

AMPHIBIANS AND LAND USE IN THE CHIHUAHUAN DESERT BORDER REGION

PAULETTE L. FORD^{1,2} AND DEBORAH M. FINCH¹

¹*Rocky Mountain Research Station, Albuquerque, NM 87106*

and ²*University of Arizona, School of Renewable Natural Resources, Tucson, AZ 85721*

ABSTRACT

The pressures of growing borderland populations, increased land use, and increased water use are threatening amphibians in the Chihuahuan Desert border area. In this paper, we describe potential direct threats such as loss or contamination of aquatic habitats, and indirect threats such as the sublethal effects of pesticides on developing larvae and tadpoles. More research is needed on amphibians of the Chihuahuan Desert region to develop guidelines for managing the natural resources of the region in ways that benefit both wildlife and humans.

INTRODUCTION

The population declines of many amphibian species globally may signal widespread environmental problems, such as the presence of toxic chemicals and other contaminants in air, water, or soil; the disruption of ecosystem linkages, processes, and food chains; or the vanishing of critical habitats or keystone species (Wake, 1991). Yet, the population ecologies of few amphibian species are well-understood, and fewer have been evaluated in relation to environmental disturbance. This paper reviews issues of land use and development in the Chihuahuan Desert region of the United States-Mexico border area and the possible effects on the amphibians found there.

The Chihuahuan Desert region is a diverse and unique ecosystem that includes deserts, grasslands, mountains, wetlands, and sand dunes within its boundaries. Though it stretches into southern New Mexico and southwestern Texas in the United States, over 80% is in the Mexican states of Chihuahua, Coahuila, Nuevo Leon, Durango, Zacatecas, San Luis Potosi, Tamaulipas, and extreme northern Guanajuato (MacMahon and Wagner, 1985). The Chihuahuan Desert straddles the United States-Mexico political border for approximately 270 km from the Arizona-New Mexico border to Big Bend, Texas.

The ecological and biological concerns of this region cannot be separated from the socioeconomic factors affecting it. The demands of many people seeking economic opportunities in border towns must be balanced with the need to sustain the available natural resources. This is especially crucial since the recent passage of the North American Free Trade Agreement (NAFTA) is expected to bring increased foreign investment, industry, and jobs to border towns.

RESULTS

Land Use on the Border.--The last 50 years has seen tremendous urban growth and economic development in the Mexico-United States borderlands, giving the area a higher standard of living than anywhere else in Mexico (Ganster, 1990). Approximately 1,454,548 people now live in the counties and municipalities in the Chihuahuan Desert region (EPA, 1992).

Historically, the economy of the United States-Mexico border area, including the Chihuahuan Desert region, has been dominated by mining, livestock raising, and agriculture. The area is rich in copper, gold, silver, lead, phosphate, and manganese. Due to widespread irrigation, large quantities of fruits and vegetables are grown and processed along the border (EPA, 1992). In the Lower Rio Grande Valley, 90% of surface water supplies are allocated to agricultural uses (Kelly, 1991). The area also supports cattle and sheep ranches and farms producing wheat, maize, and millet (EPA, 1992).

In 1965, the Mexican government established the Border Industrialization Program to create jobs and expand the industrial base in the border cities. The industrialization, primarily by U.S.-based corporations operating maquiladora plants (assembly plants), has been accompanied by a drastic increase in environmental and public health problems (Kelly, 1991) such as contamination of water supplies, air pollution, cancer, and birth defects.

In the Chihuahuan Desert border area, there are approximately 326 maquiladoras on the Mexican side, and approximately 26 factories on the U.S. side (EPA, 1992). The maquiladoras and factories manufacture a variety of products including electronic equipment, petroleum products, and textiles (EPA, 1992; Iglesias, 1990).

There are approximately 881,258 ha of protected natural areas in the Chihuahuan Desert region including national and state parks, wildlife refuges, and biosphere reserves, in both the United States and Mexico (Table 1). The protected areas on the border include Big Bend National Park, Black Gap Wildlife Management Area, Big Bend Ranch State Park, and the Casas Grandes Reserve. Casas Grandes is a newly created reserve in Chihuahua, Mexico. Administered by the Centro de Ecología, Universidad Nacional Autónoma de México, it is located 75 kilometers south of the Mexico-U.S. border. The boundaries and size of the reserve are currently being established.

