HOUSTON TOAD
RECOVERY PLAN

U.S. FISH & WILDLIFE SERVICE
DEPARTMENT OF THE INTERIOR

Albuquerque, New Mexico

1984

RECOVERY PLAN FOR THE HOUSTON TOAD (*BUFO HOUSTONENSIS*)

Prepared by

Houston Toad Recovery Team

August 1984

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Date: 9/17/84

SUMMARY

The Houston toad (Bufo houstonensis) declined sharply in distribution and abundance primarily because of Texas' severe drought of the 1950s and secondarily because of loss of habitat from land development. Continued loss of habitat suppresses recovery of Houston toad populations during wet years and the secretive nature of the species makes it difficult to find previously unreported populations as well as known, but diminished, populations.

Three principal types of recovery actions are proposed herein: 1) Search for additional Houston toad populations in areas of likely habitat; 2) reestablish Houston toad populations in suitable habitat in the historic range of the species, and 3) determine if Bufo houstonensis is the same animal as B. americanus charlesmithi.

DISCLAIMER

The Houston toad recovery plan was developed by the Houston Toad Recovery Team, an independent group of biologists sponsored by the Albuquerque Regional Director of the U.S. Fish and Wildlife Service.

The recovery plan is based upon the belief that State and Federal conservation agencies and knowledgeable, interested individuals should endeavor to preserve the Houston toad and its habitat and assure its long term survival. The objective of the plan is to make this belief a reality.

The Regional Director, U.S. Fish and Wildlife Service, has used the best information available in producing this recovery plan. It will be used by all agencies, institutions, and individuals concerned with the Houston toad and its ecosystem to coordinate conservation activities. Periodic revisions will be necessary as the plan is implemented. Revisions will be the responsibility of the Regional Director and implementation is the task of managing agencies, primarily the Texas Parks and Wildlife Department and the U.S. Fish and Wildlife Service.

This is the completed Houston toad recovery plan. It has been approved by the U.S. Fish and Wildlife Service. It does not necessarily represent official positions or approvals of cooperating agencies and it does not necessarily represent the views of all recovery team members who played the key role in preparing this plan. This plan is subject to modification as dictated by new findings and changes in species status and completion of tasks described in the plan. Goals and objectives will be attained and funds expended contingent upon appropriations, priorities, and other budgetary constraints.

Literature citations should read as follows:

U.S. Fish and Wildlife Service. 1984. Houston toad recovery plan. U.S. Fish and Wildlife Service, Albuquerque, New Mexico. 73 pp.+iii

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ACKNOWLEDGEMENTS

We thank the following persons who gave freely of their time and knowledge in assisting the formulation of this recovery plan:

J. F. Bentley
W. F. Blair
D. B. Bowman
B. C. Brown
L. D. Densmore
J. R. Dixon
C. K. Dodd, Jr.
G. W. Ferguson
J. Glidewell
D. M. Hillis
B. Hinderstein
N. L. Jacobson
D. L. Jameson
J. E. Johnson
R. F. Martin
W. T. McPherson, Jr.
P. Mehlhop
H. R. Quinn
O. Sanders
B. G. Stewart
O. Thornton
F. Wills
the late J. C. Wottring

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PART I

INTRODUCTION

Background Information

In the late 1940s there were several active amateur herpetologists in the vicinity of Houston, Texas. Notable among these enthusiasts was the airplane mechanic John C. Wottring from East Haven on the south side of the city. During his nighttime herpetological field trips in the semi-rural area around his residence, Wottring came upon a number of small toads with a beautiful mating call which sounded like the tinkling of a small bell. Other amateur herpetologists (e.g., Werner Gottsch, Walter J. Greer) and Wottring collected the toad at additional localities in southeastern Texas. However, the taxonomic identity of the toad remained a mystery. Consequently, Wottring continued to study the habits of the toad, and he recorded and sonographically analysed the toad's mating call. Interestingly, Wottring was one of the earliest persons,(perhaps the first), to employ this technique with salientians. In subsequent years this approach became widely adopted for systematic and behavioral studies. Wottring showed specimens of the toad and played recordings of its mating call to the famous Albert Hazen Wright of Cornell (who with his wife Anna authored "Amphibians of Texas" in 1938) and other professional herpetologists. None of these persons was sure of the identity of the toad, but a relationship to the American toad (Bufo americanus) was

suspected. When Ottys Sanders of Dallas saw the toad he thought it was a new species and he formally described it as Bufo houstonensis in 1953. In recognition of Wottring's substantial assistance, he indicated that the common name for the species should be The Wottring toad.

The 1950s were a time of severe drought in Texas as well as a period of rapid expansion of Houston, and little was heard or seen of B. houstonensis. W. Frank Blair of the University of Texas had started a research program on Bufo and tried to obtain some B. houstonensis. Only a few were found and this led Blair in 1961 to suggest to L.E. Brown that the species might be nearing extinction.

In 1965, graduate students in zoology at the University of Texas accidentally rediscovered the species at a new locality, Bastrop State Park in central Texas. These specimens were preserved in formalin as they were thought to be Bufo woodhousei. Blair later correctly identified the specimens and Lauren E. Brown began a study of the natural hybridization and trend toward extinction of the species as part of his Ph.D. dissertation. Clark Hubbs (University of Texas) became a strong advocate of the conservation of B. houstonensis and worked with James A. Peters to have it included in the "Redbook" of rare and endangered species in 1968.

In the late 1960s there was a great increase in concern about the quality of the environment in the United States and about the plight of endangered species. An important result of this concern was the passage

of the Endangered Species Act of 1973, which mandated that the Secretary of the Interior establish and implement programs to conserve endangered species. Subsequently, the Houston toad was listed as endangered (35 FR 16047) and critical habitat designated (43FR4022). This recovery plan for the Houston toad (Bufo houstonensis) is an outgrowth of that mandate. The recovery plan is made up of three parts: (1) an introduction which reviews the biological data available on the species; and (2) the action plan which outlines procedures for conservation of the species; and (3) an implementation schedule. The aim of the Fish and Wildlife Service and the hope of the Houston Toad Recovery Team is that the recovery plan will reverse the trend toward extinction of B. houstonensis and increase its numbers along with enhancing the environment of the species so that there is no further danger of extinction.

Description

Adult Bufo houstonensis are small- to medium-sized toads with males between 45-70 mm snout-vent length and females 52-80 mm. The dorsum is light brown (sometimes reddish) with a variable number of dark brown to black spots. These spots usually contain a single, or several fused, nonspinous warts. The spot may appear as a narrow black margin around the warts. The venter is cream colored with at least one brown spot in the pectoral region (usually heavily mottled). The parotoid glands are elongate but otherwise variable in shape. The interorbital and postorbital cranial crests are sometimes thickened, but this character is much more obvious in the type series than in other individuals. Within the jelly tube, the eggs are separated from one another in compartments.

For more extensive descriptions of the morphology of the Houston toad see Sanders (1953) and Brown (1973). Photographs of adult B. houstonensis are presented by Sanders (1953), Blair (1959, 1972), Kennedy (1962), Brown (1971), West (1975), Thomas (1977), Thomas and Potter (1975), Ehrenfeld (1976), Hardy (1977), and Bury et al. (1980).

Tadpoles of the Houston toad are quite distinct from all sympatric anuran species but visually inseparable from those of B. americanus. The body and upper 3/4 of the tail are heavily pigmented. Total length of 15 specimens examined (states 33-42 of Gosner 1960) ranged 13.7-19.4 mm ($\bar{x}$ = 17.3 mm). The labial tooth row formula is 2(2)/3.

The mating call consists of a long, high-pitched trill (Brown 1967, 1971, 1973, and Blair, 1956). Characteristics of the mating calls of 38 B. houstonensis (air temperature range = 4.5 - 24.0°C; water temperature range = 14.5 - 23.0°C) were summarized by Brown (1973) as follows: $\bar{x}$ pulse rate = 24.6 pulses/sec. (range = 14 - 36 pulses/sec.); $\bar{x}$ call duration = 14.2 sec. (range = 7.3 - 22.2 sec.); $\bar{x}$ dominant frequency = 1980 cycles per second (range = 1646 - 2300 cycles per second). The release call consists of two portions: a short, barely audible release vibration and an even shorter vocalized release chirp. Characteristics of release calls of 15 B. houstonensis ($\bar{x}$ cloacal temperature = 22.9°C; range = 21.3 - 25.8°C) were summarized by Brown and Littlejohn (1972) as follows: $\bar{x}$

vibration pulse rate = 40.2 pulses/sec. (range = 28.9 - 53.8 pulses/sec.); $\bar{x}$ vibration duration = 0.66 sec. (range = 0.24 - 1.15 sec.); $\bar{x}$ chirp duration = 0.14 sec. (range = 0.08 - 0.22 sec.); $\bar{x}$ chirp dominant frequency = 1596 cycles per second (range = 1094 - 2375 cycles per second).

Taxonomic Status

Houston populations of B. houstonensis were originally called B. terrestris by Harwood (1932). Sanders (1953) used the Houston area toads as a basis for the description of B. houstonensis, saying that they differed from B. americanus in color pattern, skeletal morphology, and the presence of "egg compartments." Brown (1971) showed that the call of the Houston toad differed from that of New Jersey B. americanus.

A. P. Blair (1957) considered the Houston toad to be a subspecies of B. americanus but all recent authors have considered it a full species. W. F. Blair (1965) suggested that it represents a slightly differentiated Pleistocene relic of B. americanus. Due to the general acceptance of the latter theory, many herpetologists feel that the relationships of B. houstonensis to nearby populations of B. americanus have not been adequately studied and are not well understood.

Bufo houstonensis is morphologically similar to populations of B. americanus charlesmithi in southern Oklahoma and north-central Texas. Preliminary studies show that these populations of American and Houston toads are electrophoretically similar but not identical and that their mating calls may not be separable (Thomas and Dessauer 1982).

Historical Distribution

Bufo houstonensis has been reported only from the following Texas counties (Map 1):

