NATURAL HISTORY AND HABITAT USE OF THE ORNATE BOX TURTLE *TERRAPENE ORNATA ORNATA* AT A MIXED-GRASS PRAIRIE IN SOUTHWEST NEBRASKA

A Thesis

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by

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THESIS ACCEPTANCE

Acceptance for the faculty of the Graduate College, University of Nebraska, in partial fulfillment of the requirements for the degree Master of Arts, University of Nebraska at Omaha.

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ABSTRACT

Using radiotelemetry and field searches, the ornate box turtle (*Terrapene ornata ornata*) population on an upland mixed-grass prairie in Red Willow County of southwestern Nebraska was studied. Their natural history and habitat use were investigated. Forty-six turtles were captured at least once. During the second summer of research, three adult females were outfitted with transmitters and located repeatedly. Two main types of habitat were used by the turtles; 1), shady areas screened from above and to the side served both as hiding and thermal cover; 2), areas of bare ground or very short, flexible vegetation, such as buffalo grass, were preferred by travelling turtles. The turtles' behavior, diet, and reproductive ability were consistent with the reports in the literature.

ACKNOWLEDGEMENTS

This thesis would not exist without the assistance and support of many people. I want to thank the members of my committee. Dr. James Fawcett has been a major motivator. He has given me helpful suggestions and references from sources not included in any library, such as herpetological club newsletters. Dr. Steele Lunt freely provided encouragement and his insect identification books. Dr. James Wood gave assistance and advice on tracking methods.

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INTRODUCTION

The ornate box turtle *Terrapene ornata ornata* (Agassiz, 1857) is a terrestrial turtle which infrequently enters the water except to drink, soak, and prey on animals which inhabit shorelines, like tadpoles. It is not a large turtle, rarely exceeding 500g or 400 mm total carapace length. Populations of this animal have been declining due to habitat degradation and destruction, and the excessive collecting for the pet trade (Doroff and Keith, 1990; New York Turtle and Tortoise Society, 1994; Stevens, 1994), so in June 1994, the Fish and Wildlife Service proposed to list it and all other species of North American box turtles in CITES Appendix II (Lieberman, 1994).

T. o. ornata ranges over much of the Great Plains states of North America (Figure 1). The range of habitat types where it is found is quite diverse. For example, in northeastern Kansas, Fitch (1958) and Legler (1960) studied *T. o. ornata* in a deciduous forest and a grazed tallgrass prairie, respectively. In Nebraska, it inhabits cottonwood-dominated riparian forest (personal observation, 1992), sand-sage prairie, and sandhills mixed-grass prairie (Lynch, 1985; Freeman, 1990; Lynch 1994). It ranges over most of Nebraska (Figure 2), but is most common in the sandhills, an area of mixed-grass prairie with sandy soil (Lynch, 1985; Freeman, 1990).

Various aspects of the ecology of *T. o. ornata* and the closely related taxa *T. carolina carolina* (Eastern box turtle) and *T. c. triunguis* (three-toed box turtle) have been reported. These studies have dealt with such topics as home range (Legler, 1960; Strang, 1983; Schwartz *et al.*, 1984; Stickel, 1989), movement (Muegel and Claussen, 1994), feeding behavior (Norris and Zweifel,

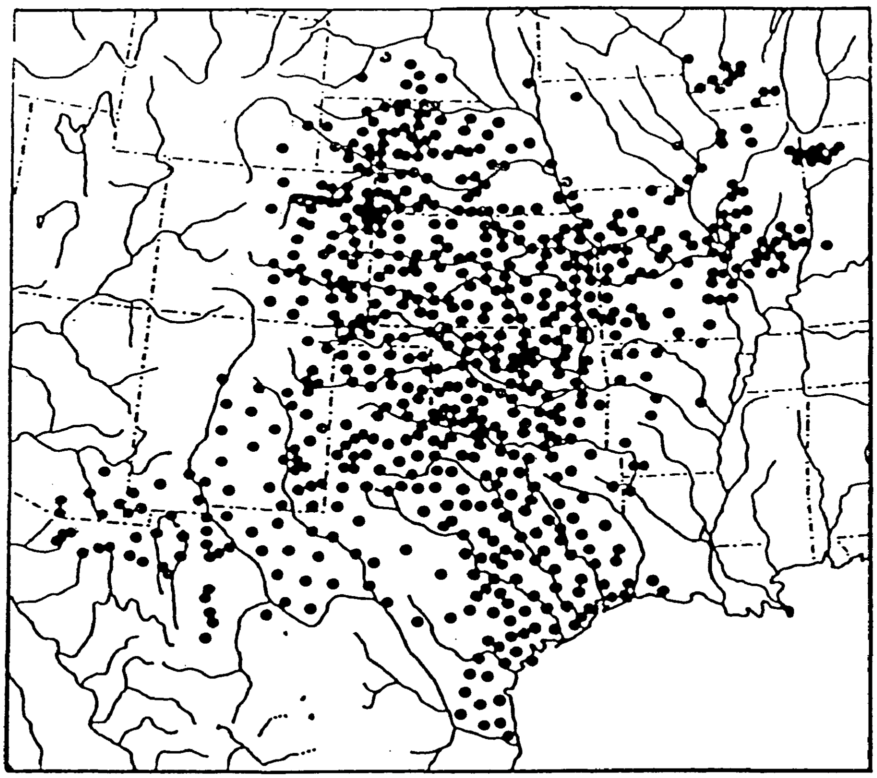

Figure 1. Distribution map of the ornate box turtle, *T. o. ornata*. From Ernst and Barbour (1972).

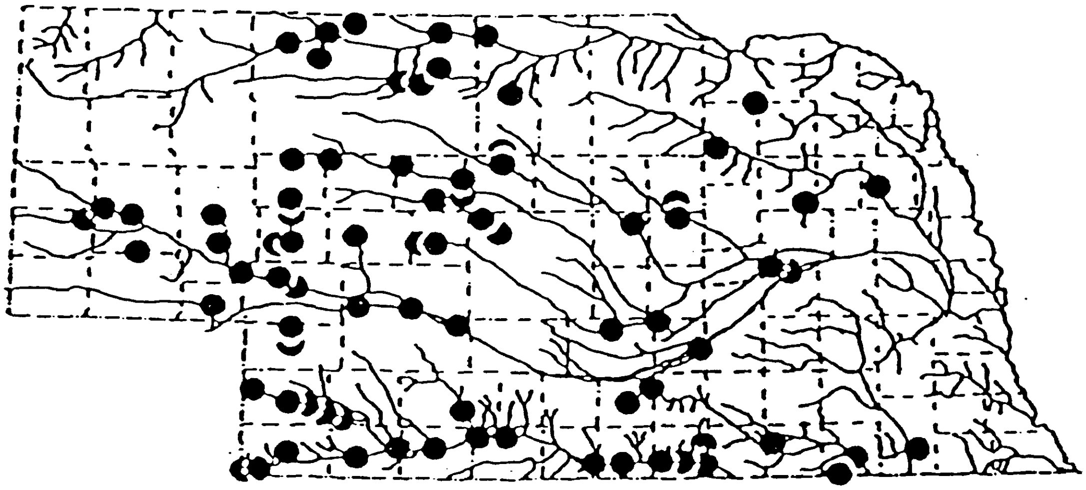

Figure 2. Distribution map of the ornate box turtle in Nebraska. From Lynch (1985).

1950; Legler, 1960; Thomasson, 1980; Parker, 1982), thermal biology (Ellner and Karasov, 1993), hibernation (Cahn, 1933; Clarke, 1956; Peters, 1959), population density, (Legler, 1960; Doroff and Keith, 1990) nesting behavior and reproduction (Fitch, 1958; Legler, 1960; Stickel, 1989; Tucker, 1995), and longevity (Metcalf and Metcalf, 1985).

No studies of ornate box turtles have been carried out in Nebraska. Therefore, this thesis focuses on the natural history and habitat use of a *Terrapene ornata ornata* population at a mixed-grass prairie in southwestern Nebraska.

STUDY SITE

Location

Red Willow County is in southwestern Nebraska (Figure 3). The county is sparsely populated (the largest town's population is less than 9000), and its primary industry is farming (Figure 4). The floodplains support irrigated crops and floodplain forest, and the uplands are used mostly as a pasture for beef-cattle, with some irrigated crops. The study site's legal description is: Red Willow County, T3N R30W S32 SE 1/4. It is approximately 8 km from McCook.

Climate

This region of the United States experiences a windy, dry, temperate climate. The cold, dry winter features temperatures which can reach -40 C and snowfall accumulation rarely exceeds thirty centimeters. If there is enough moisture, frost will penetrate over a meter into the soil (Soil Survey, 1967).

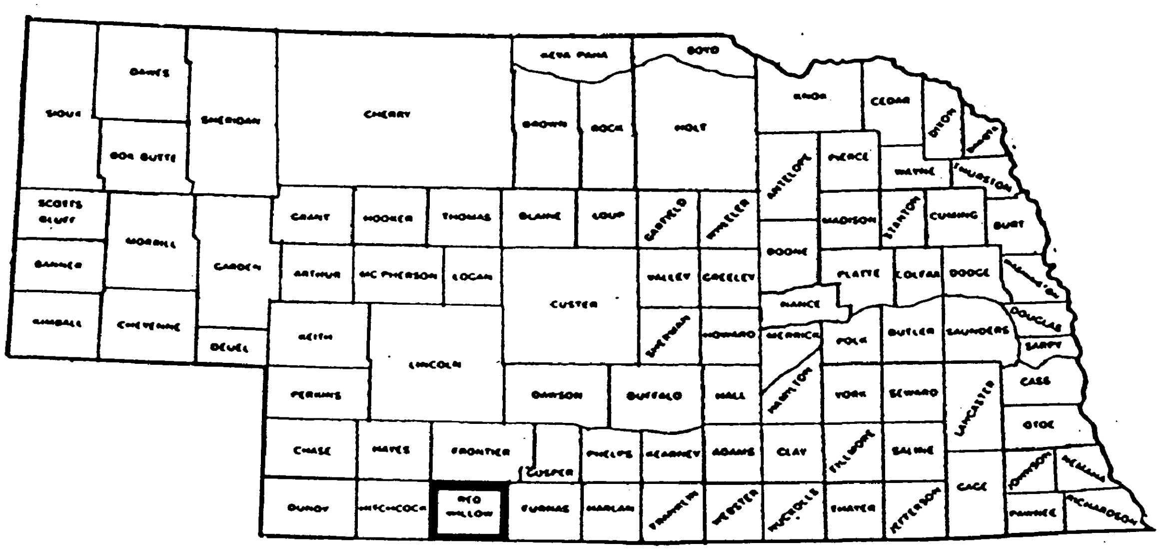

Figure 3. County map of Nebraska. Adapted from Stephens (1973). Note: the heavily bordered county is Red Willow County.

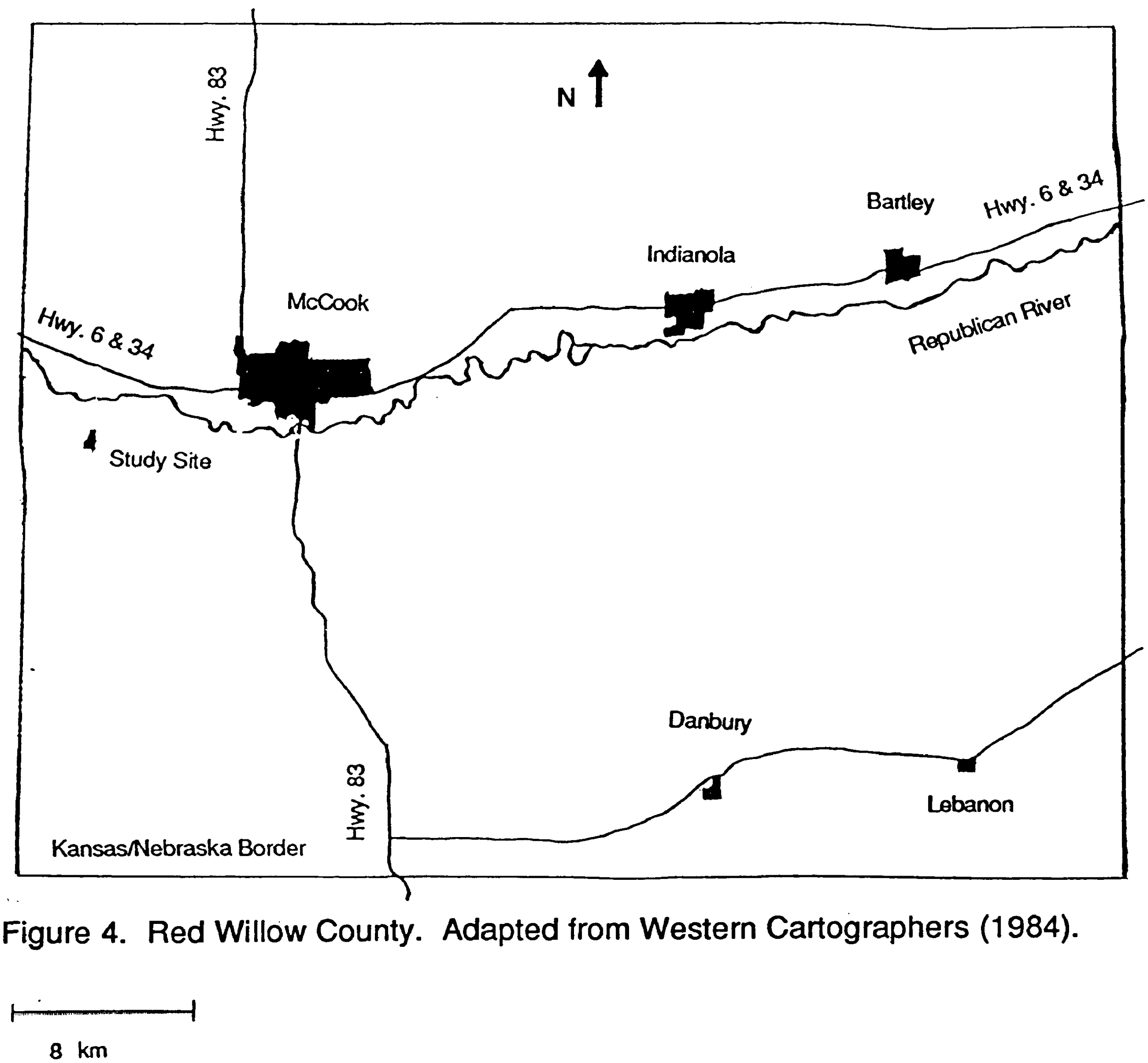

Figure 4. Red Willow County. Adapted from Western Cartographers (1984).