Since 1935, Mexican and American officials have been attempting to create a 485,829 ha park or preserve of the Sierra del Carmen and surrounding desert in northern Coahuila, adjacent to the Big Bend National Park in Texas (Parent, 1990). Negotiations are still in progress (TCPS, 1993). If successful, more than 809,716 ha of land would be protected in the U.S./Mexico border area of the Chihuahuan Desert.

Amphibians.--Approximately 23 species of amphibians inhabit the Chihuahuan Desert region. All but one species, *Hyla eximia*, have a range that includes the border area (Appendix).

Most amphibians have a life cycle that requires both aquatic and terrestrial

TABLE 1.--Protected natural areas in the Chihuahuan Desert region.

MEXICO

Parque Nacional Balneario de Los Novillos, Coahuila	54 ha
Parque Nacional Cumbres de Majalca, Chihuahua	4,722 ha
Reserva de La Biosfera Mapimi, Durango	20,000 ha
Reserva de La Biosfera La Michilia, Durango	35,000 ha
Total Protected Area	59,776 ha

UNITED STATES

Big Bend National Park, Texas	286,459 ha
Big Bend Ranch State Park, Texas	106,882 ha
Bitter Lake National Wildlife Refuge, New Mexico	9,453 ha
Black Gap Wildlife Management Area, Texas	44,534 ha
Bosque del Apache Natl. Wildlife Refuge, New Mexico	23,154 ha
Carlsbad Caverns National Park, New Mexico	18,704 ha
Elephant Mountain Wildlife Management Area	10,121 ha
Franklin Mountains State Park, Texas	9,613 ha
Grulla National Wildlife Refuge, New Mexico	1,619 ha
Guadalupe Mountains National Park, Texas	32,117 ha
Jornada Experimental Range, New Mexico	104,166 ha
Muleshoe National Wildlife Refuge, New Mexico	2,351 ha
San Andreas National Wildlife Refuge, New Mexico	23,155 ha
Sevilleta National Wildlife Refuge, New Mexico	89,842 ha
White Sands National Monument, New Mexico	59,312 ha
Total Protected Area	821,482 ha

habitats in some aspect of their of development (Table 2). Because of this dependence on multiple habitats, they are especially vulnerable to exploitive land use practices. Their thin permeable skins, complex life cycle, and prolonged exposure to aquatic and terrestrial environments make amphibians particularly sensitive to environmental stressors of both natural and anthropogenic origins, e.g., freezing, desiccation, or pollution. In addition, amphibian tadpoles and larvae undergo considerable morphological and physiological changes during development. With rapid changes taking place, there are many opportunities for interference or malfunction during the various stages of development. This increases the chance of deformities caused by environmental stress (Berrill et al., 1993; Cooke, 1981). Monitoring tadpole performance can be a useful technique for detecting side effects of toxic pollutants in freshwater systems because tadpoles are morphologically similar to the later embryonic stages in higher vertebrates, and therefore, are fairly representative of freshwater wildlife (Cooke, 1981).

Environmental Stressors.--The allocation of water for different uses, e.g., for wildlife, human consumption, industry, agriculture, mining, and livestock raising, is one of the biggest problems the Chihuahuan Desert border area has to face

TABLE 2.--Habitat uses and life cycle stages of amphibians.

Stage	Terrestrial Habitat	Aquatic Habitat
Breeding Adults	calling, courtship, amplexus, egg-laying, fertilization.	calling, courtship, amplexus, spawning.
Eggs	laid terrestrially beneath logs, stones, debris, or in burrows; direct development; in foam nest suspended from vegetation over water.	floating in water; in foam nest floating in water; attached to aquatic vegetation; laid on bottom of pool.
Tadpoles/Larvae	parental care.	metamorphosis, feeding.
Juveniles	feeding, maturing.	feeding, maturing.
Adults	feeding, hibernating, burrowing, migrating.	feeding.