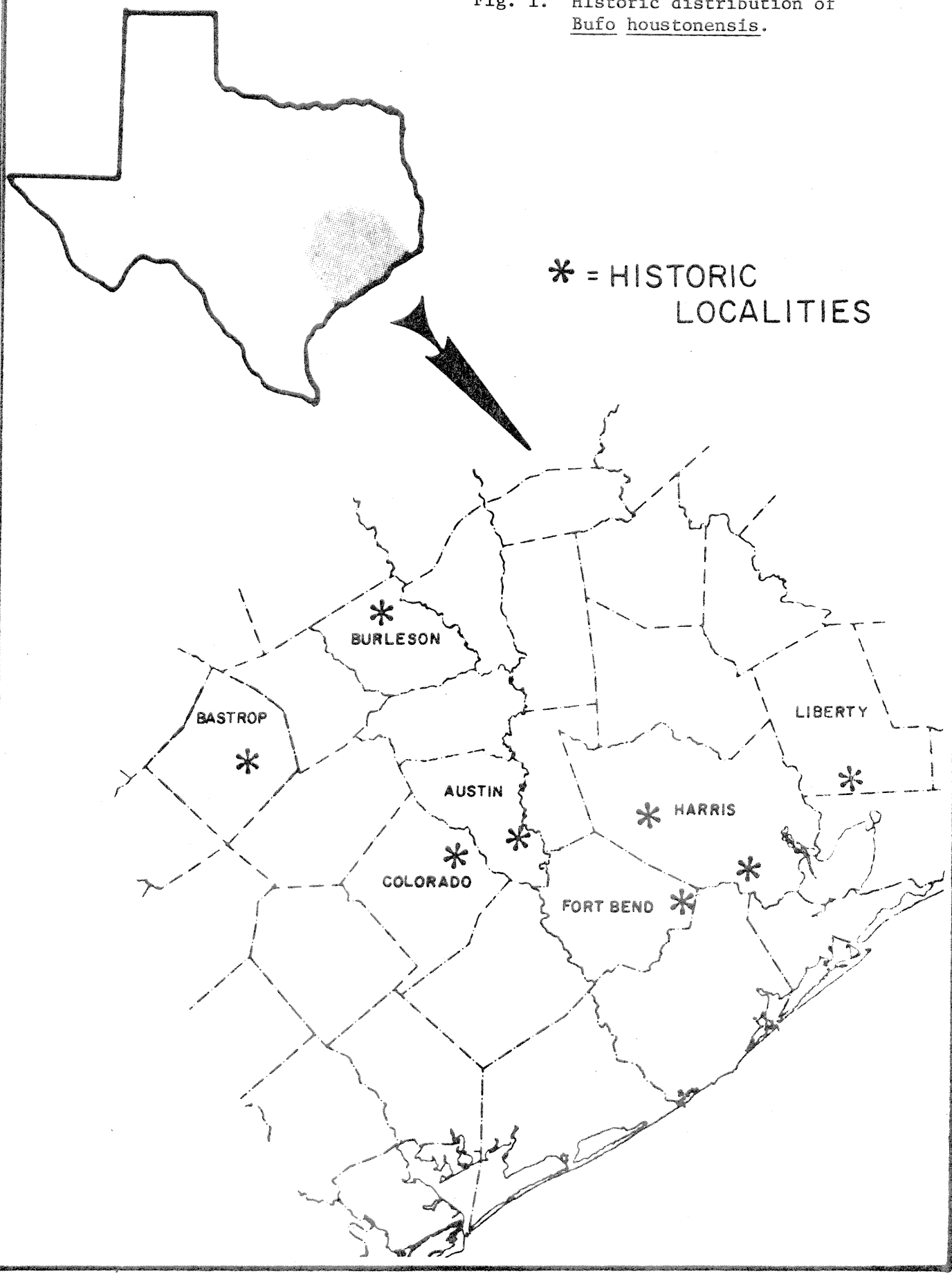
1. Harris County, NW and SE Houston (Sanders, 1953).
2. Burleson County, Lake Woodrow (Sanders, 1953).
3. Liberty County, 6 mi S Liberty (Sanders, 1953).
4. Austin County, Sealy (Sanders, 1953, pers. comm.;.Blair, pers. comm.)
5. Colorado County, 6 & 12.6 mi E Columbus (Sanders, 1953; Blair, 1956).
6. Fort Bend County, 2 mi W Fresno (Brown, 1971).
7. Bastrop County, vicinity Bastrop and Buescher State Parks (Brown, 1971).

No fossil record for B. houstonensis is known, although genetic similarities between B. houstonensis and B. woodhousei led Guttman (1969) to hypothesize that the Houston toad occurred near Fredericksburg, Gillespie County, Texas, during the Pleistocene.

Present Distribution

Houston toads are currently thought to exist only (last observed in 1976) in Harris, Bastrop and Burleson Counties, Texas (Maps 2-4). They may occur also in other historical localities, however, there is no recent supporting information.

Fig. 1. Historic distribution of Bufo houstonensis.



MAP # 1

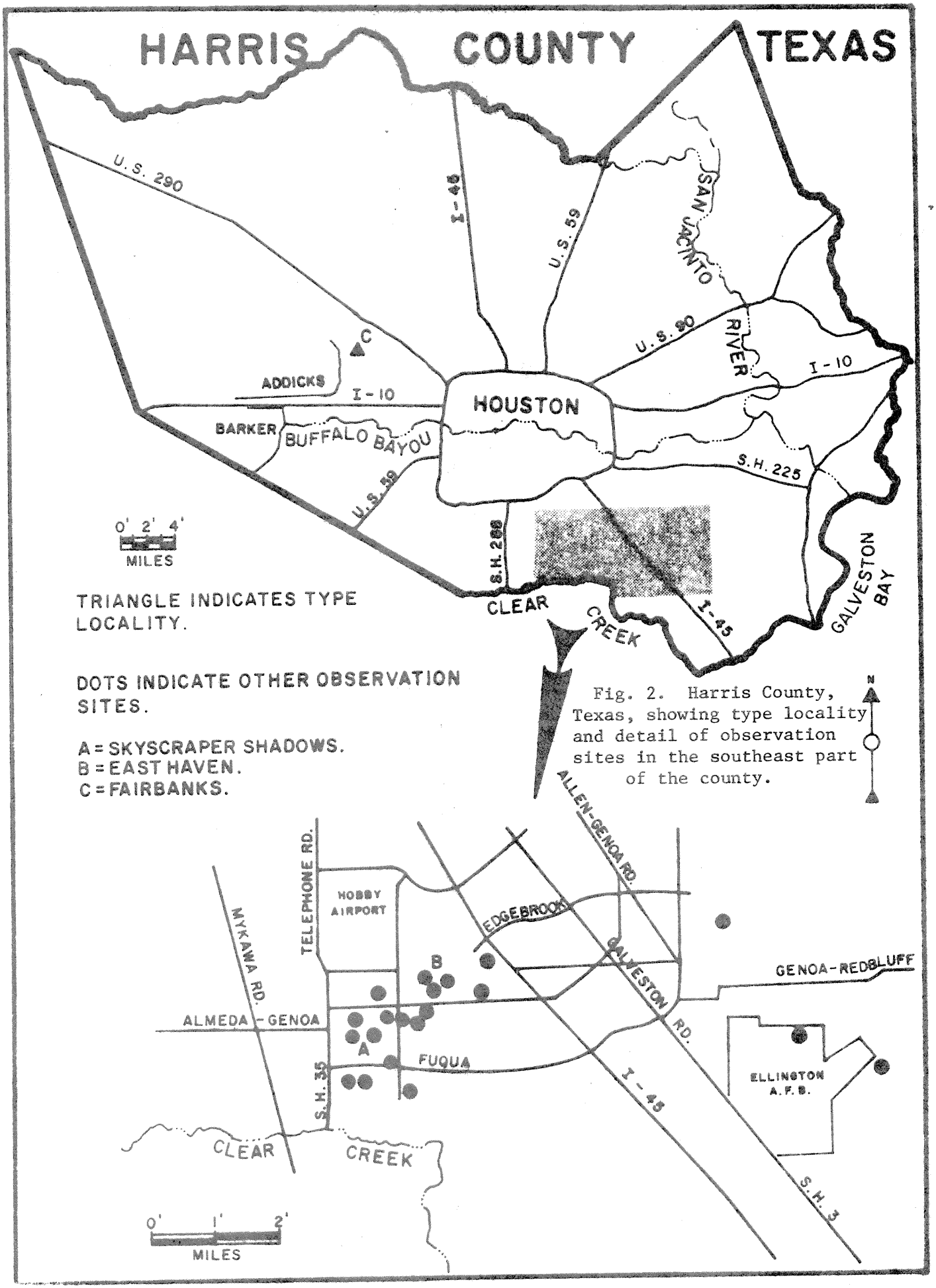


Fig. 2. Harris County, Texas, showing type locality and detail of observation sites in the southeast part of the county.

MAP # 2

BASTROP COUNTY TEXAS

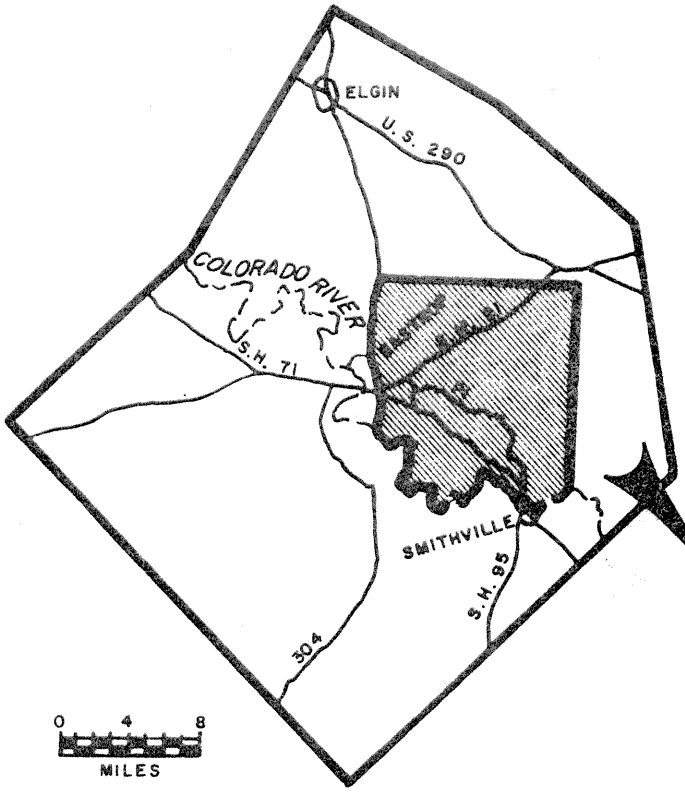
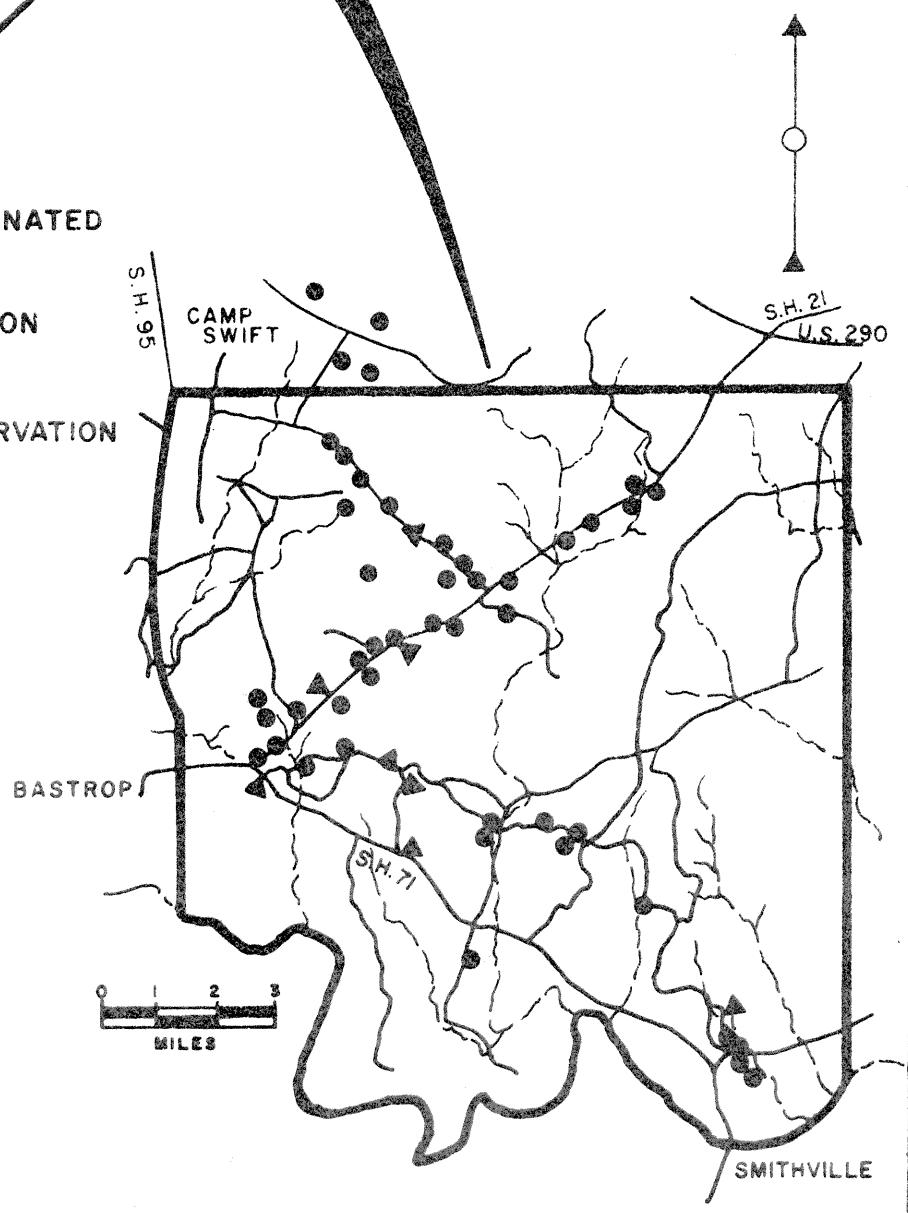


Fig. 3. Bastrop County, Texas, showing designated critical habitat and observation sites.