Summer temperatures often reach between 32 and 37 C. The highest temperature reached in the last twenty years was 46 C, which was attained daily for a week (personal observation). Some years have a drought of one to three months' duration. Average annual temperature is 17 C.

Average yearly precipitation is fifty-two centimeters, most of which falls during the summer. The amount of rain which falls at one time is usually less than two centimeters, but rains of seven centimeters or more sometimes fall, causing brief flooding. Wind is a constant factor, for it rarely slows to less than a stiff breeze. Winds are highest in late fall, and during winter and spring.

The summers of 1992 and 1993 were cooler and wetter than normal. According to the Weekly Weather and Crop Bulletin (1992, 1993), temperatures averaged 1.3 to 3.3 C less than normal, and crop moisture ranged from slightly dry to wet . (Note that crop moisture is based on the ideal moisture content of the top meter and a half of soil for corn.) Crop moisture in "normal" years for this region usually ranges from abnormally dry to severe drought. The springs of 1992 and 1993 were up to fifty percent or more drier than normal, even though the summers were up to sixty percent wetter than normal (National Oceanic and Atmospheric Administration, 1992;1993). For more specific temperature and precipitation information, see Appendices 4 and 5.

Soil Characteristics

Soil on the study site is light beige, five to twelve cm thick, with little organic material incorporated, especially where it was previously cultivated. It's composition is Ulysses silt-loam and the Holdredge-Keith association. The parent material is calcareous Peorian loess (windblown silt). In previously cultivated areas, tillage has incorporated underlying parent material with the soil (Soil Survey, 1967).

Habitat Types

The study site is 27.86 hectares of the uplands rising south of the Republican River floodplain (Figure 5). Roughly half the site (13.72 ha) is an abandoned terraced wheat field which has reverted to a mixed-grass prairie containing mature cottonwood trees, *Populus deltoides*, intermittent pools with associated riparian plants, and a small (estimated maximum of ten individuals) black-tailed prairie dog (*Cynomys ludoviscianus*) town (Figures 6 and 7).

On June 6, 1993, the entrances of the prairie dog town were filled in by someone using a spade. It is unknown whether toxic gas and/or poisoned peanuts were also used, but their use is a common practice in this area. Within a week, all but two or three of the entrances had been re-opened by the prairie dogs. The only known fatality from this occurrence was a juvenile burrowing owl (*Athene cunicularia*). Although there seemed to be fewer prairie dogs, I did not know for certain because they keep dead individuals inside the colony instead of ejecting the remains. The burrows which remained closed were those which had not been used by the prairie dogs before this incident. Some

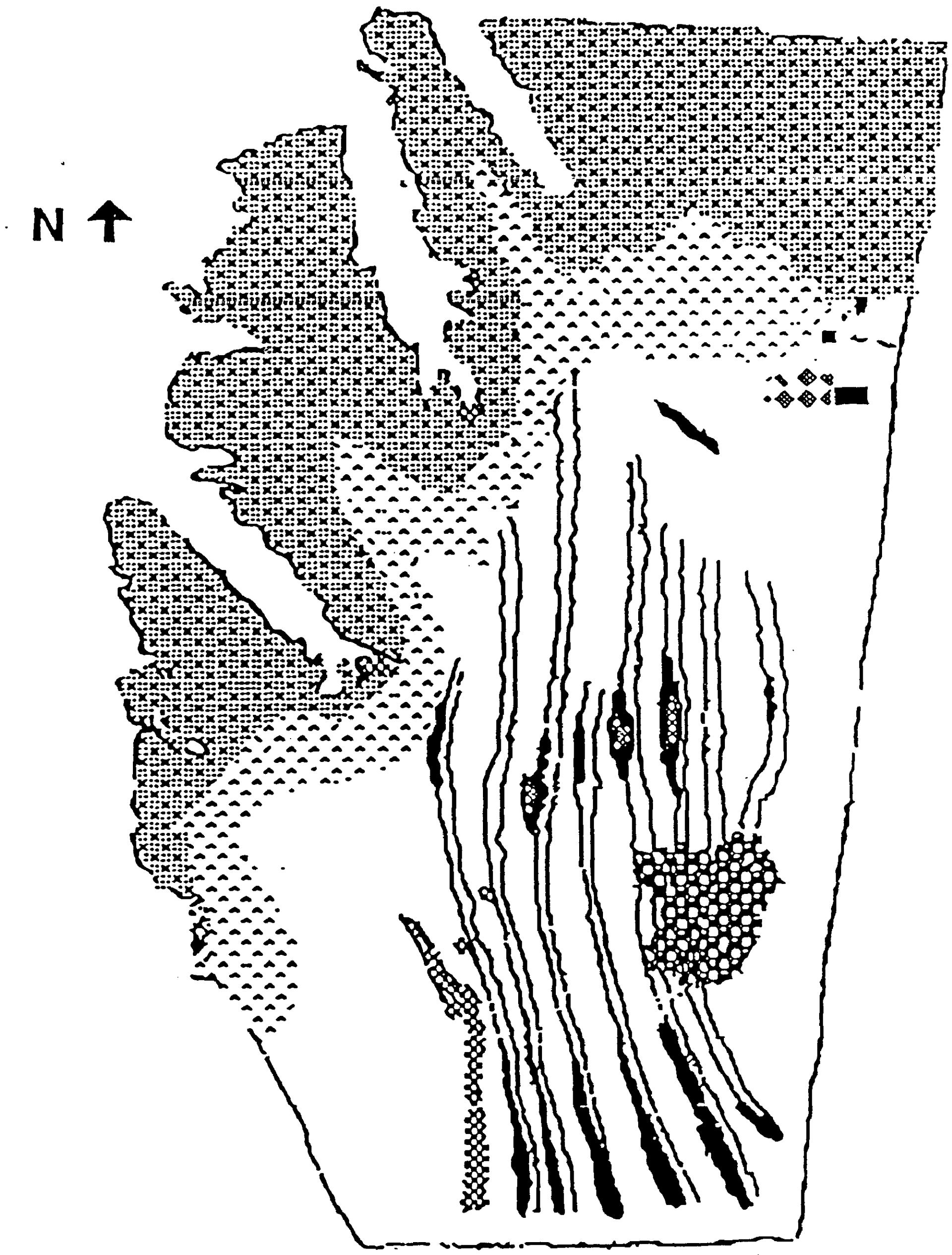

Figure 5 **STUDY SITE VEGETATION MAP**

cottonwood trees 100 meters
senescent windbreak
intermittent pool
yucca-dominated mixed-grass prairie
snakeweed-dominated mixed-grass prairie
western wheatgrass-dominated mixed-grass prairie
riparian mixed-grass prairie
prairie dog town
artificial structures

Figure 6. Abandoned wheatfield at study site.

Figure 7. Prairie dog town at study site.

had had an accumulation of cobwebs across the entrances or were occupied by burrowing owls.

The remainder of the study site is rugged. It is comprised of arroyos, shallow canyons, and uplands which have never been cultivated (Figures 8 and 9). The plant community contains mixed-grass and shortgrass prairie dominated in places by yucca (*Yucca baccata*) and prickly pear cactus (*Opuntia macrorhiza macrorhiza*). The two areas are delineated by a decrepit barbed-wire fence which does not hinder the movement of turtles, cattle, or humans because it has not been repaired for so long that many of the wooden posts have fallen due to dry rot (an infestation by fungus). The whole study site is used as pasturage for beef cattle, but is not grazed to the extent that the populations of ice-cream plant species are disappearing.

In the cottonwood association (Figures 10 and 11), trees between six and nine m tall grow in depressions which frequently hold standing water. Due to the effects of cattle access, the pools under these trees varied from 25 cm deep with a churned mud bottom to trampled hardpan. Amphipods (scuds), brachiopods (fairy shrimp), aquatic predacious beetles and bugs, and thousands of spadefoot toad tadpoles (*Scaphiopus bombifrons*) constitute the larger inhabitants of these pools. Dozens of spadefoot toad tadpoles are often trapped in one cattle hoofprint as the pools dry, but I never found dead tadpoles. Raccoon (*Procyon lotor*) and striped skunk (*Mephitis mephitis*) tracks are frequently found at the verges of the pools, and killdeer (*Charadrius vociferus*) were often seen foraging at the pools' verges. However, I never observed killdeer consume tadpoles.

Figure 8. Canyon at study site.

Figure 9. Uplands at study site.

Figure 10. Distant view of cottonwood association.

Figure 11. Close view of cottonwood association.

The second tree association (Figure 12), is a stunted and senescent windbreak to the west of the ruins of a building. About 70% of the trees have died. The understory varies from 95% hard-packed soil (due to cattle access) to 80% cover of invader plant species.

Between terraces on the abandoned wheatfield (Figure 13) grows mixed-grass prairie dominated by western wheatgrass (*Agropyron smithii*) and sideoats grama (*Bouteloua curtipendula*). Distance between flower stems varies between 0 and 10 cm. Flower stem height ranges from 20 to 26 cm.

The crests of terraces are dominated by the short grasses blue grama (*Bouteloua gracilis*) and buffalo grass (*Buchloe dactlyloides*). Maximum flower stem height is ten centimeters, and up to 80% of the area is bare soil or soil covered only by a thin blue-green bacterial mat.

Uphill of the terraces, rainwater collection allows communities typical of riparian zones (Figure 14). These are dominated by switchgrass (*Panicum virgatum*) and smartweed (*Polygonum amphibium*) which reach one meter tall. A few pools produce pondweed (*Potamogeton pectinatus.*) when cattle are not present.

On the arroyo uplands, snakeweed (*Gutierriza sathrothrae*) is prevalent where there is moderately high grazing pressure, such as along fencelines (Figure 15). It is a sub-shrub which reaches a maximum diameter of 45 cm and is usually associated with little bluestem (*Andropogon scoparius*). Yucca and prickly pear cactus are nearly ubiquitous throughout the upland mixed-grass prairie (dominated by sideoats grama and blue grama), but are sparser in the upland short-grass prairie (blue grama and buffalo grass dominated). Burrows

Figure 12. View from east of the senescent windbreak and abandoned building.

Figure 13. Mixed-grass prairie of abandoned wheatfield.

Figure 14. Rainwater pool with riparian plants on abandoned wheatfield.

Figure 15. Upland snakeweed association.

of large animals, possibly badgers (*Taxidea taxus*) and/or coyotes (*Canis latrans*) are frequent on west-facing slopes.

The areas of the different habitat types are shown in Table 1.

The vertebrates and vascular plants identified on the study site are listed in Appendices 1 and 2.

In mid-June, 1992, cattle were introduced to the area to graze. They were removed in mid-July. In 1993, cattle were introduced June 5 and removed June 20, then re-introduced July 18. They remained until after the end of my study.

Table I. Areas of the different habitats within the study site.

Habitat Type	Area (ha)	Percent of Total Area
windbreak	0.13	0.5
riparian pools	0.24	0.9
road ditch	0.27	1.0
prairie dogs	0.50	1.8
snakeweed	2.80	10.0
yucca-cactus	10.20	36.6
wheatfield	13.72	49.2
Total	27.86	100.0

MATERIALS AND METHODS

Turtles were captured by hand following intensive searching as described by Karns (1986). These searches were always conducted between

7:30 am and 12:30 pm, and lasted about four hours. Captured turtles were measured as follows: carapace length (CL), total carapace length (TCL), plastron length (PL), total plastron length (TPL), carapace height (CH), carapace width (CW); then weighed and sexed (Brumwell, 1940; Legler, 1960; Schwartz et al., 1984; Metcalf and Metcalf, 1985; Freeman, 1990). Metric calipers were used when measuring carapace and plastron length, carapace height, and carapace width. A metric measuring tape was used to measure total lengths of the carapace and plastron. The method of grouping the turtles by age classes was adapted from Schwartz et al. (1984), Metcalf and Metcalf (1985) and Zug (1991). A battery-powered fish scale and tared plastic-net bag (such as is used for grocery produce) were used to determine weight to the nearest ounce during the summer of 1992. These weights were later converted mathematically to grams. During the summer of 1993, a one-kilogram field scale, accurate to the nearest ten grams was used with the net bag. Once measurements were complete, the turtle was marked by carefully notching marginal scutes on the turtle's carapace (see Mills, 1991; Diemer, 1992) and released. See Appendix 3 for individual measurements.