(Carmona, 1990; Utton, 1990). The diversion of water by dams, underground wells, and irrigation canals causes rivers, streams, springs, and aquifers to dry up or have high salt concentrations because of reduced amounts of water for dilution (Scudday, 1977). Underground drilling for wells establishes new, but limited, water supplies that support increased livestock densities and may encourage overgrazing and desertification of the Chihuahuan Desert grasslands (Morafka, 1990).

Water shortages have already occurred throughout the border region. The water supply for Ciudad Juarez/El Paso is sufficient only for immediate needs and rapid pumping from underground wells is creating salinity problems. In various areas along the border, cities are pumping groundwater at a rate 20 times faster than aquifers can recharge (Kelly, 1991; Szekely, 1993).

Many endemic fish species have been lost or are severely threatened due to increasing salinity in the Rio Grande/Rio Bravo and the loss of spring flow in areas of Coahuila and Nuevo Leon (Contreras and Lozano-Vilano, 1991). Loss of spring flow has also caused the demise or confinement to relictual areas of many amphibians and reptiles in the northern Chihuahuan Desert (Scudday, 1977).

Pollution is also a major environmental stressor in the border area. Current environmental problems along the border include: 1) long-term primary and secondary effects of increasing air pollution; 2) contamination of surface water and groundwater, and growing problems of treatment and disposal of wastewater; 3) large amounts of hazardous wastes, chemicals and pesticides, some illegally

transported, used, and disposed of; 4) extinction of species of flora and fauna; and 5) the impact of human activity on fragile ecosystems (Ganster, 1990; Kelly, 1991).

All of the above mentioned practices have the potential to affect amphibians in all stages of their life cycle. Direct contact with toxic chemicals and salinization or loss of aquatic habitat would, of course, be a cause of mortality to most amphibians, but there are many indirect effects that need to be considered.

In their aquatic stage, temporary pond/opportunistic breeders, such as *Bufo* and *Ambystoma* species, and more permanent water breeders, such as *Rana* species are affected by environmental pollution. Agricultural pesticides are common pollutants of amphibian aquatic habitats. Distribution of pesticides to the breeding habitat of amphibians can occur through improper disposal, direct spills into aquatic habitats, run-off, spraying drift, etc.

When treated with pollutants (pesticides, insecticides) in laboratory tests, anuran embryos (pre-hatching stages) or tadpoles (larval stages) can show a variety of sublethal responses such as changes in growth, developmental rates, pigmentation, or a proliferation of morphological deformities. Tadpoles susceptible to developing a particular deformity may have increased incidence of abnormalities after exposure to a pollutant. Natural environmental stress, freezing for example, can also increase the incidence of common deformities such as curved bodies or kinked tails (Cooke, 1972; 1981).

DDT is among 40 pesticides and herbicides banned for use in the United States but still in use in Mexico (Applegate and Bath, 1990; Szekeley, 1993). In anurans, DDT will induce different deformities or mortality depending on the rate and stage of development. Tadpoles with a slow developmental rate and slow growth are more likely to have a high incidence of deformities (Cooke, 1972; 1981).

DDT was banned in the United States in 1972. However, it is in the drinking water supplies of numerous localities along the Rio Grande and residues from DDT move across the border in significant amounts (Taylor, 1990). The dust of DDT acts as particulate matter and can be transported as precipitation droplets through the atmosphere to different locations (Taylor, 1990). Concern is growing about DDT entering the Great Lakes from Mexico and Central America where it is still used widely. DDT's long-range transport is facilitated by the air circulation pattern that brings moisture from the Gulf of Mexico into the United States (Szekeley, 1993).