SHADING INDICATES DESIGNATED CRITICAL HABITAT.

DOTS INDICATE OBSERVATION SITES.

TRIANGLES INDICATE OBSERVATION SITES WITH HYBRIDS.



MAP # 3

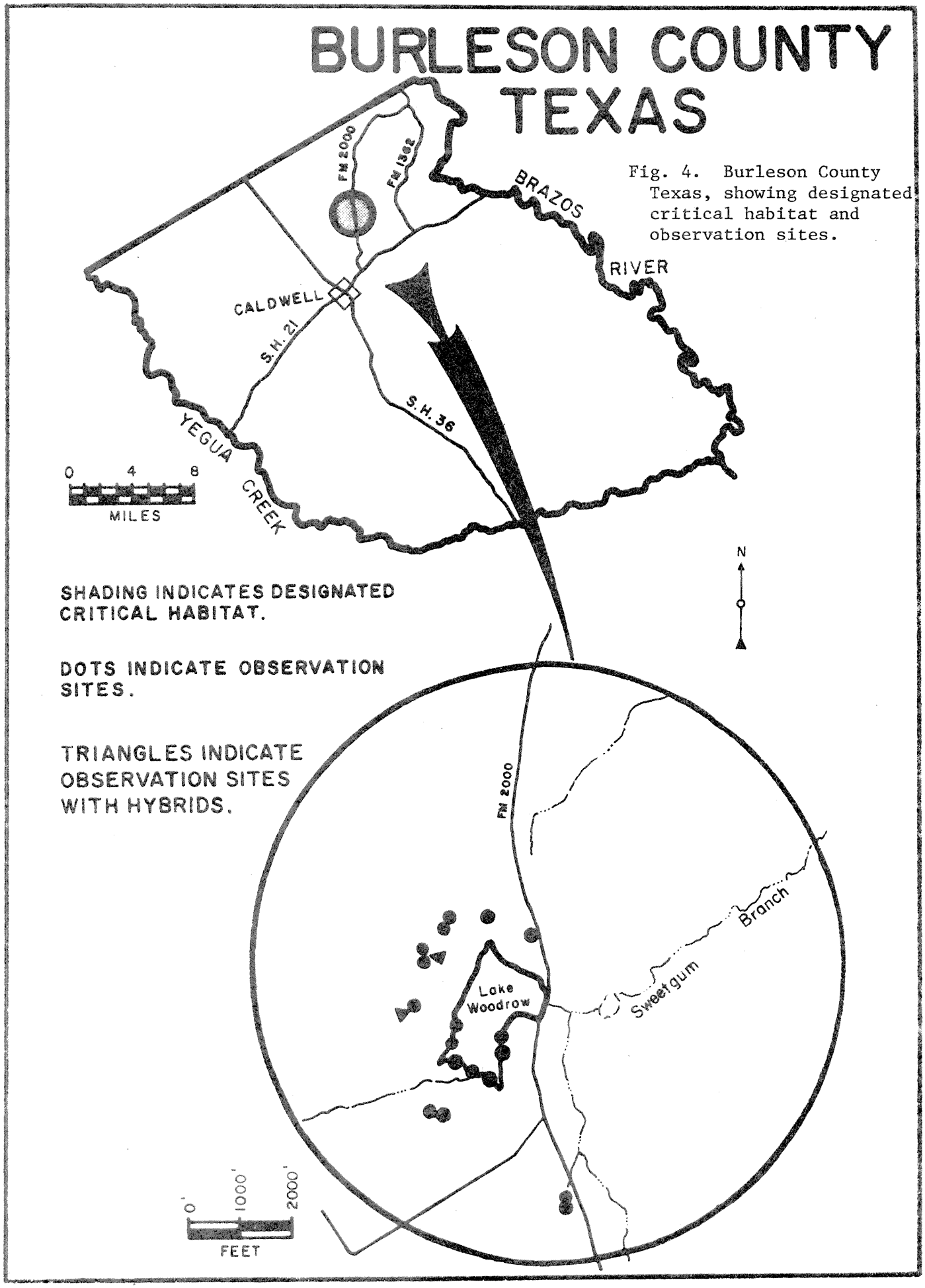


Fig. 4. Burleson County Texas, showing designated critical habitat and observation sites.

MAP # 4

The last Houston toad seen in Harris County was collected by a resident of a neighborhood near Hobby Airport and given to L. D. Densmore in 1976. Identification of the specimen was verified by R. A. Thomas and it was released at the site of capture the next day. Other than W. L. McClure's (pers. comm.) 1976 record of a presumed hybrid involving B. houstonensis and B. valliceps, no specimens have been observed at the type locality (the vicinity of Tanner and Campbell Roads in Houston) since the early 1960s.

Low humbers of Houston toads still exist in Burleson County but frequently fail to breed because of the absence of sufficient water (Dixon 1983).

Bastrop County has the largest number of B. houstonensis known today. Prior to 1978, most observations of the species were from the vicinity of Bastrop and Buescher State Parks. The Houston toad is widely distributed within the county north of the state parks.

Habitat Modification

Following is a discussion of the most apparent habitat modifications at the three localities where B. houstonensis has been studied most frequently.

Bastrop County - Brown (1971) described habitat alteration in the mid-1960s in Bastrop County as follows:

"Much of the forest is being logged or cleared for housing developments and agricultural use. Cattle roam through much of the forest that has not been cleared. Within the last few years the Texas Highway Department has undertaken the 'improvement' of Park Road 1 which runs through the forest. This involved large scale land excavations clearing away many pines. Further habitat alteration was due to the development of Bastrop and Buescher State Parks. Alterations ranged from the creation of a golf course to the formation of small artificial lakes. Much land was leveled for camping and picnicking grounds. Pines have been cut down along powerline rights-of-ways and at refuse dumps. A meshwork of roads was laid out producing artificial drainage patterns through roadside ditches and many stock ponds were constructed creating new and atypical breeding sites for anurans. In addition, some areas have suffered fire damage."

Since the mid-1960s a number of changes have occurred at the Bastrop locality. By the mid-1970s management of the parks was more compatible with the conservation of B. houstonensis. Thomas and Potter (1975) indicated:

"The state land in Bastrop and Buescher State Parks is under intense management and no major environmental alterations take place without consultation with state nongame personnel. There is presently a trend within state agencies to refrain from duplicating municipal recreational facilities on public land and we can expect some stability in management of these areas. Camping facilities are minimally developed and the presence of wildlife is taken into account in their placement."

The habitat in Bastrop County has improved in some ways. Land clearing is still evident but is no longer as prevalent as in the mid-1960s. A number of areas formerly without pines now have healthy pine stands. Cattle grazing also seems less prevalent. In 1979, the recovery team visited the main site where refuse was dumped in the mid-1960s. Pieces of broken glass and rusted metal were found but there was no indication of active dumping and many pines were established in the area.

In recent years, a number of houses were built in the pine forest and real estate agencies erected billboards in the area advertising lots for sale. Extensive suburban development of the Bastrop forest would be quite detrimental to B. houstonensis. However, owners of small rural acreages frequently excavate ponds on their properties and such ponds could be breeding sites by B. houstonensis.

Other types of serious habitat modification occur in Bastrop County. Highways 71 and 21 cut wide swaths through the pine forest and B. houstonensis are subject to being killed by traffic. Blacktopping of Park Road 1 also may have resulted in more traffic. Periodic mowing adjacent to the highways and on the golf course also occasionally may kill B. houstonensis.

Herbicides are used along highways and may be harmful to B. houstonensis. The commonly used herbicide Atrazine has been shown by Hazelwood (1970)

to seriously affect ranid eggs. Pesticides commonly used by area residents likely adversely impact toads. Heavy metals deposited along highways may accumulate to the point of becoming toxic to B. houstonensis.

A stratum of lignite exists across a portion of critical habitat in Bastrop County. Lignite mining could have drastic, deletrious effects on the habitat of B. houstonensis. Serious harm will be done to breeding sites of B. houstonensis if pollutants are deposited in the watersheds.

Fire damage was noted on pine trees in the mid-1960s (Brown 1967, 1971), and a larger burn (1 sq mi.) occurred in 1978. In 1980, the Texas State and County agencies carried out prescribed burns at certain locations in the Bastrop pine forest, which encompassed the area of critical habitat. For the last 10-15 years, burning has been a popular management tool for clearing brush in pine forests and for controlling the invasion of woody species in prairies. Fire, including prescribed burns, could be an adverse type of habitat alteration because B. houstonensis and the invertebrates (e.g., ground beetles) upon which the toad feeds may be killed. Fire also could kill pines in the Bastrop County forest and result in a new complex of woody species. Similar effects in an oak forest were reported by Anderson and Brown (1981) and Anderson and Schwegman (1971) in Illinois. Although fires presumably have always been a part of the ecology of the area, the long-range effects of fire are unknown.

Much land around the Bastrop pine forest (and near or at several other B. houstonensis localities) is cropland. Consequently, plowing, movement of heavy equipment over the land, compaction of soil, and the

application of fertilizers, herbicides, and pesticides may harm B. houstonensis.

Burleson County - The habitat at the Lake Woodrow locality apparently changed little from 1965-1966 when Brown (1967, 1971) worked in the area to 1979 when the recovery team visited the site. The most evident types of habitat alteration include the presence of several cabins along the edge of the lake and cattle grazing in adjacent areas. Cattle are potentially detrimental to the small population of B. houstonensis. Livestock grazing can change drastically the age distribution and species composition of native vegetation (Johnson and Jones 1977, Brown and Birkenholz 1975). Overgrazing can cause soil erosion, producing a change in the nature of the substrate and soil water retention. Cattle also may step on B. houstonensis and excessive manure could foul toad breeding sites. Thus, the presence of livestock could affect adversely the toad's habitat, but the effects of cattle on populations of B. houstonensis have not been studied. However, the creation of several stock ponds may have enhanced the habitat.

Human activities around the cabins (e.g., driving cars, mowing grass) could be detrimental to B. houstonensis.

Harris County - Devastating habitat modifications have occurred throughout much of Harris County from expansion of the Houston metropolitan area

and has obliterated much of the habitat once available to B. houstonensis. The types of habitat modification discussed below are characteristic of the two Harris County areas where these toads were common in the past.