At the beginning of the 1993 field season, three females which weighed over 120 g each were outfitted at the capture site with MOD-050 radio transmitters (Telonics, Inc.) before release (Kaufmann, 1991, 1992; Diemer, 1992; Breininger et al., 1994). First, the carapace was cleaned using a plastic-bristled brush and water. Once it had dried, (usually no more than five minutes) the transmitter, which weighed only 3 g, was affixed with wire through two holes drilled through the posterior edge of the carapace. It was then covered with

Dow Silicone Sealer. Transmitters were removed at the end of the season. The battery lasted the entire season at a rate of 30 pulses per minute. A Telonics TR-2 receiver with earphones and a handheld Telonics RA-2A antenna were used for tracking (Kaufmann, 1992). Detection ranged up to one-half kilometer under ideal conditions, but topography usually limited the range to a few hundred meters. Once the turtles were released, compass readings were made of two fixed points (allowing for the nine-degree standard deviation of magnetic north from polar north [from an aeronautical map of Nebraska, and a USGS map of the study site]) to allow triangulation of capture points.

Plant cover analysis was conducted in a one-quarter square meter plot centered on the capture point. A metric tape measure was used to define an area 0.5 m on each side. Then, percent plant cover was estimated as described by Barbour et al. (1980: 165-167). (Note: This method can easily yield greater than 200% plant coverage).

At the start of the 1992 field season, brightly colored plastic flags on wire stems were placed at each capture site, in addition to compass triangulation. This worked quite well until cattle were allowed onto the study site, when the cattle tasted and then discarded the flags. This habit did the cattle no harm, but it moved the flags. Since the cattle tasted all new flags as soon as they were in position, I soon discontinued the practice.

RESULTS

Population Characteristics

Forty-six turtles were captured on the study site. Nineteen of these were recaptured at least once, and five were recaptured twice. Captures for each unit effort (four hours of searching) ranged from zero to five, with a mode of one (+/- 1.08). The population was estimated at forty-eight turtles, following the method described by Davis and Winstead (1980) (Figure 16). Turtle density was approximately 1.65 per hectare.

The three radio-tagged females (L2R2; L1,2R10; L3R4) had total ranges of 15.770, 2.435 , and 2.215 hectares (ha) respectively. Their home ranges, where they spent their time during inclement weather (too hot, dry, and/or windy), had areas of 0.8900, 0.3850, and 0.710 ha respectively. The total ranges and home ranges of these individuals are shown on Figure 17.

The ratio of adult males to adult females was 20:8 (Figure 18). The juveniles and subadults were excluded from this comparison because their sex could not be reliably determined.

Annuli counts on the third left costal scute indicated that the following age classes were present: Class 1, juveniles and subadults (0 to 13 years), Class 2, adults (13 to 35 years) and Class 3, old adults (35+ years). Of the 46 turtles captured, 36% were in Class 1, 48 % were in Class 2 and 17 % were in Class 3 (Figure 18).

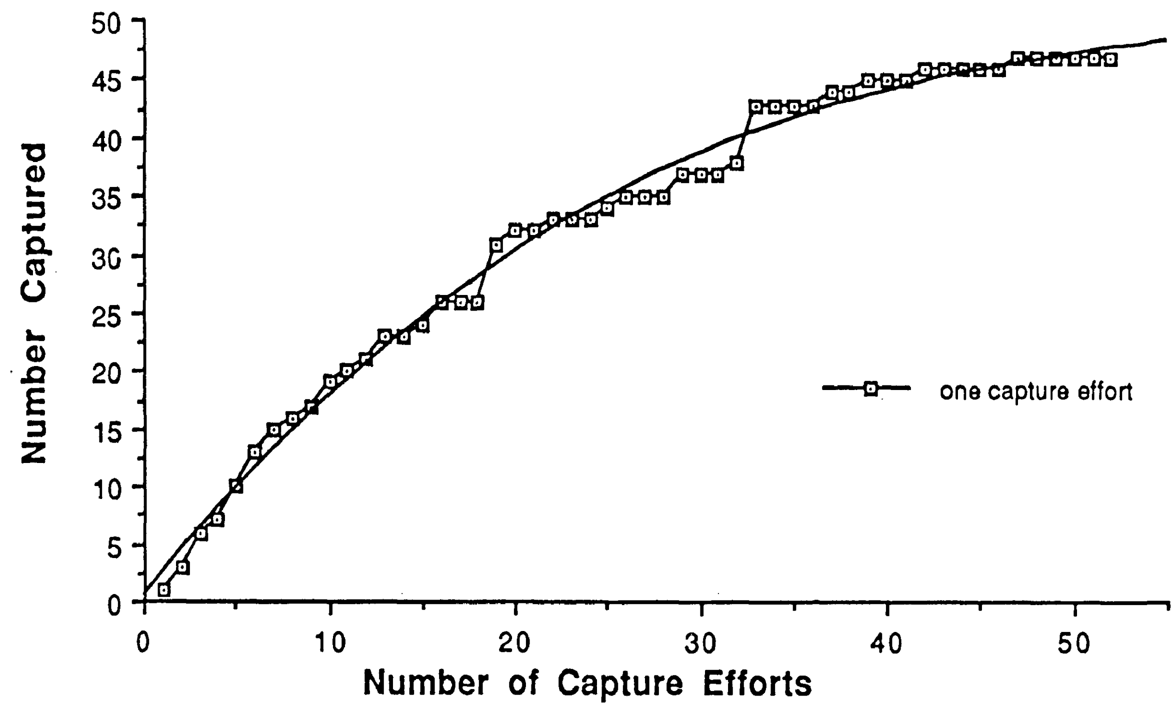

Figure 16. Cumulative number of unmarked turtles captured at the study site. (One unit of effort is four hours' search.) R^=0.992

Key to Figure 17

Contour interval 10 feet

Turtles' color codes:

L1,2 R10:	blue
L2 R2:	green
L3 R4:	red

Capture site ●

Nest Location ▲

Home range boundaries - - - - -

Total range boundaries – — – —

Nesting journey route . .>. . . . .>. .

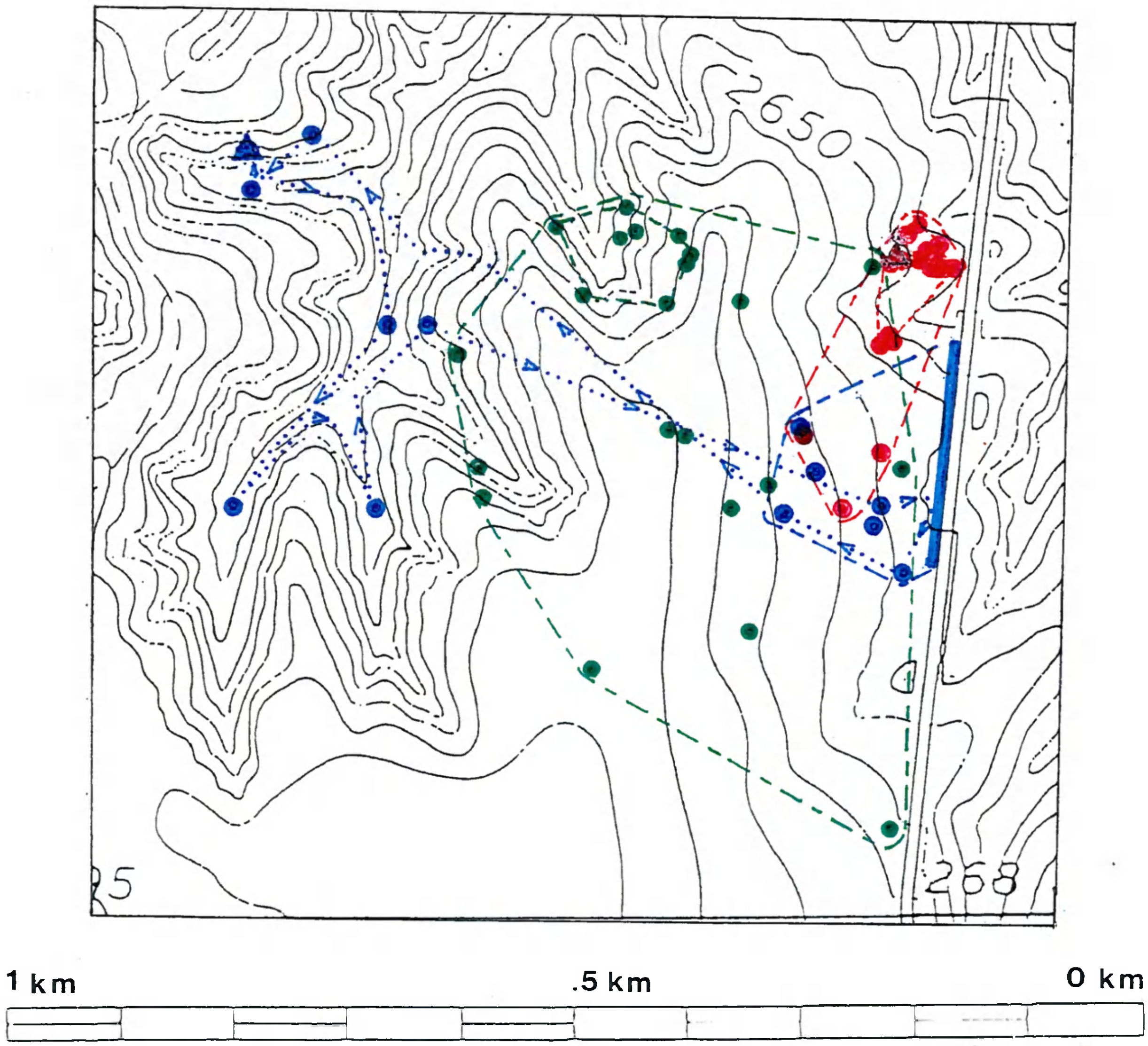

Figure 17. Map of home ranges and capture sites of the three radio-tracked *T. ornata*. Adapted from the U.S.G.S. map of McCook West, Nebraska.

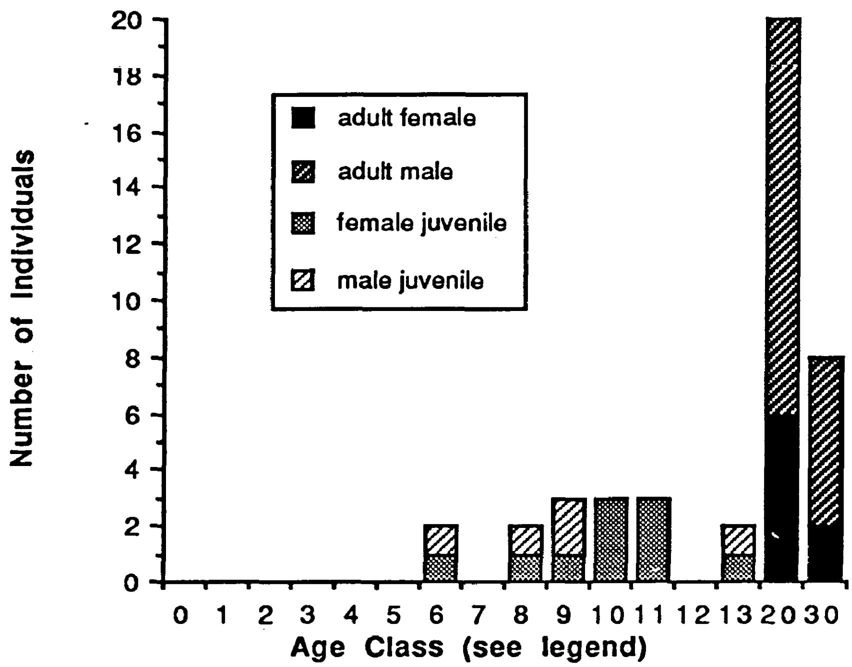

Figure 18. Age and sex structure of the study population of ornate box turtles. (Age 0=hatchlings; Ages 1 to 13=actual years; Age 20=Age Class 2; Age 30=Age Class 3.) Note: Sexual identification of juveniles is tentative.

Body size and mass of the 46 turtles are summarized in Table II and Figures 19 to 23. Detailed physical characteristics of every individual captured are in Appendix 3.

T. ornata in this study commonly bore scars on their shells. Scutes were usually slashed and chipped, as if a mammalian predator had chewed on the turtle. No turtle was found with fresh injuries. Three turtles were found with major injuries: ribs broken (Figure 24), right forefoot removed (Figure 25), large sections of the carapacial scutes gone.

Two unmarked adult male turtles were found killed on the gravel road bordering the study site, on June 13, 1993. These were the only observed fatalities for the two study seasons, although one of the nests may have been eaten by a hognose snake. Otherwise, there was no evidence of mortality on the study site: skin scraps, bones, pieces of shell, or remains in predator scats.

Even though I only captured about half the turtles in 1993 compared to 1992, this difference was probably not due to population decline, but to my concentration on locating radio-tagged turtles.