Even pesticides considered to be non-threatening to wildlife can harm amphibians. A study of the sublethal impact of pyrethroid pesticides was found to have gross sublethal effects on permanent and temporary pond-breeding amphibians. Pyrethroid pesticides are common household pesticides able to kill arthropods at dosages that do not harm birds and mammals. They are considered to be one of the safest pesticides (Berrill et al., 1993). The pyrethroid pesticide enters aquatic systems as a result of spray drift, spills, or direct application for mosquito control. The sublethal effects documented include slower growth of tadpoles following exposure. This may result in delayed metamorphosis and smaller size at metamorphosis. Delay in growth or metamorphosis may result in failure to outgrow potential predators rapidly enough, or failure to transform before disappearance of

an ephemeral habitat. The loss of avoidance or antipredator responses of anuran tadpoles and salamander larvae is another effect. This loss is caused by partial paralysis and includes the inability to dart away, leaving the tadpole and larva more susceptible to predation (Berrill et al., 1993).

Because they are considered to be less toxic to humans and wildlife, synthetic pyrethroid pesticides are of increasing interest globally for use in protecting crops, rangelands, livestock, and forests (Coats and Bradbury, 1989). However, as demonstrated by Berrill et al. (1993), even low-level contamination of aquatic habitats can be devastating to temporary-pond breeding species that may have evolved rapid metamorphosis to take advantage of the ephemeral ponds in the Chihuahuan Desert.

In their terrestrial stage as juveniles and adults, amphibian diets consist mainly of invertebrates. Studies of invertebrates from contaminated grasslands in the vicinity of a copper refinery showed that invertebrates had significant elevations of total body copper and cadmium concentrations relative to control values. Predation on invertebrates could therefore represent a potential pathway for the accumulation of cadmium by predatory small mammals and birds (Hunter et al., 1987). In addition, research on avian wildlife indicates that species of insectivorous migrant birds were higher in DDT residues per body weight than seed eaters (Taylor, 1990).

Though these studies do not specifically target amphibians, it is possible that predation by amphibians on invertebrates could cause amphibians to suffer cadmium and DDT poisoning in a similar fashion with the accompanying tissue damage, organ damage, and mortality. Predation on amphibians by birds, mammals, and reptiles could represent a pathway for heavy metal and pesticide poisoning of wildlife. It is also possible that many species that hibernate in underground burrows, like the spadefoot toad, could soak up toxins from prolonged exposure to contaminated soil through their skin. These possible avenues of poisoning should be considered by biologists studying amphibians in the Chihuahuan Desert region because of the mining, smelting, and agricultural practices that use or produce these toxins in the area.

DISCUSSION

The sensitivity of amphibians to environmental contaminants and their close ties to both aquatic and terrestrial habitats during their life cycle make amphibians valuable indicators of environmental quality. The global declines in many amphibian populations that scientists have recently reported were recognized primarily because formerly abundant populations of some amphibians have already gone locally extinct or almost extinct. Lack of knowledge of how amphibian populations respond to disturbance prevents natural resource managers from incorporating amphibians into habitat conservation plans. This is especially true in the Chihuahuan Desert where few scientists have studied amphibians.

Amphibian research, conservation, and management should be a high priority in the Chihuahuan Desert Region because of the declining numbers of amphibians worldwide, the lack of information on how to maintain their populations, and their

unique contributions as indicators of environmental pollution. We recommend the goals stated by the IUCN/SCC Declining Amphibian Populations Task Force (1992) as the initial steps for managing and conserving amphibians in the Chihuahuan Desert region: 1) Catalyze, catalogue, and coordinate efforts to gain an understanding of declining amphibians. 2) Identify target populations, species and regions/areas that merit immediate attention. 3) Gather and critically examine evidence concerning causal factors contributing to amphibian declines and identify remedial action. 4) Promote data collection on amphibian populations on a longterm basis. 5) Enlist the support of appropriate scientific disciplines needed to address issues.

As human populations continue to grow, we need to manage our natural resources in ways that are optimal to wildlife and humans. This is especially true in the border area of the Chihuahuan Desert region where wildlife and humans often have direct conflicts of interest regarding natural resources.

ACKNOWLEDGMENTS

We thank N. J. Scott, Jr. and C. R. Schwalbe for reviewing this manuscript and making valuable suggestions and comments. We also thank J. L. Vial for providing valuable literature citations.