Dense suburban housing was developed at the Skyscraper Shadows/ East Haven locality and in the immediate vicinity of the Fairbanks locality. At both localities, native vegetation has been reduced greatly or eliminated, and roads with considerable traffic crisscross the subdivision. Much of the sand at Skyscraper Shadows/East Haven (and presumably Fairbanks) has been covered with several inches of clay loam for lawns and gardens. No houses are at the small pond that constitutes the type locality. However, clay has been spread in the area and there has been considerable disruption and probable compaction of the soil from land moving equipment and housing development.

At Ellington Air Force Base (near East Haven), habitat disruption includes construction of drainageways, runways, streets, and buildings. Airplane exhaust fumes and fuel likely deposit high levels of heavy metals and other pollutants in the soil and water. Suburban development is occurring on the land adjacent to the base.

In conclusion, many different types of habitat alteration occur within the range of B. houstonensis. No single type of habitat modification is solely responsible for the decline of B. houstonensis, and different

types of disturbance in different areas may have contributed to local population declines. Definitive evidence is lacking as to the relative significance of the different types of habitat modification.

Changes in Abundance

Due to localized research, the sporadic breeding pattern and discontinuous distribution, it has been difficult to estimate Houston toad populations. The following statements summarize field research done to date. Since the late 1940s, populations of Houston toads in Harris County have decreased markedly. John Wottring's field notes indicate that he collected 66 individuals from a single chorus in 1949 and still found "quite a lot" in 1953. Brown (1967, 1971) found three Houston toads during the breeding seasons of 1965-67. During extensive surveys in the springs of 1974-1978, only two Houston toads were observed in Harris County. One Houston toad from southeast Harris County was observed by L. D. Densmore in 1976. Extensive surveillance had not confirmed the Houston toad's presence in Harris County since that time.

Burleson County has a small population of Houston toads near Lake Woodrow. Brown estimated 12 or fewer individuals in the mid-1960s and Thomas estimated the population at around 300 individuals in the mid-1970s. Most observations were of one to several calling males. Dixon (1983) found no Houston toads during the springs of 1979-1982, but in 1983, four different calling males were observed.

Apparent population sizes in Bastrop County have increased. Brown (1975) reported the population probably was represented by no more than 300 individuals in 1967. By the mid-1970s, Thomas and Potter (1975) estimated 1,500 individuals. Hillis et al. (1984) and Jacobson (1983) studied Houston toad populations during the breeding seasons of 1981-1982, with emphasis on several ponds north of Highway 21 in Bastrop County. They commonly encountered choruses of 30-100 individuals. A mark-recapture study at one pond indicated 50-75 percent of males on many subsequent nights were new. These authors estimated that 300-1,000 toads used each pond. However, no in-depth study of the number of B. houstonensis has ever been completed that has used the restrictive conditions listed by Poole (1974) as required to assure a valid estimate of population size.

Reproduction

Houston toads use rain pools, flooded fields, and natural or manmade ponds for breeding. They call in or near water, as early as January 22 (Jacobson 1983). Early breeding often occurs on the first nights when the air temperatures of the preceeding 24 hours has not fallen below 14°C. Later in the season, Houston toads may breed primarily in response to wet

weather (Hillis et al., 1984). Reported egg-laying dates range from February 18 to June 26 (Kennedy 1962, Hillis et al., 1984). Quinn (1980) reported that captive-raised males matured at 1 year of age, and active sperm was present at 8 months (snout-vent length 31 mm). Females matured sexually at 1-2 years (Quinn 1980). Kennedy (1962) reported a female produced 728 eggs in the lab. Egg masses from wild-caught females spawned in the laboratory contained 513-5999 eggs (Quinn, in press).

Associated Species

The following anurans frequent the same or adjacent calling sites as the Houston toad and may use the same resources at various stages of their life histories: Rana clamitans, R. sphenocephala, R. catesbeiana, R. areolata, Hyla crucifer, H. cinerea, H. chrysoscelis, H. squirella, H. versicolor, Acris crepitans, Scaphiopus holbrooki, Gastrophryne olivacea, G. carolinensis, Pseudacris clarki, P. triseriata and P. streckeri. The only Bufo species known to be sympatric with the Houston toad are B. valliceps and B. woodhousei, although B. speciosus and B. punctatus occur within 20 miles of some sites. For a significant portion of their breeding seasons, Houston toads are temporally isolated from B. valliceps, but some overlap occurs (Brown 1971; Hillis et al., 1984). The breeding seasons of Houston toads and B. woodhousei are similar, but habitat segregation sometimes occurs (Brown 1971, Hillis et al., 1984).

Hognose snakes (Heterodon nasicus, H. platyrhinos) can feed on Houston toads and David Hillis collected a Nerodia erythrogaster that

contained two Houston toads and the snake was swallowing another. Nerodia rhombifera, N. fasciata, and Thamnophis proximus are also potential predators. Other occasional predators could include Kinosternon subrubrum, K. flavescens, Sternotherus odoratus, and Chelydra serpentina. Micropterus salmoides, Lepomis species and other piscine predators might feed on toad larvae or eggs. However, tadpoles of closely related B. americanus are relatively free from fish predation (Voris and Bacon 1966).

Warmblooded predators that may prey on B. houstonensis include various bird species, such as herons and egrets, and mammals such as raccoons, opossums, skunks, and coyotes.

Parasites

Harwood (1932) identified two Harris County specimens of the Houston toad as B. terrestris and reported Cosmocercoides dukae (Oxyuridae) in both and Oswaldocruzia pipiens (Diaphanocephalidae) in one. Thomas et al. (in press) list the following parasites found in a sample of 17 toads: Rhabdias ranae (Rhaldiasidae), Physaloptera ranae (Spirwridae), Cosmocercoides dukae, Oswaldocruzia pipiens (all nematodes), Brachycoelium storeriae (Brachycoeliidae) (A trematode), and some tetrathyridia (larval cestodes).

Food

Bragg (1960) reported captive Houston toads fed on various insects, a small spadefoot toad (Scaphiopus), and presumably a small Great Plains toad (Bufo cognatus). Thomas examined the digestive tracts of 17 Houston toad adults. All were empty except one which was stuffed with ants (Crematogaster cf. minutissima, fide P. Mehlhop) and one which had beetle remains. Postmetamorphic B. houstonensis presumably feed on small arthropods while tadpoles are known to ingest algae and pollen (R. A. Thomas, unpublished). Hillis, et al. (1984) reported Houston toad tadpoles consuming jelly envelopes of recently hatched conspecifics as well as pine pollen.

Habitat Requirements

Houston toads are restricted to areas of sandy soils. The two areas supporting the largest populations (Bastrop and Burleson Counties) are characterized as wooded (pine and/or mixed deciduous), interspersed with some open grassy areas. The known Harris County localities were coastal prairie. Optimum habitat requirements for egg and tadpole development, based on data reported by Hillis, et al. (1984) appear to be nonflowing pools that persist for at least 60 days.

Calling and breeding Houston toads are frequently found in temporary rain pools. They may, however, be found in a variety of aquatic habitats.

The area surrounding the primary calling site in Burleson County had been bulldozed and is grazed by cattle. This pond site is surrounded by a minimally 10 m wide strip of thick yaupon (Ilex vomitoria). Other calling sites in Burleson County include waters associated with open pasture, cleared shallow ravines, the vicinity of dwellings around a lake, and roadside ditches. Calling sites in Bastrop County include lakes, manmade ponds, roadside ditches, pools in cleared areas within the pine forest, temporary rain pools in the forest, flooded fields and pastures, and puddles near cabins. Known calling sites in Harris County have been manmade pools, roadside ditches, flooded plowed fields, prairie potholes, moist spots in residential areas, and aquatic sites near runways on Ellington Air Force Base.

Upon leaving the breeding ponds, toads seek refuge in areas with sand substrates in such places as under logs, in leaf litter, in existing burrows, beneath undercut banks around ponds, and in the actual sand substrate (Hillis et al., 1984).

Misconceptions

Brown and Thomas (1982) reported three common misconceptions about B. houstonensis disseminated in a number of publications and unpublished reports. The first misconception concerns the importance of enlarged postorbital cranial crests as a diagnostic character of B. houstonensis. A number of specimens from Harris County and some specimens

from Bastrop County have thickened postorbitals. However, this hardly can be considered excessive enlargement and many specimens have postorbitals of moderate size. Furthermore, Thomas observed specimens of Bufo woodhousei from Chambers, Hardin, and Jefferson Counties, Texas, and Beauregard Parish, Louisiana, that had enlarged postorbitals. Thus, the structure of the postorbital cranial crests is variable and cannot be used alone to identify B. houstonensis.

The second misconception is the assumption that pine trees occur at all B. houstonensis localities. An abundance of natural loblolly pine (Pinus taeda) characterizes most localities in Bastrop County and pines are found at or near some other localities. However, the pine stand at Lake Woodrow (Burleson County) was planted in 1959 (Thomas 1977). Also, the habitats at the Skyscraper Shadows/East Haven and Fairbanks localities (both in Harris County) were coastal prairie without pines before being developed for housing. However, a common characteristic of all known localities for B. houstonensis is friable, sandy soil (Brown 1971, Kennedy 1962) which, coincidentally, is conducive to pine growth. Thus, the toads are probably reliant upon the substrate but not on the presence of pine trees.

The third misconception is the emphasis often placed on the importance of natural hybridization as a cause of the trend toward extinction. Little evidence indicates that natural hybridization has had such an effect.

Lack of food could be a limiting factor, particularly if insects and other invertebrates that dwell near the ground are killed by fire, drought, insecticides, or other effects. However, under normal circumstances food probably is plentiful and not limiting.

PART II

RECOVERY

The Action Plan

GOAL: The ultimate goal of the recovery plan is to improve the status of the Houston toad to the point that survival is secured and the species can be delisted. This goal should result from implementation of the recovery plan.

This goal may be achieved through implementation of the action plan proposed below. The species should be considered for down listing to threatened status when (1) moderately sized, self-sustaining populations are located in two more Texas counties in addition to Bastrop and Burleson Counties and (2) when the survival of existing populations in Bastrop and Burleson Counties is assured. The Houston toad should be considered for reclassification if taxonomic studies find it is synonymous with the dwarf American toad (Bufo americanus charlesmithi). The species should be eligible for delisting consideration when breeding populations of the Houston toad are self-sustaining in five or more counties.

Recovery Outline

Primary goal: To delist the Houston toad to nonthreatened status as a result of (1) protecting its known populations and habitats, (2) locating and protecting additional natural populations and habitats, (3) determining its taxonomic status with respect to other forms of Bufo,

and (4) introducing and establishing self-sustaining wild populations on sites in its historic range.

1.0 Maintain and enhance existing Houston toad populations in their present habitats.

1.1 Monitor existing populations and habitats.

1.2 Identify population needs and habitat requirements.

1.21 Study existing populations and habitats, including human uses of land, pesticides, and herbicides.

1.22 Study ecological relationships between the Houston toad, and other species of Bufo, predators, and competitors.

1.23 Monitor study progress and evaluate results.

1.3 Protect existing populations.

1.31 Seek cooperation of landowners (private or public) and provide them with conservation information.

1.32 Review and comment on all projects which might affect the Houston toads or their habitat.

1.33 Prepare habitat management plans.

1.34 Enhance habitat for Houston toad.

1.35 Obtain management rights to habitat, if necessary, to protect continued existence of a county's Houston toad population.