Food Preferences and Foraging Techniques

I observed seven turtles eating. Two consumed immature prickly pear cactus (*Opuntia macrorhiza*) fruit , one browsed a prickly pear cactus pad, one ate the leaves of a forb, *Koschia scoparia*, one ate an earthworm, and two were observed foraging in and under cattle feces. The two turtles foraging near cattle feces used different techniques. One (a female) which was at a semi-liquid dropping had waded in and was attempting to catch the beetles and maggots.

Table II Body size and mass of *Terrapene ornata ornata*.[a]

	N	CL (mm)	PL (mm)	TCL (mm)	TPL (mm)	CW (mm)	CH (mm)	Mass (g)
Juvenile male and female	15	94 +/- 11[b] 76 to 112[c]	90 +/- 11 76 to 112	119 +/- 12 98 to 137	111 +/- 12 92 to 128	77 +/- 8 66 to 91	44 +/- 5 34 to 52	242 +/- 85 113 to 383
Adult Male	20	108 +/- 6[b] 90 to 116[c]	107 +/- 8 87 to 119	133 +/- 8 112 to 143	127 +/- 8 110 to 138	88 +/- 6 80 to 96	49 +/- 4 41 to 55	353 +/- 53 230 to 420
Adult Female	8	104 +/- 6[b] 95 to 111[c]	102 +/- 6 94 to 111	131 +/-5 123 to 137	128 +/- 6 115 to 137	84 +/- 8 75 to 96	47 +/- 5 37 to 52	353 +/- 37 270 to 390

[a]N, number; CL, carapace length; PL, plastron length; TCL, total carapace length; TPL, total plastron length; CW, carapace width; CH, carapace height

[b]Mean +/- Standard deviation

[c]Range

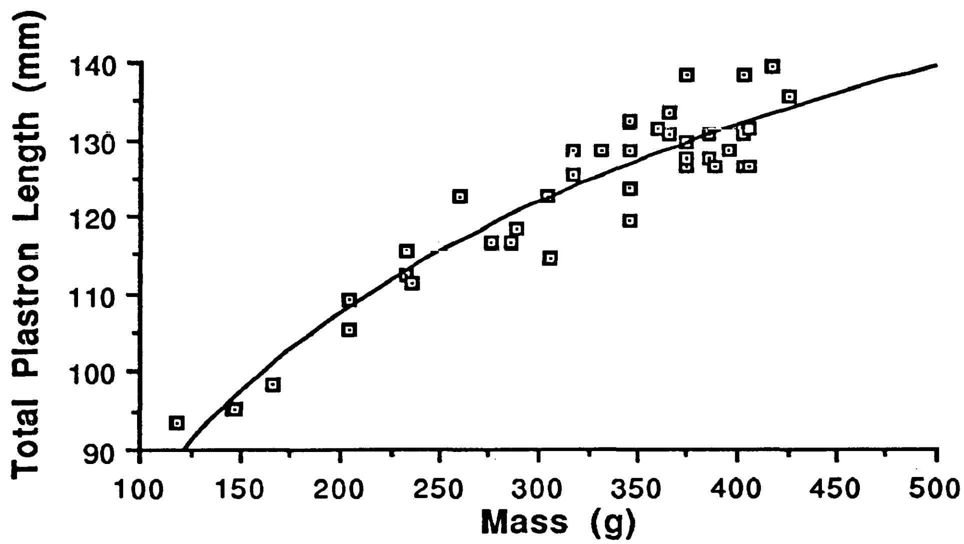

Figure 19. Relationship between total plastron length and mass for 40 ornate box turtles (R^2=0.890).

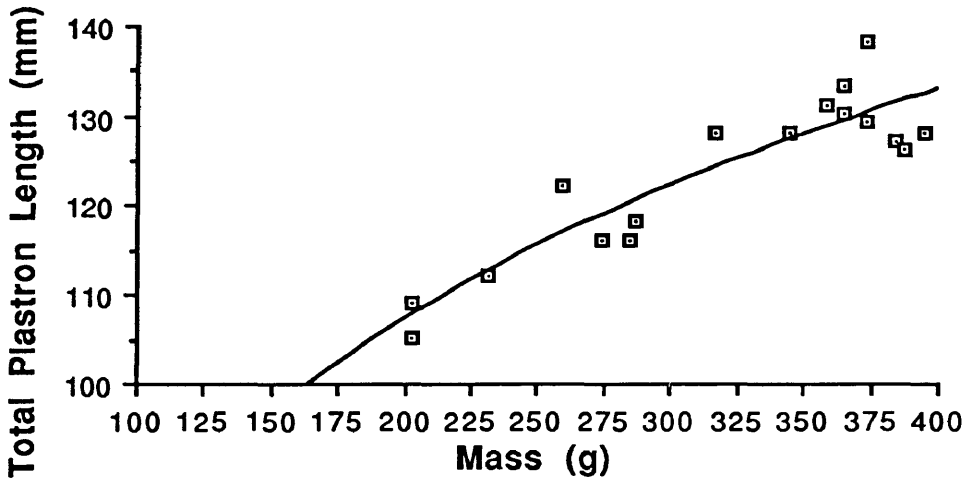

Figure 20. Relationship between total plastron length and mass for 17 female ornate box turtles (R^2=0.826).

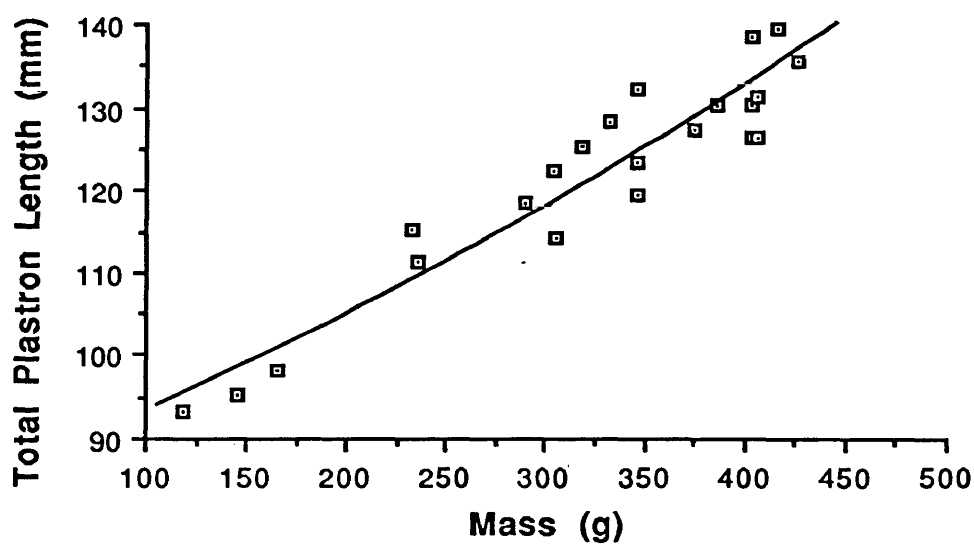

Figure 21. Relationship between total plastron length and mass for 22 male ornate box turtles (R^2=0.900).

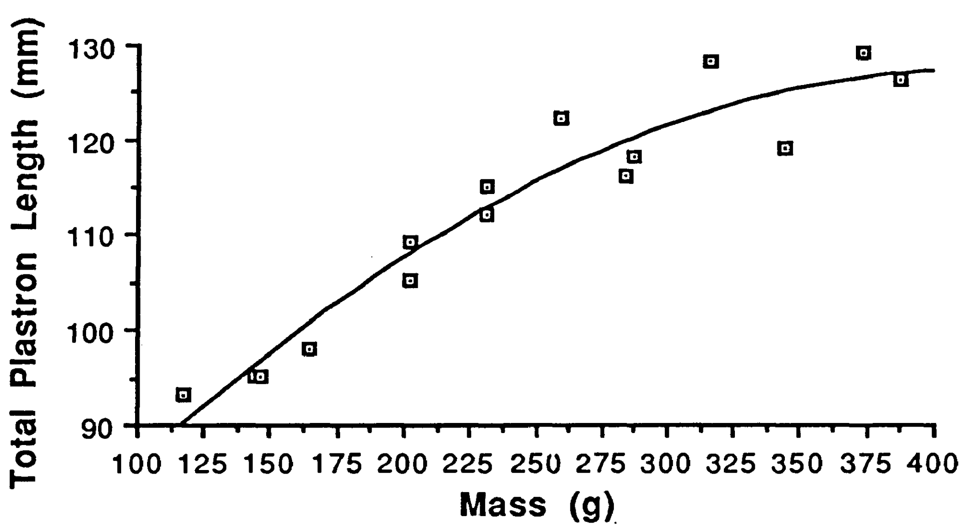

Figure 22. Relationship of total plastron length to mass for 15 juvenile ornate box turtles (R^=0.930).

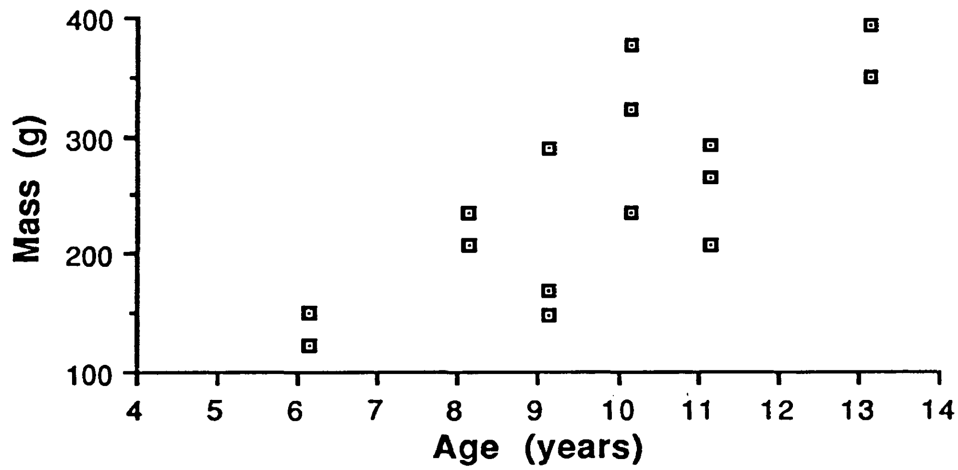

Figure 23. Juvenile turtle mass correlated to age.

Figure 24. Evidence of broken ribs (1993).

Figure 25. Adult *T. ornata* missing the right forefoot (1992).

While the other, lifted an old dropping free of the ground with his forefeet then propped it up with his carapace while he ate the invertebrates there. I also observed evidence that turtles ate the fallen fruit of the solitary mulberry tree at the study site. Three turtles were found with forefeet, plastron, neck and mouth stained purple. The turtles found in the rain pools were probably hunting the larger inhabitants of those pools as well as soaking or drinking. Both in 1992 and 1993, the ornate box turtles were concentrated near the rain pools when there were large organisms there. They also concentrated near the mulberry tree (*Morus alba*) when the fruit was falling.

Of two roadkilled adult males, the less decayed turtle was collected and frozen. Later, the turtle was thawed, the stomach removed and it's contents examined . The stomach contained finely divided plant material with a few larger plant fragments such as grass stems. There were no cactus prickles or seeds, or indeed any seeds. Since the plant fragments appeared to have been already digested, they were not selected by the turtle, but had been incidentally ingested with the insects present in the stomach. Although no hairs, feathers, scales, bones or flesh were present in the stomach, but a carrion beetle was, I concluded that the turtle had foraged near carrion recently. With the exception of a caterpillar and carrion beetle, all the insects were those which could have been found on or near herbivore dung. Three round worms, two of which were females, were observed in the turtle's stomach. At the conclusion of my examination, the stomach contents were preserved in 70% denatured ethanol, and deposited in the University of Nebraska at Omaha herpetological collection, Allwine Hall, Room 527.

Daily Behavioral Patterns

Until about 8:00 am, or when temperatures reached about 22 C, the turtles were found in their forms (hollows dug into the dirt in the shape of the plastron), which were usually screened laterally by plants. Forms located on a slope were dug into the slope so that the turtle rested on the level. If the day was not overcast, the turtles would leave their forms and bask before becoming active. If it was overcast, they stayed in their forms until the ambient temperature reached about 25 C.

Active turtles foraged and traveled until temperatures reached about 30 C. They were then found soaking in water or seeking shade. The thermal cover they chose was not only shady, but was also screened laterally, so it also served as hiding cover (Figures 26, 27 and 28). For example, one radio-tagged female was frequently found under the thatch at the base of yucca clumps, another stayed in the road ditch (Figure 29) and the last preferred the scrap metal around the ruined buildings (Figure 12) During hot, dry weather, the turtles used mammal burrows or made deeper forms, sometimes deep enough to cover the carapace.

Typically, traveling turtles chose routes where plants were low, flexible, and/or spaced widely enough for them to pass between stems (Figure 30).