LITERATURE CITED

- APPLEGATE, H.G. AND C.R. BATH. 1990. Hazardous and toxic substances along the U.S.-Mexican Border. Pp. 119-129 in *Environmental Hazards and Bioresource Management in the United States-Mexico Borderlands* (P. Ganster and H. Walter, eds.). UCLA Latin American Center Publications, University of California, Los Angeles, California.
- BEHLER, J.L. AND F.W. KING. 1992. *The Audubon Society Field Guide to North American Reptiles and Amphibians*. Alfred A. Knopf, Inc. New York, New York.
- BERRILL, M., S. BERTRAM, A. WILSON, S. LOUIS, D. BRIGHAM, AND C. STROMBERG. 1993. Lethal and sublethal impacts of pyrethroid insecticides on amphibian embryos and tadpoles. *Environmental Toxicology and Chemistry*, 12:525-539.
- BIG BEND NATURAL HISTORY ASSOCIATION. 1989. Amphibian and reptile checklist, Big Bend National Park, Rio Grande Wild and Scenic River. National Park Service.
- BROWN, L.E. 1992. *Rana blairi*. Pp. 536.1-536.6 in *Catalogue of American Amphibians and Reptiles*. Society for the Study of Amphibians and Reptiles.
- CARMONA, L.S. 1990. Border ecological planning. Pp. 215-229 in *Environmental Hazards and Bioresource Management in the United States-Mexico Borderlands* (P. Ganster and H. Walter, eds.). UCLA Latin American Center Publications, University of California, Los Angeles, California.
- COATS, J.R. AND S.P. BRADBURY. 1989. Aquatic toxicology of synthetic pyrethroid insecticides. *Environmental Toxicology and Chemistry*, 8:671-679.

- CONANT, R. AND J.T. COLLINS. 1991. Reptiles and amphibians of eastern/central North America. Peterson Field Guide Series. Houghton Mifflin Company, Boston, MA.
- CONTRERAS, S. AND LOZANO-VILANO. 1991. Peces en peligro de extincion, agua y perspectivas de desarrollo en zonas aridas de Mexico. Texas Center for Policy Studies, Austin.
- COOKE, A.S. 1972. The effects of DDT, dieldrin and 2,4-D on amphibian spawn and tadpoles. *Environmental Pollution*, 3:51-68.
- . 1981. Tadpoles as indicators of harmful levels of pollution in the field. *Environmental Pollution (Series A)*, 25: 123-133.
- CREUSERE, F.M. AND W.G. WHITFORD. 1976. Ecological relationships in a desert anuran community. *Herpetologica*, 32:7-18.
- ENVIRONMENTAL PROTECTION AGENCY. 1992. Summary, Environmental plan for the Mexican-U.S. Border Area, First Stage (1992-1994). United States Environmental Protection Agency.
- GANSTER, P. 1990. General Introduction. Pp. xiii-xviii in *Environmental Hazards and Bioresource Management in the United States-Mexico Borderlands* (P. Ganster and H. Walter, eds.). UCLA Latin American Center Publications, University of California, Los Angeles, California.
- GEHLBACH, F.R. 1967. *Ambystoma tigrinum*. Pp. 52.1-52.4 in *Catalogue of American Amphibians and Reptiles*. Society for the Study of Amphibians and Reptiles.
- HUNTER, B.A., M.S. JOHNSON AND D.J. THOMPSON. 1987. Ecotoxicology of copper and cadmium in a contaminated grassland ecosystem, II. Invertebrates. *Journal of Applied Ecology*, 24:587-599.
- IGLESIAS, N. 1990. Border industries and environmental damage. Pp. 157-168 in *Environmental Hazards and Bioresource Management in the United States-Mexico Borderlands* (P. Ganster and H. Walter, eds.). UCLA Latin American Center Publications, University of California, Los Angeles, California.
- IUCN/SCC DECLINING AMPHIBIAN POPULATIONS TASK FORCE. 1992. *Froglog*, June, No. 2.
- KELLY, M. 1991. Facing reality: the need for fundamental changes in protecting the environment along the U.S./Mexico Border. Texas Center for Policy Studies, Austin, Texas.
- MACMAHON, J.A. AND F.H. WAGNER. 1985. The Mojave, Sonoran, and Chihuahuan Deserts of North America. Pp. 105-202 in *Ecosystems of the World* (M. Evenari, I. Noy-Meir, and D.W. Goodall, eds.). Elsevier Science Publishers B.V., New York, New York.
- MORAFKA, D.J. 1977. A biogeographical analysis of the Chihuahuan Desert through its herpetofauna. Dr. W. Junk B.V., Publishers, The Hague.
- . 1990. The Mismeasure of North American Deserts: causes, conflicts, and consequences. Pp. 459-480 in *Environmental Hazards and Bioresource Management in the United States-Mexico Borderlands* (P. Ganster and H. Walter,