2.0 Locate additional natural populations of Houston toad.

2.1 Design a systematic search for additional populations.

2.2 Monitor and evaluate study progress.

3.0 Determine the systematic status of the Bufo houstonensis.

3.1 Design and conduct a study of the taxonomic relationships of the Houston toad to other Bufo.

3.2 Consult with systematic herpetologists and evaluate taxonomic data.

4.0 Restore and manage populations of Houston toads in suitable areas of former range.

4.1 Select suitable habitat in former range occupied by Houston toad.

4.11 Identify and enhance suitable habitat.

4.12 Develop management plans.

4.2 Introduce Houston toads.

4.3 Monitor introduced toads and habitat.

4.4 Continue introductions.

4.5 Manage restored habitat and populations.

4.51 Seek cooperation of owners of Houston toad habitat, including owners of adjoining properties.

4.52 Review and comment on all projects which might affect Houston toads and their habitats.

5.0 Enforce all Federal and State laws protecting populations and habitats of the Houston toad.

5.1 Inform agencies.

5.2 Consult with agencies on their proposed projects and their responsibilities under the law.

6.0 Produce and disseminate information.

Narrative

The Houston toad can be considered reasonably safe from extinction if existing populations are protected from decimation, if their habitats are protected from degradation, and if viable populations of the species are reestablished or found in three additional counties (total of 5 counties). Introduced colonies will be considered to be self-sustaining if they persist without additional introductions for at least 10 years and if at least 100 calling males can be located within any single week during the eighth, ninth, or tenth years. In addition, the habitats of existing and introduced populations must be free of significant threats that might make the habitat unsuitable for the Houston toad. If, in the opinion of the U.S. Fish and Wildlife Service after consultation with herpetological systematists, Bufo houstonensis is synonymous with dwarf the American toad (B. americanus charlesmithi) it should be considered for reclassification.

In order to accomplish the primary goal of delisting the Houston toad the following recovery efforts are proposed.

1.0 Maintain and enhance existing Houston toad populations in their present habitats.

Populations of Houston toads occur in Bastrop and Burleson Counties, Texas. The recovery team recommends that the primary thrust of the recovery

effort be protection and maintainance of known populations. Bastrop County populations are in no apparent jeopardy, providing the habitat is not further degraded. The status of the Burleson County population is poorly known, but every management option should be employed to increase the Houston toad population there.

1.1 Monitor existing populations and habitats.

Population monitoring provides a means of assessing the status of a species and feedback on the success of management programs. Little is known about annual fluctuations in Bastrop and Burleson Counties and a data base is essential to further management. In order to establish a long term data base, the team recommends monitoring all populations each year in February, March, and April until the species is delisted or becomes extinct. Suggested minimal monitoring procedures based on calling male and tadpole surveys is contained in Appendix II. These should be implemented wherever Houston toads are known to occur.

1.2 Identify population needs and habitat requirements.

To understand important characteristics of Houston toad habitats, a study and multivariate analysis of existing populations and their habitats should be carried out. Variables critical to the existence of the Houston toad need to be identified.

1.21 Study existing populations and habitats, including human uses of land, presticides, and herbicides.

Past records of Houston toads should be collected and organized in a file. Records should be entered on quadrangle maps and keyed to supporting

narrative data. Narrative data should include as much information as possible concerning field conditions, observers, dates, times, numbers and kinds of toads, pertinent biological correlates, and type of observation. These records should be updated annually.

The environmental correlates of areas now occupied by B. houstonensis should be analyzed statistically. Efforts should be made to determine summer foraging and winter hibernation areas. Land use patterns should be examined to determine their effects on Houston toad populations. All types of land use should be evaluated, including mining, grazing, timber management, burning, cultivation, highway construction, and residential, recreational, and utility uses. The evaluation should include experimental studies where necessary. The role of succession in the Houston toad's habitat should be examined experimentally. A survey of chemical use in the areas inhabited by the Houston toad should be undertaken, and the responses of postmetamorphic toads, tadpoles, and eggs of B. houstonensis to these chemicals should be studied if necessary.

Because of the experimental nature of these studies and because of variation in weather patterns, these

studies should be long term. Five years should be the minimum period used to evaluate effects of experimental manipulations. During the first year, populations should be estimated and environmental correlates should be determined and analyzed. Experiments should be set up with priorities given to the effects of grazing, burning, and succession. Much of the data gathered by the monitoring personnel should be directly applicable to this phase of the study.

1.22 Study ecological relationships between the Houston toad and other species of Bufo, predators, and competitors.

The impacts of predators, competitors, and other Bufo species on populations of Houston toads should be evaluated. Predation and competition can be addressed through experimental studies while levels of natural hybridization can be monitored through field observations, mating and release call analyses, electrophoretic analyses, and morphological studies.

1.23 Monitor study progress and evaluate results.

The results of this research should be evaluated annually and the progress assessed.

1.3 Protect existing populations.

Habitat currently used by known populations of Houston toad is either State-owned or private lands. The latter cannot now be managed directly.

1.31 Seek cooperation of landowners (private or public) and provide them with conservation information.

Efforts should be made to seek the cooperation of private landowners whose property is now used by Houston toads. Cooperation should provide for the conservation of the habitat and allow access and experimental habitat manipulation for study and monitoring.

1.32 Review and comment on all projects which might affect Houston toads or their habitat.

The Fish and Wildlife Service should monitor land use changes by means of field inspection trips to Houston toad habitats as often as warranted.

1.33 Prepare habitat management plans.

Brief habitat management plans should be drafted for each population of Houston toads.

1.34 Enhance habitat for Houston toad.

Habitat enhancement procedures should be determined from research under Section 1.2 and recommendations for specific techniques should be made to landowners according to the management plans developed in 1.33.

1.35 Obtain management rights to habitat, if necessary, to protect continued existence of a county's Houston toad population.

If it becomes apparent that the Houston toad in any county is threatened with extinction because of proposed changes in land use, serious consideration should be given to purchase of essential habitats.

2.0 Locate additional natural populations of Houston toad.

Much of the area in and surrounding the historic range of B. houstonensis has not been surveyed systematically for additional populations.

2.1 Design a systematic search for additional populations.

The recovery team has designed a project to locate other populations (Appendix IV). Using soil maps as a guide, suitable habitats will be surveyed for the presence of tadpoles and postmetamorphic toads.

2.2 Monitor and evaluate study progress.

The Regional Director should monitor and evaluate the progress of the search for additional populations and make recommendations for the design of future searches.

3.0 Determine the systematic status of Bufo houstonensis.

The relationships and distribution of toads closely related to Bufo americanus (B. houstonensis, B. a. charlesmithi) are not adequately known in northeastern Texas and southern Oklahoma. Knowledge of these relationships is important to evaluate the evolutionary perspective of the Houston toad. It is important to obtain the

highest levels of expertise in these studies.

3.1 Design and conduct a study of the toxonomic relationships of the Houston toad to other Bufo.

A design of the taxonomic study needed is presented in Appendix V. The design covers standard taxonomic techniques, including morphologic, electrophoretic, karyotypic, sonographic and field studies. These studies should span a 3-year period and results should be published in a refereed scientific journal.

3.2 Consult with systematic herpetologists and evaluate taxonomic data.

Because of the importance of the interpretation of the results of these studies at least five herpetologists experienced in systematic studies should be asked to evaluate the findings and to advise the Southwest Regional Director on the relationships of B. houstonensis and other toads.

4.0 Restore and manage populations of Houston toads in suitable areas of former range.

Prior to efforts to introduce Houston toads into other areas of their former range, these areas should be surveyed thoroughly for the presence of unknown populations of Houston toads and for the sites' suitability based on present knowledge of Houston toad requirements. The reestablishment of Houston toads will greatly enhance their prospects for long term survival. An introduction protocol is presented in Appendix III.

4.1 Select suitable habitat in former range occupied by Houston toads.

The former range of the Houston toad will be surveyed using soil maps and other sources of information to select appropriate sites for reintroduction.

4.11 Identify and enhance suitable habitat.

Sites within the historic range of B. houstonensis should be surveyed for existing populations of Bufo as required by Task 2.1 and for suitability for the Houston toad. These sites should be enhanced by use of management tools, such as vegetation manipulation, water provision, and suppression of competing species of Bufo.

4.12 Develop management plans.

Management plans should be prepared for all sites tentatively suitable for Houston toad transplants. The plans should be detailed enough to recommend specific management practices. Preparation of plans should begin as soon as appropriate sites are identified and should be finished before the toads are introduced.

4.2 Introduce Houston toads.

Eggs, tadpoles, and recently metamorphosed Houston toads from Bastrop County can be introduced as soon as a suitable site has been identified, necessary enhancement has been performed, and a management plan has been approved. Voucher specimens from introduced groups should be preserved for future morphological study. Frozen samples should be taken for electrophoretic profiles. Eggs and tadpoles may be released after heavy spring rains and metamorphosed Houston toads after heavy summer rains.

4.3 Monitor introduced toads and habitat.

After the Houston toads have been transplanted, each population must be monitored to determine success. Late winter and early spring searches for calling males and spring tadpole surveys should be the major tools used for monitoring. This monitoring schedule should be continued until the species is delisted or until the site has been abandoned.

4.4 Continue introductions.

Continue introductions at each site for five years, then monitor and evaluate reintroduced populations to determine if they are self-sustaining as defined on p.33 or until a decision

is made to abandon the site.

4.5 Manage restored habitat and populations.

Restored habitats and populations should be managed similarly to existing habitats as described under Section 1.3 above.

4.51 Seek cooperation of owners of Houston toad habitat, including owners of adjoining properties.

4.52 Review and comment on all projects which might affect Houston toads and their habitats.

5.0 Enforce all Federal and State laws protecting populations and habitats of the Houston toad.

The Houston toad is protected by Federal and State laws. Enforcement of these laws is the responsibility of the U.S. Fish and Wildlife Service and participating State and Federal agencies.

5.1 Inform agencies.

The U.S. Fish and Wildlife Service will keep the involved agencies informed as to the status of the Houston toad and the progress of recovery efforts. Possible problems must be identified and communicated among agencies.

5.2 Consult with agencies on their proposed projects and their responsibilities under the law.

Agencies or groups with projects within the range of present or projected Houston toad populations must be informed of the status of the toad and its habitat so that unintentional infractions of laws and/or inadvertent destruction of toads or habitats do not occur. Similarly, agencies should be encouraged to incorporate conservation actions for Houston toads into their planned activities. Section 7 consultation requirements must be pointed out to all Federal agencies supporting projects which may impact the species or its habitat.

6.0 Produce and disseminate information.

Literature on the Houston toad and its conservation will be made available to landowners, field personnel of the Texas Parks and Wildlife Department, schools, and other interested parties. Draft and final management plans should be sent to all owners of lands containing Houston toads. Once identified, the effects on Houston toads of chemicals used to control pests and plants should be presented in brochures and other forms of informative material.

LITERATURE CITED

Anderson, R. C., and L. E. Brown. 1981. Influence of a prescribed burn on colonizing black locust. Pp. 330-336. In H. E. Garrett and G. S. Cox (Eds.), Proc. Central Hardwood Forest Conf. III, Univ. Missouri, Columbia, Missouri.

Anderson, R. C., and J. Schwegman. 1971. The response of southern Illinois barren vegetation to prescribed burning. Trans. Ill. State Acad. Sci. 64:287-291.

Ashton, R. E. (Compiler), S. R. Edwards and G. R. Pisani (Eds.). 1976. Endangered and threatened amphibians and reptiles in the United States. Herpetol. Circ. No. 5, Soc. Study Amphib. Rept., v + 65 pp.

Blair, A. P., 1957. Amphibians, p.211-271. In Vertebrates of the United States, 1st ed. by W. F. Blair, A. P. Blair, P.Brodkorb, F. R. Cagle, and G. A. Moore. McGraw-Hill, N.Y. i-ix + 819 pp.

Blair, W. F. 1956. Call difference as an isolation mechanism in southwestern toads (genus Bufo) Tex. J. Sci. 8:87-106.