Seasonal Behavioral Patterns

In 1992, I observed a difference between the numbers of males and females on the study site at different times of the summer. From June 1 to June 22, I captured nine males (including two recaptures) ($p=0.250$) and eleven

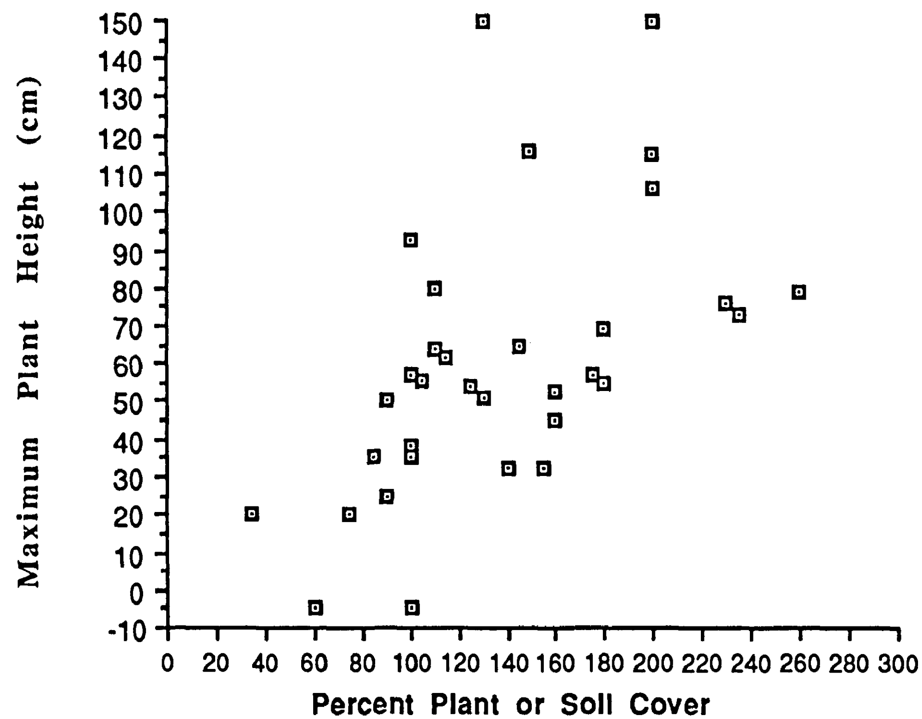

Figure 26. Vertical and coverage aspects of the hiding and thermal cover chosen by ornate box turtles at the study site. Negative values indicate hiding sites below ground (N=33).

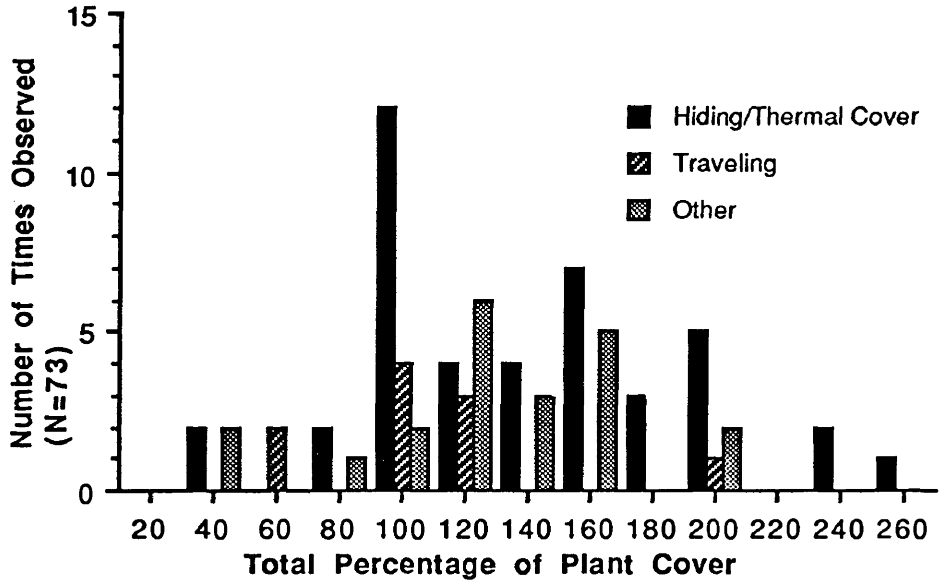

Figure 27. Habitat use according to activity.
The category "other" includes foraging, basking, soaking, etc.

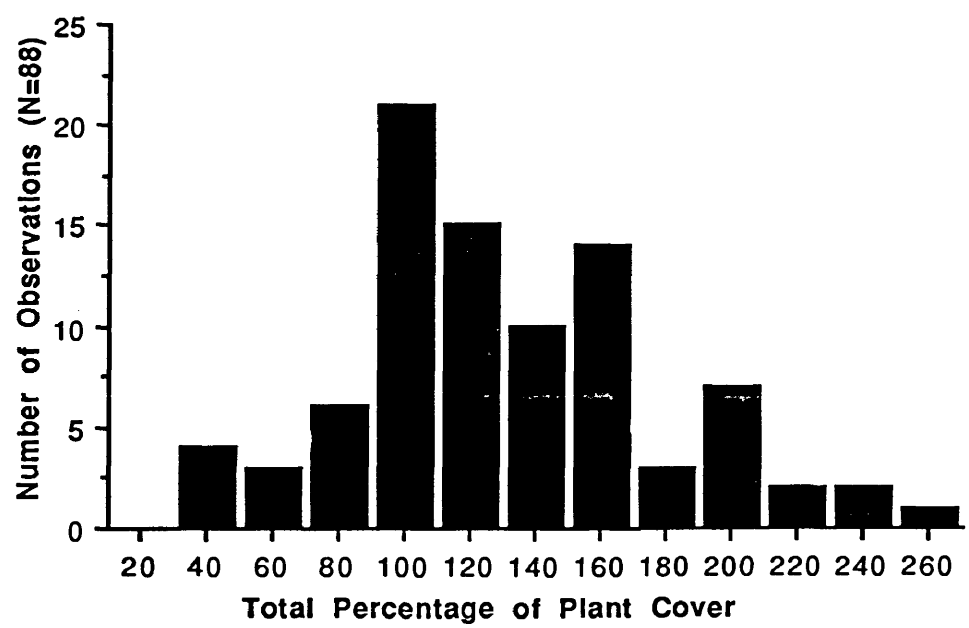

Figure 28. Use of plant cover by ornate box turtles at the study site.

Figure 29. Dense vegetation about one and a half meters tall in the road ditch.

Figure 30. Typical vegetation where the turtles chose to travel.

females (including one recapture) ($p=0.100$). Nearly all were found on the western slopes of canyon uplands, travelling uphill and eastward. From June 27 to July 8, none of the pools on the study site had standing water, and no turtles were found. Then on the 9th, after a rain, two were found. Captures were regular thereafter. From July 9 to August 6, 1992, eight females (three recaptures) ($p=0.990$) and thirteen males (four recaptures) ($p=0.900$) were captured. From early July on, almost all turtles were captured on the old wheatfield. Since $p<.05$ is necessary for significance, the differences between male and female captures were not significant.

On June 6, 1992, one female was discovered excavating a hole into a west-facing bank under the canopy of a snakeweed (*Gutierrezia sathrothrae*). She was left alone after discovery, and observed from a distance, but she did not continue what I suspect was nest excavation.

During 1993, two of the three tagged females constructed nests. On June 15, the nest of L1,2 R10 was located about a kilometer west of her home range (Figure 18). She spent five days finding the site, which was dug halfway up the south-exposed wall of a canyon in loose soil with no plant cover. The return trip lasted another five days. Since she spent two days at the nest site, the whole trip lasted twelve days.

The nest of L3 R4 was within her home range, and dug into the shallow bank (about 20 cm high) of a very shallow gully near a windmill on June 13. Between July 1 and July 6, a tunnel approximately 2.5 cm in diameter was made leading from the nest. There was no till pile (fan of loose dirt) which would indicate excavation by a raccoon or skunk, and the soil was too hard-packed for a snake to excavate the tunnel.

The weight loss by the female turtles was 40 g and 90 g . Ernst and Barbour (1972) state that the mean mass for a *T. ornata* egg is 10.09 g. Therefore, each female probably produced 4 and 9 eggs, respectively. The female which was Age Class 2 (L1,2R10) lost 40 g (10% of her mass) and the other (L3R4), which was in Age Class 3 lost 90 g (25% of her mass). Clutch sizes were not confirmed because while attempting to excavate one nest, I almost put my finger through an egg. Since I did not want to damage the eggs, I did not continue excavation and replaced the soil over the nest.

DISCUSSION

Population Characteristics

T. ornata and closely related taxa (*Terrapene carolina carolina*, Eastern box turtle; *Terrapene carolina triunguis*, three-toed box turtle) are known to stay in one home range their whole life, with the exception of nesting forays by females (Legler, 1960; Schwartz et al., 1984; Stickel, 1989). Schwartz et al. (1984) have studied the three-toed box turtle in Missouri, and Stickel (1989) has investigated the eastern box turtle in Maryland. Both Legler (1960) and Stickel (1989) concluded that home ranges of *Terrapene* of all ages and both sexes overlapped with no indication of territoriality or social hierarchy. However, Ernst and Barbour (1972) mentioned that juvenile ornate box turtles are sometimes consumed by adults.

In the habitat Legler (1960) studied, turtle density was 6.5 to 15.0 per hectare. Stickel (1989) discovered that box turtles kept the same home range during her fourteen year study and that males had a slightly larger home range (1.20 ha.) than females (1.13 ha.). Schwartz et al. (1984) also found that box turtles remained in the same home range throughout life, except for a few transients which settled down after about a year.

The *T. ornata* of my study site also kept the same home range for the study period, and no territoriality or social hierarchy was observed. Density was much lower (about 1.65/ha) than that found by Legler (1960), but that was either due to habitat which supported fewer turtles, or the cumulative result of fatalities on the nearby road. Probably both factors have affected the population.

The home and total ranges of the three radio-tagged females varied too widely to make a meaningful average of either total or home range. None of the other turtles in this population were captured enough to estimate their ranges.

Noticing the preponderance of males in this population, I suspected that females used the arroyo uplands as nesting sites then travelled elsewhere. This was disproven for the three adult females which had transmitters attached. However, the preponderance of males may be due to their migration, or perhaps there is no migration and the sex ratio is skewed toward the males. It is also possible that the apparently larger number of males is an artifact of a larger home range than that of females, such as reported by Schwartz et al. (1984), Stickel (1989), Doroff and Keith (1990), and Kaufmann (1991, 1992).

Doroff and Keith (1990) state that egg laying in south-central Wisconsin was complete after June.

Food Preferences and Foraging Techniques

Ernst and Barbour (1972) state that ornate box turtles are opportunistic omnivores, with invertebrates comprising ninety percent of their diet. The invertebrates are usually obtained in and under ungulate dung (Legler, 1960). However, box turtles also take carrion(Parker, 1982), earthworms (Leger,1960), spadefoot toad tadpoles (*Spea bombifrons*) (Legler, 1960), prickly pear cactus (*Opuntia macrorhiza*) pads, fruit, and flowers , flowers of pincushion cactus (*Coryphantha vivipara*) (Thomasson, 1980), mulberry fruit (*Morus alba*) (Norris and Zwiefel, 1950; Legler, 1960).

The *T. ornata* on the study site had access to all these food sources, and there was evidence that they ate all but the pincushion cactus flowers. When considering use of food sources compared to their availability and the distance the turtles travelled to reach the food sources, invertebrates associated with cattle dung seemed to be a staple food and mulberries were preferred. Invertebrates not associated with cattle dung were consumed opportunistically. Prickly pear cactus was very rarely consumed (few of the plants had scars), and may have been an emergency source of moisture.

Daily Behavioral Patterns

The daily behavioral patterns did not differ from those reported by Legler (1960).

Legler (1960), who studied ornate box turtles on heavily grazed tall-grass prairie, stated that turtle densities on his study site were highest in plains almost denuded by grazing cattle. Less favored habitats, in decreasing order of preference, were deciduous forest, prairie with thickly growing grass, and fallow fields with vigorous weed growth.

Except for the radio-tagged female which preferred the high weeds of the road ditch, all but one other turtle were captured on the prairie. However, this probably reflects the difficulty of finding a turtle in the road ditch. I often found myself searching for many minutes in tall weeds, only to find the tagged turtle was within inches of my feet the whole time.

Seasonal Behavioral Patterns

Doroff and Keith (1990) state that egg laying in south-central Wisconsin was complete after June. The turtles on my study site had completed egg laying by mid-June.

According to Iverson (1980), and Hailey and Loumbourdis (1988), individual egg mass does not increase with the mother's size. However, clutch size increases with the mother's body mass (Iverson, 1980; Congdon and Gibbons, 1985; Hailey and Loumbourdis, 1988). Iverson (1980) states that clutch sizes for *T. carolina* in northern Florida ranges from one to nine eggs, with a mode of five and a mean of 5.2. Congdon and Gibbons (1985) record that clutch size for *T. carolina* is 3.4 (.06). The probable clutch sizes of 4 and 9 eggs are within the recorded boundaries for *T. ornata*.

The most plausible explanations for the tunnel which was made 27 days later at the site of the 9-egg clutch are that the turtle laid her eggs twice in one place and the older clutch hatched, or a hognose snake entered by one tunnel in the softer soil of the gully bank, and excavated the tunnel which was discovered as a separate exit. *T. ornata* and similar taxa are known to "double clutch" (Legler, 1960; Turner et al., 1986; Hailey and Loumbourdis, 1988).

Nesting conditions are limiting because a female will travel up to 700 m from her home range to nest, and return to the site year after year (Fitch, 1958; Leger, 1960; Metcalf and Metcalf, 1985; Stickel, 1989). She may search for an acceptable site for more than a week before nesting (Stickel, 1989). Nest sites are open, usually with no plant cover, well drained, and have a soft substrate (Legler, 1960). The nest sites of the *T. ornata* of my study site conformed with those in the literature.

