate advisor. Marshall University, Department of Biological Sciences, 1 John Marshall Drive, Huntington, WV 25755. (304) 696-2376. pauley@marshall.edu

Sheila. E. Tuttle. Research director. 511 County Route 16, Fort Ann, NY 12827. (518) 639-8819. stuttle@skidmore.edu

Kevin L. Berner. Associate professor. State University of New York at Cobleskill, Cobleskill, NY 12043. (518) 255-5252. klberner@cobleskill.edu