Blair, W. F. 1959. Genetic compatibility and species groups in U.S. toads (Bufo). Tex. J. Sci. 11:427-453.

Blair, W. F. 1965. Amphibian speciation. Pp. 543-556. In H. E. Wright and D. G. Frey (Eds.), The Quaternary of the United States. Princeton Univ. Press, Princeton, New Jersey.

Blair, W. F. 1972. Evidence from hybridization. pp. 196-232. In Blair, W. F. (ed.) Evolution in the genus Bufo. Univ. of Texas Press, Austin.

Bragg, A. N. 1960. Feeding in the Houston toad. Southwest Nat. 5:106.

Brown, L. E. 1967. The significance of natural hybridization in certain aspects of the speciation of some North American toads (genus Bufo). Ph.D. Dissertation, Univ. Texas, Austin, Texas. x + 126 pp.

Brown, L. E. 1971. Natural hybridization and trend toward extinction in some relict Texas toad populations. Southwest Nat. 16(2):185-199.

Brown, L. E. 1973. Bufo houstonensis Sanders--Houston toad. Cat. Amer. Amphib. Rept. 133.1-133.2.

Brown, L. E. 1975. The status of the near-extinct Houston toad (Bufo houstonensis) with recommendations for its conservation. Herpetol. Rev. 6(2):37-40.

Brown, L. E. and D. E. Birkenholz. 1975. An ecological study of an isolated stand of shellbark hickories (Carya laciniosa). 66th Ann. Report North. Nut Grow. Assoc., pp. 62-66.

Brown, L. E., and M. J. Littlejohn. 1972. Male release call in the Bufo americanus group. Pp. 310-323, Chap. 16. In W. F. Blair (Ed.), Evolution in the genus Bufo. University of Texas Press, Austin, Texas.

Brown, L. E., and R. A. Thomas. 1982. Misconceptions about the endangered Houston toad (Bufo houstonensis). Herpetol. Rev. 13(2):37.

Bury, R. B., C. K. Dodd, Jr., and G. M. Fellers. 1980. Conservation of the Amphibia of the United States: A review. USDI, FWS Resource Publ. 134:1-34.

Dixon, J. R. 1983. Survey of the Houston toad at the Caldwell, Texas, site. Final Report to the U.S. Fish and Wildlife Service under Contract No. 20181-0352. 3 pp.

Ehrenfeld, D. W. 1976. The conservation of nonresources. Amer. Sci. 64: 648-656.

Gehlbach, F. R., K. A. Arnold, K. Culbertson, D. J. Schmidly, C. Hubbs, and R. A. Thomas. 1975. TOES Watchlist of endangered, threatened, and peripheral vertebrates of Texas. Texas Organ. Endan. Spec. Publ. 1:1-12.

Gosner, K. L. 1960. A simplified table for staging anuran embryos and larvae with notes on identification. Herpetologica 16:183-190.

Guttman, S. I. 1969. Blood protein variation in the Bufo americanus species group of toads. Copeia 1969(2):243-249.

Hardy, M. 1977. Froggie goes to court. Texas Monthly 5(8):76.

Harwood, P. D. 1932. The helminths parasite in the Amphibia and Reptilia of Texas and vicinity. Proc. U.S. Nat. Mus. No. 2940,81(17): ????

Hazelwood, E. 1970. Frog pond contaminated. Brit. J. Herpetol. 4: 177-185.

Hillis, D. M., A. M. Hillis, and R. F. Martin. 1984. Reproductive ecology and hybridization of the endangered Houston toad (Bufo houstonensis). J. Herpetol. 18(1):56-71.

Honegger, R. E. 1970. Houston toad Bufo houstonensis Sanders 1953. Red Data Book, Volume 3--Amphibia & Reptilia. Int. Union Cons. Nature Nat. Resources, Surv. Serv. Com., Morges, Switzerland.

Jacobson, N. L. 1983. Reproductive behavior and male mating success in the Houston toad, Bufo houstonensis. M.A. Thesis, Univ. Texas, Austin.

Johnson, R. R., and D. A. Jones (Technical Coordinators). 1977. Importance, preservation and management of riparian habitat: A symposium. U.S.D.A. For. Serv. Gen. Tech. Report RM-43, Tucson, Arizona, 217 pp.

Kennedy, J. P. 1962. Spawning season and experimental hybridization of the Houston toad, Bufo houstonensis. Herpetologica 17:239-245.

Lundelius, E. L., Jr. 1967. Late-Pleistocene and Holocene faunal history of central Texas. Pp. 287-319. In P. S. Martin and H. E. Wright, Jr. (Eds.), Pleistocene extinctions--The search for a cause. Yale Univ. Pres, New Haven, Connecticut.

Office of Endangered Species and International Activities. 1974. United States list of endangered fauna. U.S. Dept. Interior, Fish & Wildl. Serv., Washington, D.C., 22 pp.

Peters, J. A. 1968. Houston toad--Bufo houstonensis (Sanders) [sic]. Sheet RA-10. In Rare and endangered fish and wildlife of the United States. Bureau Sport Fish. Wildl., U.S. Dept. Interior, Resource Publ. No. 34, Washington, D.C.

Poole, R. W. 1974. An introduction to quantitative ecology. McGraw-Hill, Inc., New York, xii + 532 pp.

Quinn, H. 1980. Final report of captive propogation/release program of the Houston toad, Bufo houstonensis. Rept. to U.S. Fish and Wildlife Service, Albuquerque, New Mexico, 16 pp + 7 tables.

Quinn, H. and G. Mengdon. 1984. Reproduction and growth of Bufo houstonensis (Bufonidae) Southw. Nat. 29(2);189-195.

Sanders, O. 1953. A new species of toad, with a discussion of morphology of the bufonid skull. Herpetologica 9(1):25-47.

Thomas, R. A. 1977. The endangered Houston toad (Bufo houstonensis). Final report to the U.S. Fish & Wildl. Serv. under Contract No. 14-16-0002-3557, 11 pp.

Thomas, et al. In press. Helminth parasites of the endangered Houston toad, Bufo houstonensis. Sander 1953.

Thomas, R. A. and H. C. Dessauer. 1982. Taxonomy of The Houston Toad, Bufo houstonensis Sanders. unpublished report. 11 pp.

Thomas, R. A., and F. E. Potter, Jr. 1975. Species status account--Bufo houstonensis Sanders, 1953. In: Potter, F. E., Jr., Special Report, Houston toad Study, Texas Parks and Wildlife Department. 15 pp.

U.S. Fish and Wildlife Service. 1977. Endangered and threatened wildlife and plants. Proposed determination of Critical Habitat for the Houston toad. Federal Register 42:27009-27011.

U.S. Fish and Wildlife Service. 1978. Endanged and threatened wildlife and plants. Determination of Critical Habitat for the Houston Toad. Federal Register 43:4022-4026.

Voris, H. K. and J. P. Bacon, Jr. 1966. Differential predation on tadpoles. Copeia 1966: 594-598.

West, R. 1975. Texas Monthly reporter: low talk. Texas Monthly Magazine 3(10): 12.

Wright, A. H. and A. A. Wright. 1938. Amphibians of Texas. Trans. Texas Acad. Sci. 21:1-35

General Categories for Implementation Schedules

Information Gathering - I or R (research)

1. Population status
2. Habitat status
3. Habitat requirements
4. Management techniques
5. Taxonomic studies
6. Demographic studies
7. Propagation
8. Migration
9. Predation
10. Competition
11. Disease
12. Environmental contaminant
13. Reintroduction
14. Other information

Acquisition - A

1. Lease
2. Easement
3. Management agreement
4. Exchange
5. Withdrawal
6. Fee title
7. Other

Management - M

1. Propagation
2. Reintroduction
3. Habitat maintenance and manipulation
4. Predator and competitor control
5. Depredation control
6. Disease control
7. Other management

Other - O

1. Information and education
2. Law enforcement
3. Regulations
4. Administration

Task Priority

Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly.

Priority 2 - An action that must be taken to prevent a significant decline in species population habitat quality or some other significant negative impact short of extinction.

Priority 3 - All other actions necessary to provide for full recovery of the species.

PART III - IMPLEMENTATION SCHEDULE

GENERAL CATEGORY	PLAN TASK	TASK #	PRIORITY #	TASK DURATION	RESPONSIBLE AGENCY			FISCAL YEAR COSTS* (EST.)			COMMENTS
					FWS		OTHER				
					REGION	PROGRAM		FY1	FY2	FY3	
(1)	(2)	(3)	(4)	(5)	(6)	(7)		(8)			(9)
I1	Monitor populations and habitats	1.1	2	10	2	Mgmt.	TP&WD	10,000	10,000	10,000	
I3	Study existing populations	1.21	2	5	2	Mgmt.	TP&WD	10,000	10,000	10,000	Should be done as part of 1.1
I10	Ecological relationships between Houston toad other taxa	1.22	2	5	2	Mgmt.	TP&WD	10,000	10,000	10,000	Should be done as part of 1.21
I2	Monitor and evaluate results	1.23	2	5	2	Mgmt.	TP&WD	0	0	0	Should be part of 1.1, 1.21 and 1.22 at no additional cost
A3	Seek cooperation	1.31	2	ongoing	2	Mgmt.	TP&WD	25,000	25,000	25,000	
I2	Project review and comment	1.32	2	ongoing	2	Mgmt.	TP&WD	1,000	1,000	1,000	Should be done as oversight of 1.1
M3	Habitat management plans	1.33	2	ongoing	2	Mgmt.	TP&WD	2,000	2,000	2,000	
M3	Enhance habitat	1.34	2	ongoing	2	Mgmt.	TP&WD	5,000	5,000	5,000	
A2	Obtain management rights to habitat	1.35	2	3	2	Mgmt.	TP&WD	50,000	50,000	50,000	
I1	Design search for additional populations	2.1	2	1	2	Mgmt.	TP&WD	10,000	10,000	10,000	

PART III - IMPLEMENTATION SCHEDULE

GENERAL CATEGORY	PLAN TASK	TASK #	PRIORITY #	TASK DURATION (YEARS)	RESPONSIBLE AGENCY			FISCAL YEAR COSTS* (EST.)			COMMENTS
					FWS		OTHER				
					REGION	PROGRAM		FY1	FY2	FY3	
(1)	(2)	(3)	(4)	(5)	(6)	(7)		(8)			(9)
M7	Monitor and evaluate study	2.2	2	ongoing	2	Mgmt.	TP&WD	1,000	1,000	1,000	Should be done part of Task # 2.1
I5	Design a taxonomic study	3.1	2	3	2	Mgmt.	TP&WD	10,000	10,000	10,000	
I5	Consult with systematic herpetologists	3.2	2	1	2	Mgmt.	TP&WD	0	0	0	Should be part of 3.1 with no additional cost
M3	Select suitable habitat	4.1	2	10	2	Mgmt.	TP&WD	15,000	15,000	15,000	
M3	Identify and enhance suitable habitat	4.11	2	10	2	Mgmt.	TP&WD	0	0	0	Part of 4.1
M3	Develop management plan	4.12	2	10	2	Mgmt.	TP&WD	0	0	0	Part of 4.1 and similar to 1.33
M2	Introduce Houston toads	4.2	2	5	2	Mgmt.	TP&WD	20,000	20,000	20,000	
M2	Monitor transplanted populations	4.3	2	10	2	Mgmt.	TP&WD	10,000	10,000	10,000	Part of 4.2
M2	Continue introductions	4.4	2	5	2	Mgmt.	TP&WD	10,000	10,000	10,000	Part of 4.2 and 4.3

PART III - IMPLEMENTATION SCHEDULE

GENERAL CATEGORY	PLAN TASK	TASK #	PRIORITY #	TASK DURATION (YEARS)	RESPONSIBLE AGENCY			FISCAL YEAR COSTS* (EST.)			COMMENTS
					FWS		OTHER				
					REGION	PROGRAM		FY 1	FY 2	FY 3	
(1)	(2)	(3)	(4)	(5)	(6)	(6)	(7)	(8)			(9)
M3	Manage restored habitat and populations	4.5	2	10	2	Mgmt.	TP&WD	10,000	10,000	10,000	Follow-up of 4., 4.3, and 4.4
02	Inform agencies	5.1	2	ongoing	2	Mgmt.	TP&WD	5,000	5,000	5,000	
03	Consult with agencies on proposed projects	5.2	2	ongoing	2	Mgmt.	TP&WD	5,000	5,000	5,000	Part of 5.1
01	Produce and disseminate information	6.0	2	ongoing	2	Mgmt.	TP&WD	5,000	5,000	5,000	

*Refers to costs to USFWS only.