Because of the very rapid return of turtles after a rain which broke a dry spell, and the fact that many of those turtles' carapaces were caked with soil, I suspect that they did not leave the study site, but burrowed or used other animals' burrows until rain came (Legler, 1960), or were in the canyons seeking shade and became dirty when climbing out. Strang (1983) reported that *T. carolina* were not active during hot, dry weather, but were found buried in damp litter.

During hot, dry, and windy weather, the radio-tagged turtles on my study site were found in their home ranges under thermal cover. When the weather was cooler or wetter, they would venture into areas without thermal cover, such as the old wheatfield. Therefore, water and thermal cover were probably limiting factors for this population.

LITERATURE CITED

Barkley, T.M. Ed. 1977.
Atlas of the Flora of the Great Plains. Great Plains Flora Association. Iowa Sate University Press, Ames Iowa. 600 pp.

Barbour, M.G.; J.H. Burk, and W.D. Pitts. 1980.
Terrestrial Plant Ecology. Benjamin/Cummings Publishing Company, Inc., California. 604 pp.

Breininger, D.R.; P.A. Schmalzer, and C.R. Hinkle. 1994.
Gopher Tortoise (*Gopherus polyphemus*) Densities in Coastal Scrub and Slash Pine Flatwoods in Florida. Journal of Herpetology 28(1): 60-65.

Brumwell, M.J. 1940.
Notes on the courtship of the turtle, *Terrapene ornata*. Transactions of the Kansas Academy of Science. 43: 391-392.

Cahn, A.R. 1933.
Hibernation of the box turtle. Copeia 1933(1): 13-14.

Clarke, R.F. 1956.
A case of possible overwintering of *Terrapene o. ornata* in a well. Herpetologica 12(2): 131.

Conant, R. and J.T. Collins. 1991.
A Field Guide to Reptiles and Amphibians. Eastern and Central North America. Third Edition. Houghton Mifflin Company, Boston. 450 pp.

Congdon, J.D. and J.W. Gibbons. 1985.
Egg components and reproductive characteristics of turtles: Relationships to body size. Herpetologica 41(2): 194-205.

Davis, D.E and Winstead, R.L. 1980
Estimating the Numbers of Wildlife Populations. *IN* Wildlife Management Techniques Manual, Fourth Edition. S.D. Schemnitz, Editor. The Wildlife Society, Washington, D.C. 686 pp.

Diemer, J.E. 1992.
Demography of the Tortoise *Gopherus polyphemus* in Northern Florida. Journal of Herpetology 26(3): 281-289.

Doroff, A.M. and Keith, L.B. 1990.
Demography and ecology of an ornate box turtle (*Terrapene ornata*) population in south-central Wisconsin. Copeia 1990(2): 387-399.

Ellner, L.R. and W.H. Karasov. 1993.
Latitudinal variation in the thermal biology of ornate box turtles. Copeia 2: 447-455.

Ernst, C.H. and R.W. Barbour, 1972.
Turtles of the United States. University Press of Kentucky, Lexington.

Fitch, H.S., 1958.
Home ranges, territories and seasonal movements of vertebrates of the Natural History Reservation. University of Kansas Publications, Museum of Natural History 11: 63-326.

Freeman, P. 1990.
Amphibians and Reptiles. *IN* An Atlas of the Sandhills. Resource Atlas Number 5a.: 157-160.

Great Plains Flora Association. 1986.
Flora of the Great Plains. University Press of Kansas. Lawrence, Kansas. 1392 pp.

Hailey, A., and N.S. Loumbourdis. 1988.
Egg size and shape, clutch dynamics, and reproductive efforts of European tortoises. Canadian Journal of Zoology 66: 1527-1536.

Iverson, J.B. 1980.
The reproductive biology of Gopherus polyphemus (Chelonia: Testudinidae). American Midland Naturalist 103: 353-359.

Karns, D.R., 1986.
Field herpetology: Methods for the study of Amphibians and Reptiles in Minnesota. Occasional Paper 18: 26-27. James Ford Bell Museum of Natural History. University of Minnesota.

Kaufmann, J.H., 1991.
Habitat Use by Wood Turtles in Central Pennsylvania. Journal of Herpetology 26(3): 315-321.

Kaufmann, J.H., 1992.
The Social Behavior of Wood Turtles, *Clemmys insculpta*, in Central Pennsylvania. Herpetological Monographs No. 6: 1-25.

Legler, J.M., 1960.
Natural history of the ornate box turtle, *Terrapene ornata ornata* Agassiz. University of Kansas Publications, Museum of Natural History 11: 527-669.

Lieberman, S., 1994.
Can CITES Save the Box Turtle? Endangered Species Technical Bulletin 19(5): 1, 16-17.

Lynch, J.D., 1985.
Annotated Checklist of the Amphibians and Reptiles of Nebraska. Transactions of the Nebraska Academy of Sciences, XIII: 33-57.

______. 1994.
Current Distributional Summaries for Nebraska's Amphibians and Reptiles. Unpublished document.

Metcalf, A.L., and E.L. Metcalf, 1985.
Longevity of some ornate box turtles (*Terrapene ornata ornata*). Journal of Herpetology 19(1): 157-158.

Mills, M.S. 1991.
Population ecology of the turtle *Chrysemys picta bellii* (Gray, 1831) in Eastern Nebraska. Unpublished M.A. Thesis, University of Nebraska at Omaha. 67 pp.

Muegel, L.A., and D.L. Claussen. 1994.
The effects of Slope on Voluntary Locomotor Performance in the Turtle, *Terrapene carolina carolina*. Journal of Herpetology 28(1): 6-11.

National Oceanic and Atmospheric Administration, National Environmental Satellite, Data and Information Service, and National Climatic Data Center Asheville, North Carolina. 1992. Climatological Data, Nebraska.Climatological Data, Nebraska. Vol. 97(5-9): 1.

______.1993. Climatological Data, Nebraska.Climatological Data, Nebraska. Vol. 98(5-9): 1.

New York Turtle and Tortoise Society. 1994.
New York Turtle and Tortoise Society Action Alert. New York, NY. Pg. 1.

Norris, K.S., and R.G. Zwiefel, 1950.
Observations on the habits of the ornate box turtle, *Terrapene ornata* (Agassiz). Natural History Miscellaneous 58: 1-4.

Parker, J.W. 1982.
Opportunistic feeding by an ornate box turtle under the nest of a Mississippi kite. Southwestern Naturalist 27(3): 365.

Peters, K. 1959.
A physiological study of the effect of hibernation on the ornate box turtle. Transactions of the Kansas Academy of Science 62(1): 15-20.

Robbins, C.S., B. Bruun, H.S. Zim, A. Singer, 1983.
Birds of North America: A Guide to Field Identification. Golden Press, New York. 360 pp.

Schwartz, E.R., C.W. Schwartz, and A.R. Kiester, 1984.
The Three-Toed Box Turtle in Central Missouri, Part II: a nineteen-year study of home range, movements and population. Terrestrial Series #12, Missouri Department of Conservation, Jefferson City, Missouri.

Soil Survey, Red Willow County, Nebraska. 1967.
United States Department of Agriculture, Soil Conservation Service, In cooperation with University of Nebraska Conservation and Survey Division.

Stephens, H.A. 1973.
Woody Plants of the North Central Plains. The University Press of Kansas, Lawrence Kansas. 530 pp.

Stevens, W.K. 1994.
American Box Turtle Declining, Perishing Cruelly in Foreign Lands. San Diego Turtle and Tortoise Society. Voice of the Turtle 23(7): 4.

Stickel, L.F., 1989.
Home range behavior among box turtles (*Terrapene carolina carolina*) of a bottomland forest in Maryland. Journal of Herpetology 23(1): 40-44.

Strang, C.A. 1983.
Spatial and temporal activity patterns in two terrestrial turtles. Journal of Herpetology 17: 43-47.

Thomasson, J.R. 1980.
Ornate box turtle, *Terrapene ornata* (Testudinae), Feeding on pincushion cactus, *Coryphantha vivipara* (Cactaceae). Southwestern Naturalist 25(3): 438.

Tucker, J.K. 1995.
Notes on Three Clutches of Eggs of the Eastern Box Turtle, *Terrapene carolina*. Bulletin of the Chicago Herpetological Society 30(3); 41-43.

Turner, F.B., P. Hatden, B.L. Burge, and J.B. Robertson. 1986.
Egg production by the desert tortoise (*Gopherus agassizii*) in California. Herpetologica 42(1): 93-104.

Western Cartographers. 1984.
'Big Red' Atlas of Nebraska. South Sioux City, Nebraska.

Weekly Weather and Crop Bulletin. 1992.
National Oceanic and Atmospheric Administration, National Weather Service, U.S. Department of Agriculture, and U.S. Department of Commerce. Washington, D.C. Vol. 79(19-34).

______. 1993.
National Oceanic and Atmospheric Administration, National Weather Service, U.S. Department of Agriculture, and U.S. Department of Commerce. Washington, D.C. Vol. 80(19-35).

Zug, G.R. 1991.
Age Determination in Turtles. Society for the Study of Amphibians and Reptiles, Herpetological Circular No. 20. Pp. 28.

APPENDIX 1

VASCULAR PLANT SPECIES LIST

Species identified using the Great Plains Flora Association (1986) and Barkley (1977). Families are arranged alphabetically, and the species are arranged alphabetically within their family.

SPECIES NAME	COMMON NAME
AGAVACEAE (AGAVE FAMILY)	
Yucca glauca Nutt.	yucca
ANACARDIACEAE (CASHEW FAMILY)	
Toxicodendron rydbergii (Small) Greene	poison ivy
ASTERACEAE (SUNFLOWER FAMILY)	
Antennaria parviflora Nutt.	pussy toes
Aster commutatus (T. & G.) A. Gray	wild aster
Aster oblongifolius Nutt.	aromatic aster
Chrysopsis villosa (Pursh) Nutt.	golden aster
Erigeron strigosus Muhl. ex Willd.	daisy fleabane
Gutierrezia sathrothrae (Pursh.) Britt. & Rusby	snakeweed
Haplopappus spinulosis (Pursh) DC.	cutleaf ironplant
Helianthus annuus L.	common sunflower
Hymenoxys scaposa (DC.) Parker var. *glabra* (Nutt.) Parker	bitterweed
Liatris punctata DC.	gay-feather
Lygodesmia juncea (Pursh) Hook	skeletonweed
Ratibida columnifera (Nutt.) Woot. & Standl.	prairie coneflower

Senecio riddellii T. & G.	Riddell ragwort
Solidago missouriensis Nutt.	prairie goldenrod
Thelesperma megapotamicum (Spreng.) O Ktze.	sunflower

BORAGINACEAE
(BORAGE FAMILY)

Lappula echinata Gilib.	blue stickseed

BRASSICACEAE
(MUSTARD FAMILY)

Descurainia sophia (L.) Webb	flixweed

CACTACEAE
(CACTUS FAMILY)

Opuntia macrorhiza Engelm.	prickly pear cactus
Coryphantha vivipara (Nutt.) Britt & Rose	pincushion cactus

CAPPARACEAE
(CAPER FAMILY)

Polanisia dodecandra(L.) DC. subsp. *trachysperma*(T. & G.) Iltis	clammy-weed

CHENOPODIACEAE
(GOOSEFOOT FAMILY)

Chenopodium dessicatum A. Nels.	annual goosefoot
Kochia scoparia (L.) Schrad.	kochia

EUPHORBIACEAE
(SPURGE FAMILY)

Euphorbia marginata Pursh	snow-on-the-mountain

FABACEAE
(BEAN FAMILY)

Dalea candida Michx. ex Willd. var. *oligophylla*(Torr.) Shinners
white prairie clover

Dalea enneandra Nutt. nine-anther prairie clover

Melilotus alba Medic. white sweet clover

Melilotus officinalis (L.) Pall. yellow sweet clover

Medicago sativa L. alfalfa

GROSSULARIACEAE
(CURRANT FAMILY)

Ribes odoratum Wendl. golden currant

LAMIACEAE
(MINT FAMILY)

Hedeoma drummondii Benth. Drummond false pennyroyal

Nepeta cataria L. catnip

LOASACEAE
(STICKLEAF FAMILY)

Mentzelia decapetala (Pursh) Urban & Gilg blazing star

MALVACEAE
(MALLOW FAMILY)

Sphaeralcea coccinea (Pursh) Rydb. cowboys' delight
Callirhoe involucrata (T. & G.) A. Gray purple poppy mallow

MIMOSACEAE
(MIMOSA FAMILY)

Schrankia nuttallii (DC.) Standl. sensitive brier

MORACEAE
(MULBERRY FAMILY)

Morus alba L.	white mulberry

NYCTAGINACEAE
(FOUR O'CLOCK FAMILY)

Mirabilis linearis (Pursh) Heimerl.	narrowleaf four-o'clock

ONAGRACEAE
(EVENING PRIMROSE FAMILY)

Calylophus serrulatus (Nutt.) Raven	plains yellow primrose
Gaura coccinea Pursh	scarlet gaura

PAPAVERACEAE
(POPPY FAMILY)

Argemone polyanthemos (Fedde) G. Ownbey	prickly poppy

POACEAE
(GRASS FAMILY)

Agropyron smithii Rydb.	western wheatgrass
Andropogon scoparius Michx.	little bluestem
Aristida purpurea Nutt. **near** var. *robusta* (Nees) A. Holmgren	blue three-awn
Bromus japonicus Thunb. ex Murr.	Japanese brome
Bromus tectorum L.	downy brome
Bouteloua curtipendula (Michx.) Torr.	sideoats grama
Bouteloua gracilis (H.B.K.) Lag. ex Griffiths	blue grama
Buchloe dactyloides (Nutt.) Engelm.	buffalo grass
Hordeum pusillum Nutt.	little barley

Panicum capillare L.	common witchgrass
Panicum virgatum L.	switchgrass
Sitanion hystrix (Nutt.)J.G. Sm. var. *brevifolium* (J.G. Sm.) C.L. Hitchc.	squirreltail
Stipa comata Trin. & Rupr.	needle and thread
Thelosperma megapotamicum (Spreng.) O Ktze.	grass

POLYGALACEAE
(MILKWORT FAMILY)

Polygala alba Nutt.	white milkwort

POLYGONACEAE
(BUCKWHEAT FAMILY)

Polygonum amphibium L.	smartweed
Polygonella americana (Fisch. & Mey.) Small	jointweed

POTAMOGETONACEAE
(PONDWEED FAMILY)

Potamogeton pectinatus L.	sago pondweed

RUBIACEAE
(MADDER FAMILY)

Hedyotis nigricans (Lam.) Fosb.	narrowleaf bluet

SALICACEAE
(WILLOW FAMILY)

Populus deltoides	cottonwood

SOLANACEAE
(POTATO OR NIGHTSHADE FAMILY)

Solanum rostratum Dun.	buffalo burr

APPENDIX 2

LIST OF VERTEBRATE SPECIES PRESENT ON STUDY SITE

The following works were used for identification of species: Conant and Collins (1991); Robbins et al. (1983).

Species are listed alphabetically within each class.

SPECIES NAME	COMMON NAME
AMPHIBIA	
Bufo cognatus	Great Plains toad
Bufo woodhousii	Woodhouse's toad
Scaphiopus bombifrons	Plains spadefoot
REPTILIA	
Coluber constrictor flaviventris	eastern yellowbelly racer
Heterodon nasicus	Western hognose snake
Kinosternon flavescens	yellow mud turtle
Pituophis melanoleucus sayi	bullsnake
Terrapene ornata ornata	ornate box turtle
Thamnophis radix	plains garter snake
AVES	
Agelaius phoenicius	red-winged blackbird
Aix sponsa	wood duck
Athene cunicularia	burrowing owl
Bubo virginianus	great horned owl

Buteo jamaicensis	red-tailed hawk
Calamospiza melanocorys	lark bunting
Cathartes aura	turkey vulture
Charadrius vociferus	killdeer
Chondrestes grammacus	lark sparrow
Chordeiles minor	common nighthawk
Colaptes auratus	common flicker
Cyanocitta cristata	blue jay
Eremophila alpestris	horned lark
Falco sparverius	American kestrel
Hirundo rustica	barn swallow
Lanius ludoviscianus	loggerhead shrike
Molothrus ater	brown-headed cowbird
Phaisianus colchicus	ring-necked pheasant
Pooecetes gramineus	vesper sparrow
Salpinctes obsoletus	rock wren
Sayornis saya	Say's phoebe
Sialia sialis	eastern bluebird
Stelgidopteryx serripennis	northern rough-winged swallow
Sturnella neglecta	western meadowlark
Tyrannus tyrannus	eastern kingbird
Tyrannus verticalus	western kingbird
Zenaida macroura	mourning dove

MAMMALIA

Canis latrans	coyote
Cynomys ludovicianus	black-tailed prairie dog
Dipodomys ordii	Ord's kangaroo rat
Geomys bursarius	pocket gopher
Odocoileus hemionus	mule deer
Mephitis mephitis	striped skunk
Procyon lotor	raccoon
Scalopus aquaticus	Eastern mole
Spermophilus tridecilineatus	thirteen-lined ground squirrel
Sylvilagus floridanus	Eastern cottontail rabbit

APPENDIX 3

Table III. Physical measurements of individual *T. ornata* females, Age Classes[b] 2 and 3 (N=8).

Sex	CL (mm)	PL (mm)	TCL (mm)	TPL (mm)	CW (mm)	CH (mm)	Mass (g)	AC[b]
F	110	97	133	130	96	51	354	3
F	104	96	133	127	82	50	340	2
F	108	107	137	137	81	48	369	2
F	100	98	132	132	75	37	360	3
F	111	111	136	127	91	52	390	2
F	95	94	127	126	76	42	380	2
F	103	108	128	129	90	50	360	2
F	98	101	123	115	79	45	270	2

[a]CL, Carapace Length; Pl, Plastron Length; TCL, Total Carapace Length; TPL, Total Plastron Length; CW, Carapace Width; CH, Carapace Height; AC, Age Class[b].

[b]Age Class 2: the individual's age in years can no longer be determined because of the density of the scute annuli, and none of the scute annuli have worn away. Age Class 3: at least some of the scute annuli have worn away.

Table IV. Physical measurements of individual *T. ornata* juveniles and subadults (N=14). Note: identification of sex is tentative, with the probability for error increasing inversely with the age of the turtle.

Sex	CL (mm)	PL (mm)	TCL (mm)	TPL (mm)	CW (mm)	CH (mm)	Mass (g)	Age
F	87	86	114	104	66	NR	198	1 (8 years)
M	94	90	117	114	77	45	227	1 (8 years)
F	106	100	135	125	88	52	383	1 (13 years)
F	97	93	124	117	78	47	283	1 (11 years)
F	100	92	124	121	79	45	255	1 (11 years)
M	79	76	98	92	70	34	113	1 (6 years)
F	101	98	127	127	83	50	312	1 (10 years)
F	93	84	117	108	72	43	198	1 (11 years)
F	95	86	119	111	74	44	227	1 (10 years)
	76	76	99	94	65	37	142	1 (6 years)
F	112	112	137	128	87	46	369	1 (10 years)
M	81	78	100	94	68	40	140	1 (9 years)
M	108	94	133	118	91	40	340	1 (13 years)
M	85	79	116	97	71	38	160	1 (9 years)
F	96	103	124	115	80	48	280	1 (9 years)

[a]CL, Carapace Length; Pl, Plastron Length; TCL, Total Carapace Length; TPL, Total Plastron Length; CW, Carapace Width; CH, Carapace Height; AC, NR=Not Recorded.

Table V. Physical measurements of individual *T. ornata* males, Age Classes[b] 2 and 3 (N=20).

Sex	CL (mm)	PL (mm)	TCL (mm)	TPL (mm)	CW (mm)	CH (mm)	Mass (g)	AC[b]
M	109	109	127	127	85	NR	326	2
M	104	98	130	117	80	47	283	2
M	114	111	142	138	93	51	411	3
M	116	110	143	137	93	51	397	2
M	101	94	127	121	78	45	298	2
M	116	116	143	133	93	47	NR	2
M	111	110	143	133	96	52	NR	3
M	101	103	133	124	84	45	312	2
M	116	119	135	125	90	55	397	2
M	110	108	134	131	88	51	340	2
M	111	111	135	126	92	51	369	3
M	108	114	134	129	90	51	397	3
M	107	106	133	125	82	51	400	2
M	90	87	112	110	80	45	230	2
M	104	101	123	113	83	46	300	2
M	113	115	NR	NR	86	46	360	3
M	111	111	135	130	91	41	400	2
M	110	104	136	129	91	52	380	2
M	107	98	128	122	95	50	340	2
M	108	110	136	134	95	54	420	3

[a]CL, Carapace Length; Pl, Plastron Length; TCL, Total Carapace Length; TPL, Total Plastron Length; CW, Carapace Width; CH, Carapace Height; AC, Age Class[b].

[b]Age Class 2: the individual's age in years can no longer be determined because of the density of the scute annuli, and none of the scute annuli have worn away. Age Class 3: at least some of the scute annuli have worn away.

NR=Not Recorded.

APPENDIX 4

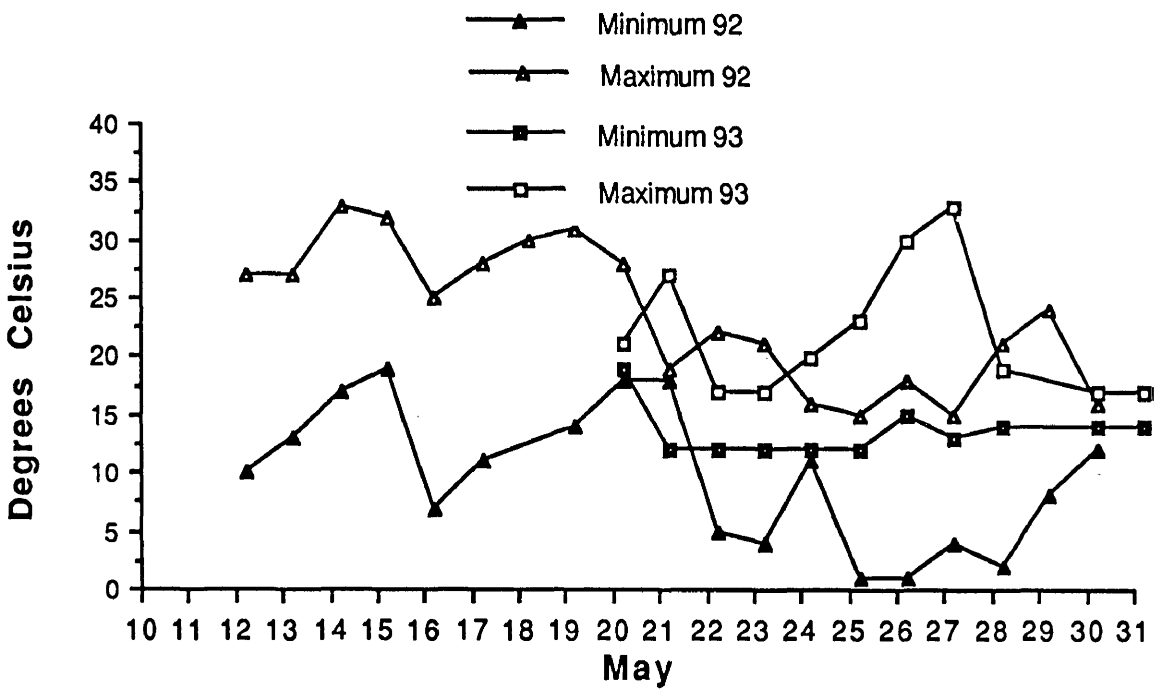

Figure 31. Comparison of daily minimum and maximum temperatures for May, 1992 and 1993.

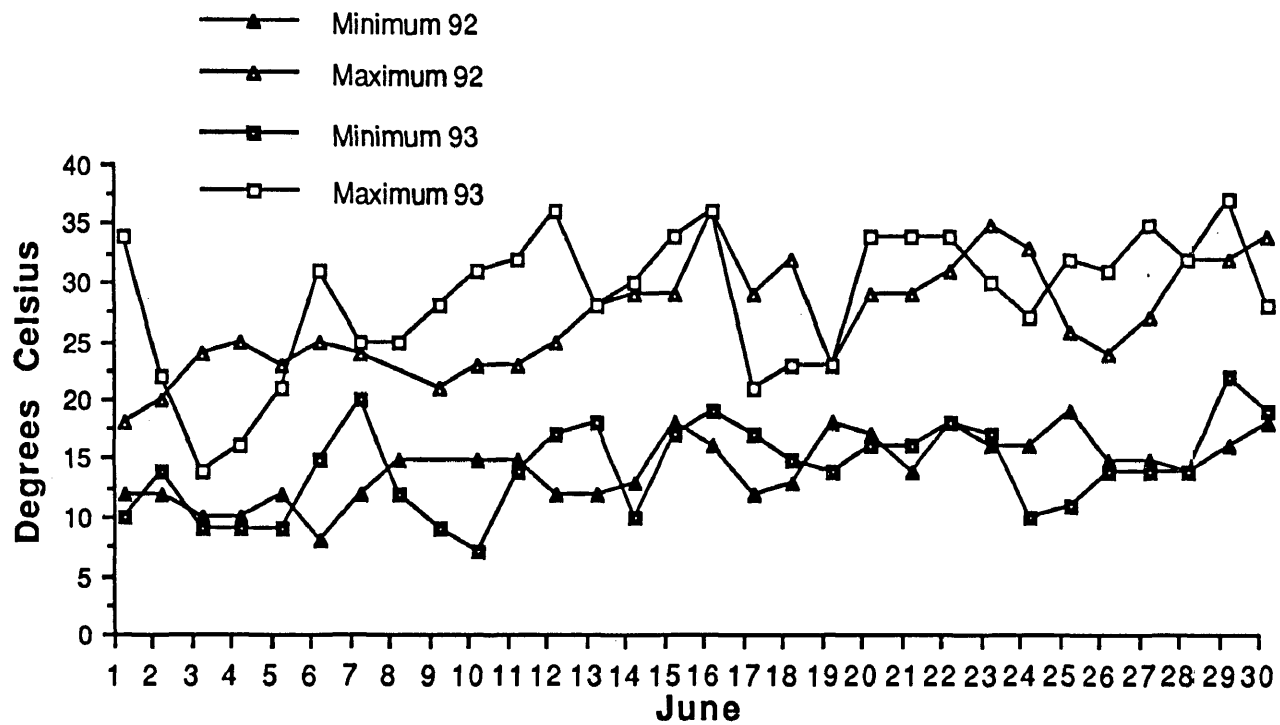

Figure 32. Comparison of daily minimum and maximum temperatures for June, 1992 and 1993.