APPENDIX I

Comments from reviewers of the technical and agency review drafts of the Houston toad recovery plan with Service response to comments. Comments are numbered alpha-numerically, i.e., A1, A2, etc., as are responses.

A1 Sufficient data exists to legitimately hypothesize that Bufo houstonensis and B.a. charlesmithi are synonymous. The Endangered Species Act allows for protection of species, sub-species, or populations, when the best available scientific and commercial information indicate protection is warranted. Therefore, regardless of the systematic relationship of B. houstonensis to other bufonides, it will receive full Federal protection as warranted.

A2 Similar wording is in the plan.

A3 See A1

A4 Appropriate wording added to plan.

A5 Same

A6 Same

A7 See Part III

A8 See Appendix II

A9 The Service contracted with the Houston Zoo to develop techniques for captive propagation of B. houstonensis as a precaution against catastrophic loss of wild populations of the species. The Zoo developed propagation techniques and the Service believes that additional development is not necessary at this time.

A10 Wording of the plan was changed appropriately

A11 Same

A12 Same

A13 Same

A14 Same

A15 This information was added to the plan, as appropriate

A16

A17 Done

A18 Done

A19 The recovery team disagreed and chose to leave the topic of taxonomy in the plan.

A20 Done

A21 Done

A22 Done

A23 Done

A24 The importance of a topic is not equivalent to how many lines are written about it

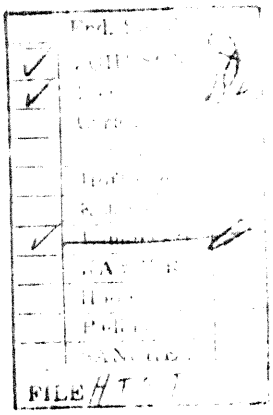
A25 The plan was reworded appropriately

A26 Corrected

A27 Corrected

THE UNIVERSITY OF TEXAS AT AUSTIN

DEPARTMENT OF ZOOLOGY



August 31, 1983

Mr. James E. Johnson
Chief, Endangered Species
U.S. Fish and Wildlife Service
P.O. Box 1306
Albuquerque, NM 87103

Dear Mr. Johnson:

I have had considerable interest in reading the draft document by the Houston Toad Recovery Team. Overall, this is a very thoroughly done report that does credit to the Recovery Team. I have only two sets of comments, only one of which might be considered negative. I am most unenthusiastic about the proposal to examine the taxonomic relation to B. a. charlesmithi and to let the opinions of a selected group of herpetological taxonomists determine the endangered status of B. houstonemsis. B. houstonemsis is a biologically interesting and significant Pleistocene isolate from B. americanus displacement. As a genetically isolated population the population known as B. houstonemsis is worth salvage, whether or not it satisfies the criteria for species recognition by a group of taxonomic lumpers. The status of the population could depend on whether one selects a panel of taxonomic lumpers or splitters.

A-1

On a more positive note, I would suggest some greater emphasis on the need to protect the Bastrop county population by land acquisition to bring more habitat under control and to improve the level of habitat protection.

A-2

Sincerely yours,

W Frank Blair

W. Frank Blair
Professor Emeritus

WFB:clj

cc: Houston Toad Recovery Team/9-12-83/vah

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

U.S. FISH & WILDLIFE SERVICE

Memorandum

TO : Regional Director, FWS, Region 2, Albuquerque, NM (SE)

DATE: SEP 14 1983

FROM : Acting Field Supervisor, FWS, Ecological Services, Houston, TX

SUBJECT: Comments on the Technical Review Draft of the Recovery Plan for the Houston Toad.

We have reviewed the subject document and are concerned by some of the findings.

This plan clearly shows how little is known and how much work remains to be done on the Houston toad. Basic questions such as the importance of a particular vegetative association to the species remain unanswered. The effects of fire and low density human habitation (i.e. cabins) are other important unknowns. Research into these items, as well as other aspects of Houston toad ecology as mentioned in the plan, should proceed as fast as funding will allow.

A-3

The recommendation to downgrade the Houston toad from endangered to threatened if the taxonomic status of the species changes is unwarrented, at least as long as the Houston toad retains subspecific status. Many subspecies are seperately listed and changing the taxonomic status will not make any more Houston toads available for breeding next spring. If research shows that the Houston toad is only an isolated population of another subspecies, the status of that subspecies should be reviewed in light of the reclassification. An automatic recommendation to relist it as threatened is not, in our opinion, warrented at this time.

Further, we offer the following specific comments for your consideration.

A-4

1) On page 30 add:

   a) 6.0 Promote voluntary conservation measures on behalf of the Houston toad by public and private entities.

cc: Houston Toad Recovery Members/12-5-83/vah

FWS REG 2
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SEP 22 '83
SE

A-5 b) 6.1 Maintain an active public relations campaign near existing and potential Houston toad habitat.

A-6 c) 6.2 Advise and assist interested parties in implementing conservation measures. This addition is requested because some desirable conservation measures may not be legally required, as addressed in item 5.0.

A-7 2) On page 33, item 1.12, the Texas Parks and Wildlife Department should be added to the list of those available for monitoring.

A-8 3) On page 41, item 4.12, the status of the Houston toad introduction management plan for the Attwater's Prairie Chicken National Wildlife Refuge should be made clear. Releases of both adults and egg masses (see page 6) have already been made on that refuge. Should that continue? Does that refuge have a Houston toad management plan?

A-9 4) The future role of the Houston Zoo's captive breeding program should be explained. If captive bred animals are not to be used for introductions (see page 46, #4), are they suitable for taxonomic and other research work? If suitable, the use of captive bred animals for research could reduce the amount of wild collecting required.

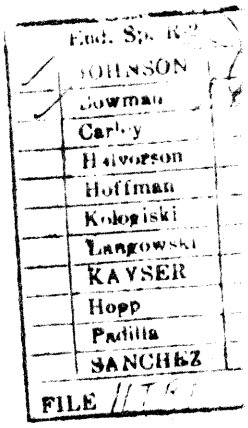
We appreciate the opportunity to offer these comments and look forward to cooperating in the recovery of the Houston toad.

A Dale Hall

AJM:es

THE UNIVERSITY OF KANSAS · LAWRENCE, KANSAS · 66045

MUSEUM OF NATURAL HISTORY



18 October 1983

Dr. James E. Johnson
U. S. Fish and Wildlife Service
P.O. Box 1306
Albuquerque, NM 87103

Dear Dr. Johnson:

I have read the Technical Review Draft of the Houston Toad Recovery plan. I have no major criticisms of the draft, but have the following minor comments to make:

A-10 p. 5, lines 3-7: I disagree that the study by Martin "revealed that apparently the species was near extinction." As one of the people involved in this study, I object in that this study found many large choruses of Houston Toads over a wide area of Bastrop County.

A-11 p. 15: I think that it is clear that population sizes in Bastrop County seem larger for two reasons, neither of which is an actual increase of population sizes. First, it was found during 1979-1982 (due to nightly visitations to the breeding sites beginning in early January) that Houston Toads breed earlier than had been thought; previous studies were carried out largely after the majority of breeding of Houston Toads was over. This was due to the misconception (still prevalent in this report---see below) that Houston Toads breed after warm spring rains. Secondly, the areas surveyed were not comparable---the 1979-1982 estimates were based on a survey of areas not previously known to harbour Houston Toads. The areas that Brown, Potter, and Thomas worked still have relatively few Houston Toads.

A-12 p. 18 (last sentence---Present distribution): This statement is misleading and/or in error. There is no reason to suspect that Houston Toads do not still occur in Liberty County, but no one (to my knowledge) has looked recently during the breeding season. There is still plenty of suitable habitat there, and I would be surprised if Houston Toads are absent. Also, how is the hybrid found in 1982 in Austin County accounted for if there are no Houston Toads there?

A-13 p. 20 (food of tadpoles): Hillis et al. reported that Houston Toad tadpoles ingested jelly envelopes of recently-hatched conspecifics and also reported Houston Toads ingesting large quantities of pine pollen.

tadpoles

cc: Team Members
Ken Dodd/11-30-83/vah

SE

A-14

page 45: "Field teams should be ready to respond to warm, moist weather fronts that may bring rain during February, March, and April." It is unfortunate to see the persistence of this misconception in this report. This misconception probably resulted in the very low early estimates of population sizes for Houston Toads. If existing populations of Houston Toads are monitored following this protocol, most of the breeding will be missed. Hillis et al. reported that Houston Toads breed when nightly lows of the previous 24 hrs rise above 14 C; during the past several years this has never been associated with a "warm, moist weather front that may bring rain." In fact, the initiation of breeding behavior by Houston Toads has occurred during clear, dry spells over the last several seasons. Only later in the spring, when the bulk of the breeding is over, do Houston toads assemble at ponds primarily during wet weather. This information is also notably absent from the section on reproduction, p. 16.

Over all, the report seems comprehensive and accurate. However, I do believe the above changes are important.

Sincerely,

David M. Hillis

P.S. -- The Hillis et al. MS is due out shortly in Journal of Herpetology.

THE UNIVERSITY OF TEXAS AT AUSTIN
DEPARTMENT OF ZOOLOGY

September 23, 1983

Dr. James G. Johnson
Chief, Endangered Species
U.S. Department of the Interior
Fish and Wildlife Service
P.O. Box 1306
Albuquerque, N.M. 87103

Dear Dr. Johnson,

I am sorry for taking so long in returning my comments on the "Technical Review Draft of the Houston Toad Recovery Plan". It sounds like a comprehensive program and I will be interested in hearing about the results of the proposed research.

I would like to point out that 50 - 75 percent of males were new (page 15) only on a few of the nights, primarily at the beginning; and that some females did return to the pond, usually within three nights, but one even returning during a different breeding period. I have included figures 3 and 4 from my Master's thesis which show the numbers and proportions for each night.

A-15

Other comments are simply thoughts I had while reading the draft. Good luck with the program.

Sincerely,

Nancy L. Jacobson

Nancy L. Jacobson

Enclosure

FWS REG 2
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SEP 2

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

4 OCT 1983

OFFICE OF
PESTICIDES AND TOXIC SUBSTANCES

MEMORANDUM

TO: Rick Stevens
Ecological Effects Branch
Hazard Evaluation Division

SUBJECT: Review of Draft Recovery Plan for the Endangered Houston Toad (Bufo houstonensis).

The recovery plan provides information which dispels certain notions about this species. First, it is clear from the existing population and habitat data presented that there are viable populations in the wild. Second, the habitat of the Houston Toad is very likely receiving substantial pesticidal (particularly herbicidal) exposure.