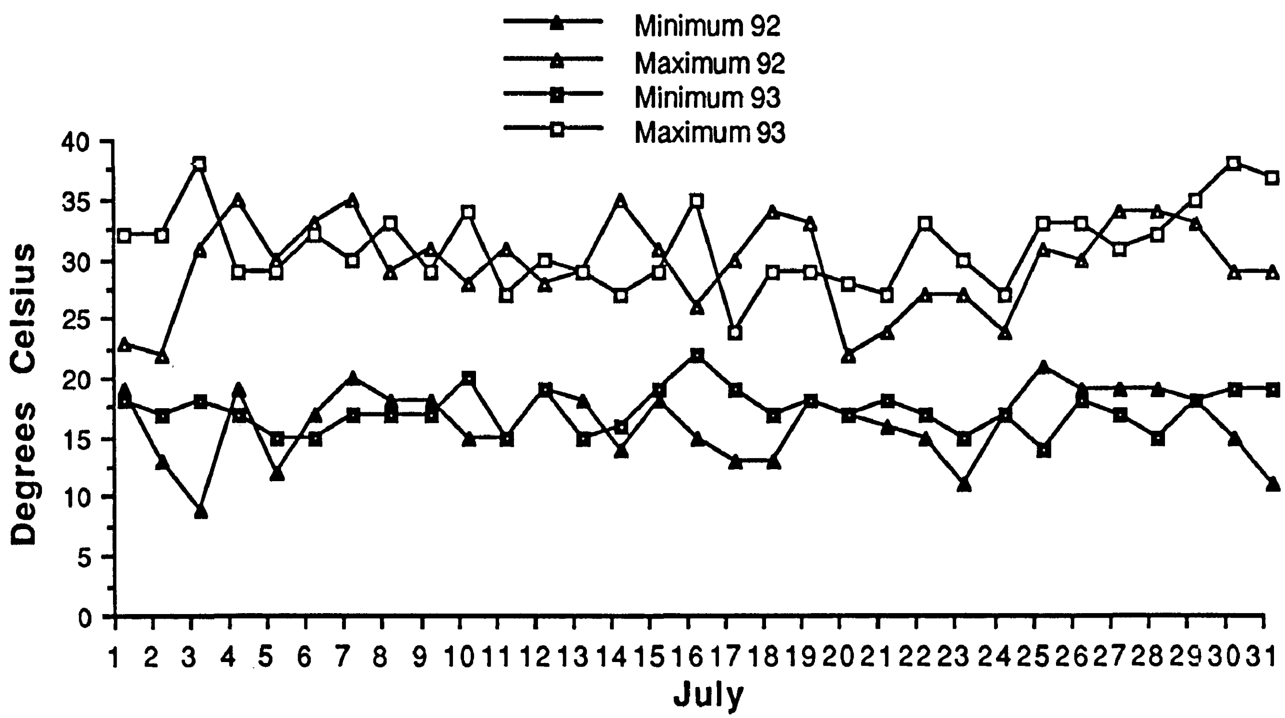

Figure 33. Comparison of daily minimum and maximum temperatures for July, 1992 and 1993.

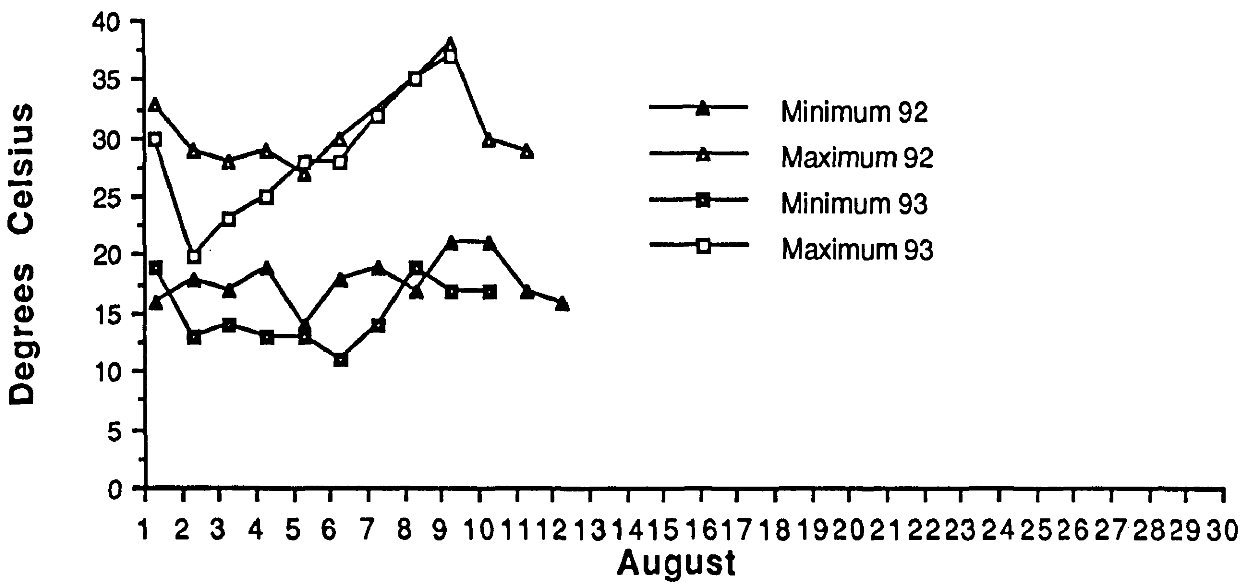

Figure 34. Comparison of daily minimum and maximum temperatures for August, 1992 and 1993.

APPENDIX 5

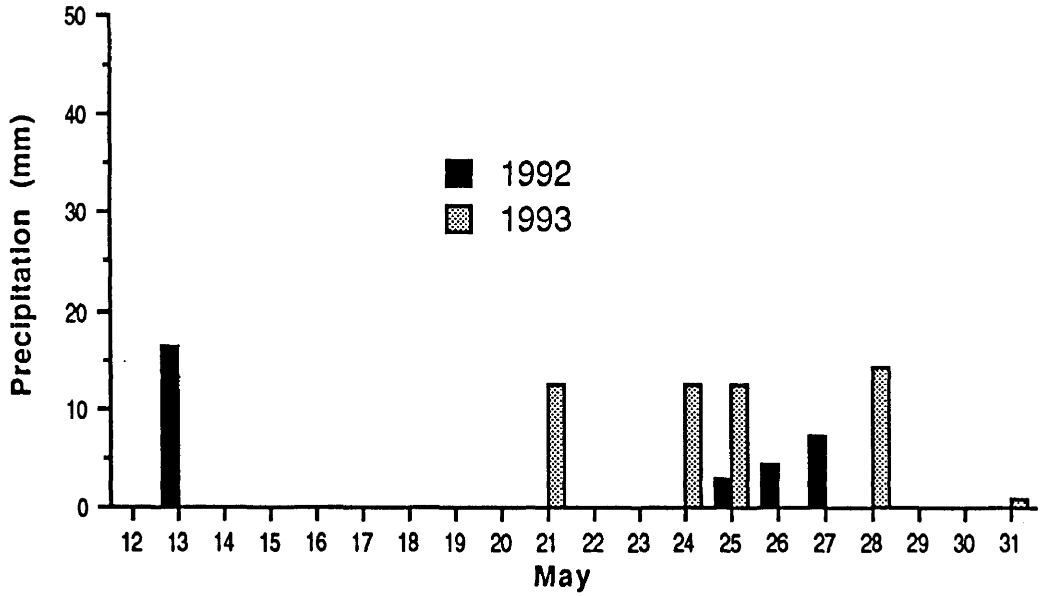

Figure 35. Comparison of precipitation during May, 1992 and 1993.

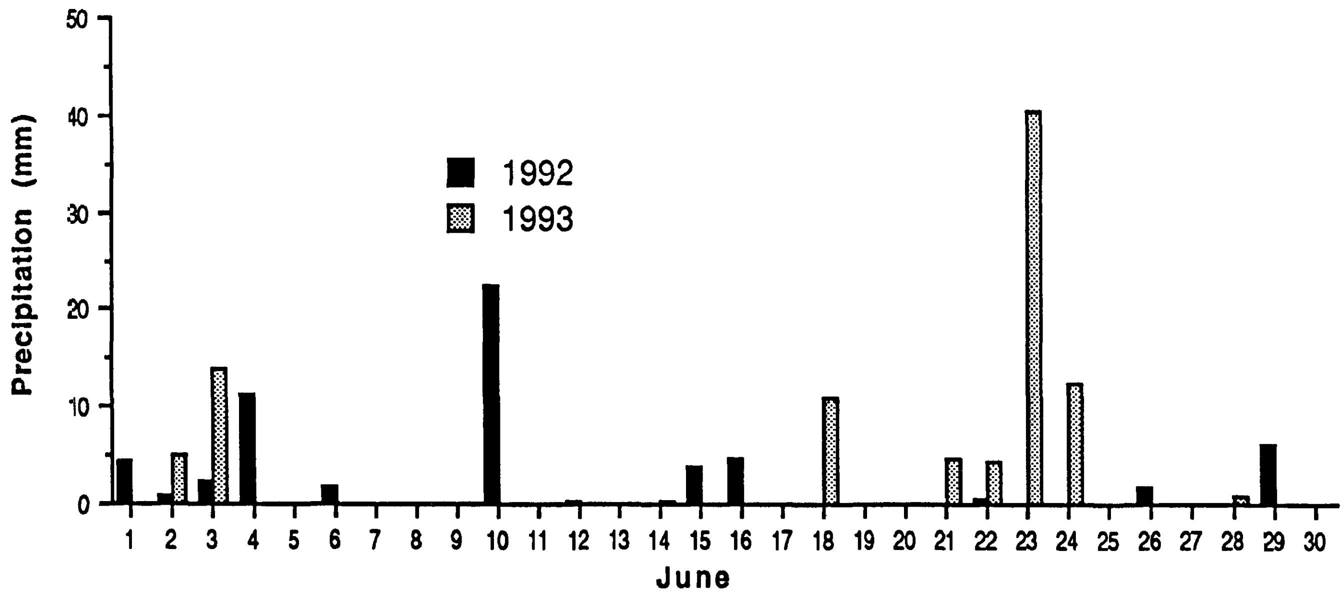

Figure 36. Comparison of precipitation during June, 1992 and 1993.

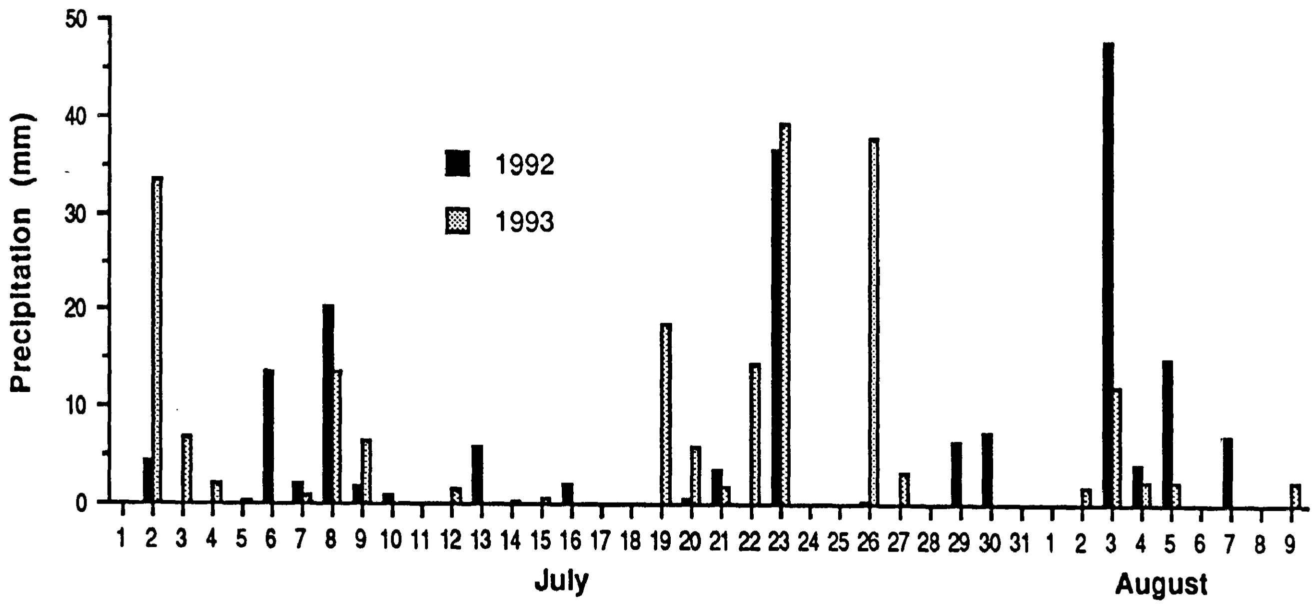

Figure 37. Comparison of precipitation during July and August, 1992 and 1993.