The major reasons for decline are cited as: a) probable difficulty in adapting to climate changes (there apparently is some confusion as to the taxonomic synonomy, therefore speciation or sub-speciation could account for difficulties of this nature); b) habitat modification and/or destruction (this, in my opinion, is the clear and imminent danger now faced by these populations, regardless of the synonomy question).

Certainly the clearing of large tracks of pine forest for residential and agricultural development is a major reason for the decline. However, these activities have necessarily led to the introduction of much higher volumes of pesticides than previously used. I am happy to see that the question of chemical exposure is treated seriously in this plan - one of the first I have reviewed, to do so.

I would like to comment on, and distill the potential exposure problems I foresee for this species. I based my analysis on the descriptions of the critical habitat and other known Houston Toad localities. These comments are offered in the hope that the Recovery Team will not underestimate the exposure potential.

First, and most important, is the fact that the largest population of the toads occurs in and adjacent to the Bueschor State Park in Bastrop County, Texas. Although this is a managed and protected area, it is not immune to

insecticidal treatments (large and small scale), particularly in unusual or "emergency" disease and/or pest outbreak situations. Should it become necessary to spray in the park for any reason, EEB's data base could prove invaluable to Texas officials in protecting the Houston Toad . We, of course, would have to base hazard assessments on acute and chronic fish data, applying these to the aquatic larval stages of Bufo houstonensis, although we do have a limited amount of acute amphibian data.

Marginal habitats supporting smaller and more scattered populations are subject to insecticide and herbicide exposure through direct applications, spray drift and/or runoff (including that through soil erosion) from many sources. The following use patterns are implicated, in my opinion, in the potential exposure of Bufo houstonensis:

- general commercial agriculture - I, H, F*
- private, small scale agriculture (including home vegetable gardens, some of which maybe very close to certain known Houston Toad localities and breeding ponds in specific suburban developments) - I, H, F.
- public health - camp and picnic grounds - I, H
- cattle dipping - I
- cattle grazing/rangeland - H
- highway rights-of-way - H
- lawns and ornamentals - (again, may be particularly acute exposure because of apparent close proximity of suburban developments to known critical habitat) - I, H, F.
- golf course turf - I, H, F.
- forestry (minor) - I.
- aquatic weed control (again, there could be significant acute exposure at known localities in the suburban developments where the toads are known to exist. Many of these localities contain artificial lakes and/or ponds, which are frequently treated for aquatic weed and mosquito control) - I, H.

* I - Insecticide
H - herbicide
F - Fungicide

I don't see a pressing need for specific warnings on Sec. 3 labels to protect Bufo houstonensis. The major exposure of the toads from pesticides in general (untrained) use appears to be from the lawn, ornamental and home garden products. Other Sec. 3 labels would probably be in the hands of trained people (hopefully!). Since the distribution of the toad is so limited (3 or 4 counties), the Recovery Team, U.S. Fish & Wildlife Service, Texas state and county officials, and E.P.A. could certainly cooperate to confine our concerns to the local people involved. This could easily be worked into the Recovery Plan's "educational" provisions.

A-16

Thank you for the opportunity to comment.

John Bascietto

John Bascietto
Sec. 3
Ecological Effects Branch, HED

United States Department of the Interior

FISH AND WILDLIFE SERVICE
WASHINGTON D.C. 20240

In Reply Refer To:
FWS/OES

MEMORANDUM

To: Regional Director, Region 2 (ARD/AFF)

From: Director

Subject: Houston Toad Recovery Plan - Technical Review Draft

AFF

We have completed our review of the subject plan. Specific comments may be found in the margin of the attached text. General comments will be discussed below.

A-17 1. Part I, pages 1-21: Though a thorough review of data is provided, the format is inconsistent. We suggest reordering the sections in this part, as described in the attached plan. Introductory and summary paragraphs should also be included.

A-18 2. Part II, page 28: The primary goal of the recovery process should be to delist the species. There is some concern whether that is a feasible goal for this species. If it is not, our goals should be changed accordingly and any new goals fully supported. Objectives should be quantified to the extent possible.

A-19 3. Part II, pages 28, 30, 39, and 40: It is not clear from the discussion whether there is a taxonomic problem with this species. Information available indicates that this is not a problem. Therefore, Task 3 is not a legitimate recovery activity and should be omitted. If necessary, a subtask could be included under Task 1.22 if you feel that the taxonomy should be given further reconsideration.

A-20 4. Part II, pages 28 and 32: The term "nonthreatened" is improperly used. Restate the sentences using the term "delist." See comment under number 2 above.

A-21 5. Part II, pages 28-30: Tasks 1 and 2 should be more specific in defining our management options with this species (see attached comments). In particular, specific tasks relative to habitat management should be included. This will affect the identification of fundable recovery activities in the implementation schedule to be included in Part III.

Also attached are comments received from EPA concerning potential pesticide problems relating to this species. Since their comments are substantial, they have been attached for your use.

We hope these comments will assist you in preparation of the agency draft. If you feel that any of these comments do not warrant revision of this plan, please respond in your return cover memorandum. Please provide five copies of the agency draft for our review.

Roman H. Koenings

Attachments

United States Department of the Interior
FISH AND WILDLIFE SERVICE
WASHINGTON, D.C. 20240

ADDRESS ONLY THE DIRECTOR,
FISH AND WILDLIFE SERVICE

In Reply Refer To:
FWS/OES

MAY 23 1984

Memorandum

To: Regional Director, Region 2 (ARD/AFF)
Acting Associate
From: Director

Subject: Review of Houston Toad Recovery Plan - Agency Draft

MAY 25 1984

We have reviewed the subject plan and have made numerous comments in the margins of the plan (attached). You will note that most comments are editorial in nature. The plan would benefit by careful editorial review prior to finalization to insure that it is properly worded. In addition, we would like to highlight the following comments:

-22 1. The tasks listed in the Stepdown Outline and the Narrative should be identical.

-23 2. Throughout the plan, the term "nonthreatened" should be replaced with "delisted."

-24 3. If determination of taxonomic status is important enough to be considered in the primary goal (page 41) and the Stepdown Outline/Narrative (Task 3.0), it deserves more than two sentences of discussion in Part I (page 5). If it is not so important, it should either be eliminated from Part II or be included as a subtask (e.g., under 1.22).

-25 4. Subtask 3.2 should be eliminated.

-26 5. The Narrative for subtasks 4.51 and 4.52 has been omitted.

-27 6. The costs and responsibilities listed in the Implementation Schedule should be broken down by subtask, if possible. The recovery plan and its Implementation Schedule are used to evaluate funding proposals, permit proposals, and Section 7 consultations. It is, therefore, important that subtasks be identified if the Implementation Schedule is to be useful.

We hope these comments will be useful in preparing the final draft of the Houston Toad Recovery Plan. If you disagree with any of the comments, please provide your rationale in a return memorandum. Please send five copies of the final draft and two signature pages to OES for the Director's approval.

Attachment

cc: Houston Toad Recovery Team members 6/6/84 ep J. R. Fielding

APPENDIX II

PROCEDURES FOR MONITORING EXISTING POPULATIONS

(See Narrative, Section 1.1)

Field teams should be ready to act on the first late-winter night following a 24-hour period during which the air temperature does not fall below 14°C. Ponds with known Houston toad populations should be visited and the number of Houston toads noted. Breeding activity (calling males, pairs in amplexus), or lack of it, should be noted. The same ponds should be visited each year in order to make useful generalizations concerning year-to-year fluctuations in the breeding populations.

If conditions permit, calling males should be marked to see what portion of males in the pond return on consecutive nights.

During the day, using both visual observations and dip nets, searches should be made for eggs and tadpoles. The ages of eggs and tadpoles should be estimated to determine the time of oviposition.

During these studies, changes in land-use patterns or other factors that may influence Houston toad populations should be noted. Other breeding amphibians, especially Bufo, should also be noted.

APPENDIX III

INTRODUCTION PROTOCOL

(See Narrative, Section 4.0)

1. Introductions should be made at localities in the historic range of B. houstonensis.
2. Candidate localities for introductions should be surveyed to assure that no Houston toads occur at that place.
3. Introductions should consist of eggs, tadpoles, newly metamorphosed toads and adult toads. Where possible, toads should be marked by toe clipping to indicate their source and date of introduction.
4. B. houstonensis from natural populations should be used. However, wild-taken eggs or animals may be reared in captivity to stages that are the most effective colonizers.
5. Introductions should be monitored at least twice monthly during the Houston toad activity season. Evidence should be gathered to determine the most biologically efficient stages for introduction.
6. Ordinarily, an animal introduction should consist of at least 100 egg masses or their products (tadpoles, metamorphosed toadlets). Initially, adult toads should be introduced only for experimental reasons.
7. Introduction efforts at a single site should continue for at least 5 years. At the end of this time data will be reviewed and recommendations will be made for continuation or termination of the project.
8. Care should be taken that the source population not be seriously depleted. Ordinarily, not more than 25 percent of the available egg masses should be taken in any 1 year.

APPENDIX IV

SEARCH PLAN FOR ADDITONAL POPULATIONS

(See Narrative, Section 2.1)

The procedure for searching for additional Houston toad populations is similar to that outlined in Appendix II, "Procedures for Monitoring Existing Populations". On spring nights, suitable ponds on sandy soils outside of the known present range of the Houston toad should be visited.

If Houston toads are found, mating calls and environmental temperatures should be recorded and voucher specimens taken and carefully prepared for systematic and electrophoretic analyses. Under no conditions should more than 10% of the toads present at one time be collected.

Intensive and extensive tadpole searches should be made during the day. Samples of all bufonid tadpoles found should be preserved for laboratory examination.

APPENDIX V

DESIGN OF TAXONOMIC STUDY

(See Narrative, Section 3.1)

The relationships of B. houstonensis to other toads need to be investigated thoroughly. The following studies are needed to determine the systematic status of the Houston toad.

A) Field Studies - These studies should focus on finding B. houstonensis and B. americanus populations outside their known ranges. Body temperatures should be taken from several calling males (at least five) and at the same time water and dry bulb temperatures should be recorded; and at least 10 and preferably 20 or more specimens should also be preserved. Some should be prepared for electrophoretic analysis (tissue work--frozen or shipped alive) and the remainder carefully preserved for morphometric analysis. The areas most likely to shed light on the systematic relationships of B. houstonensis are southern and central Oklahoma and northeastern Texas, within and south of the known range of B. americanus charlesmithi.

B) Mating Call Studies - Thirty to forty calling males should be recorded at various temperatures at each of three nonhybridizing populations within the range of B. americanus in southern Oklahoma and two pure populations of B. houstonensis. These calls sould be analyzed sonographically and compared.

C) Electrophoretic Studies - Electrophoretic profiles, using as many isozymes as possible, should be prepared for large numbers of bufonid populations of closely related species. These results can be used not only for taxonomic analyses, such as calculation of electrophoretic distance, but also for monitoring of hybridization frequencies (see Appendix II).

D) Morphologic Studies - Standard morphometric and other phenotypic measurements and observations can be used to analyze population relationships. Large samples (25 adult individuals) should be taken from a few populations that are thought to be pure B. houstonensis and B. a. charlesmithi. Past morphological studies have not used the available material to adequately characterize populations, and we have a poor understanding of the variation in any single area. Care should be taken to correctly preserve the specimens taken.

E) Karyotypic Studies - Recent developments in the study of banding patterns of chromosones may help evaluate the relationship of B. houstonensis. An extensive survey should be undertaken to locate and evaluate B. a. charlesmithi, B. woodhousei, B. houstonensis, and presumed hybrids.