- eds.). UCLA Latin American Center Publications, University of California, Los Angeles, California.
- NELSON, C.E. 1972. *Gastrophryne olivacea*. Pp. 122.1-122.3 in Catalogue of American Amphibians and Reptiles. Society for the Study of Amphibians and Reptiles.
- PARENT, L. 1990. Tex-Mex Park: making Mexico's Sierra del Carmen a sister park to Big Bend. National Parks, 64, 7/8:30-36.
- PLATZ, J.E. AND J.S. MECHAM. 1984. *Rana chiricahuensis*. Pp. 347.1-347.2 in Catalogue of American Amphibians and Reptiles. Society for the Study of Amphibians and Reptiles.
- PORTER, K.R. 1970. *Bufo valliceps*. Pp. 94.1-94.4 in Catalogue of American Amphibians and Reptiles. Society for the Study of Amphibians and Reptiles.
- SCUDDAY, J.F. 1977. Some recent changes in the herpetofauna of the northern Chihuahuan Desert. Pp. 513-522 in Transactions of the Symposium on Biological Resources of the Chihuahuan Desert Region United States and Mexico (R.H. Wauer and D.H. Riskind., eds.). United States National Park Service.
- STEBBINS, R.C. 1985. Peterson Field Guides to Western Reptiles and Amphibians. Houghton Mifflin Company, Boston.
- SZEKELY, A. 1993. Emerging boundary environmental challenges and institutional issues: Mexico and the United States. Natural Resources Journal, 33:34-46.
- TANNER, W.W. 1989. Amphibians of western Chihuahua. Great Basin Naturalist, 49, 1:38-70.
- TAYLOR, R.G. 1990. Evidence for transfrontier movement of selected insecticides. Pp. 137-149 in Environmental Hazards and Bioresource Management in the United States-Mexico Borderlands (P. Ganster and H. Walter, eds.). UCLA Latin American Center Publications, University of California, Los Angeles, California.
- TEXAS CENTER FOR POLICY STUDIES. 1993. Biodiversity protection in the Texas-Mexico Border Region. Austin, Texas.
- UTTON, A.E. 1990. Transboundary water quality: institutional alternatives. Pp. 49-67 in Environmental Hazards and Bioresource Management in the United States-Mexico Borderlands (P. Ganster and H. Walter, eds.). UCLA Latin American Center Publications, University of California, Los Angeles, California.
- WAKE, D.B. 1991. Declining amphibian populations. Science 235(5022):860.
- WASSERMAN, A.O. 1970. *Scaphiopus couchii*. Pp. 85.1-85.4 in Catalogue of American Amphibians and Reptiles. Society for the Study of Amphibians and Reptiles.
- ZWEIFEL, R.G. 1967. *Eleutherodactylus augusti*. Pp. 41.1-41.4 in Catalogue of American Amphibians and Reptiles. Society for the Study of Amphibians and Reptiles.

APPENDIX

AMPHIBIANS OF THE CHIHUAHUAN DESERT REGION.

Species	Range	Habitat	Breeding	Reference
Order Caudata, Family				
Amphystomidae:				
<i>Ambystoma tigrinum</i> (Tiger Salamander)	Widespread from c. AB and Saskatchewan, south to FL and MX, but absent from New England, Appalachian Mts., Far West.	Arid sagebrush plains to pine barrens, mountain forests, and damp meadows where ground is easily dug.	Mates in temporary pools, fishless ponds, stream backwaters, and lakes. Egg masses adhere to submerged debris.	Behler and King, 1992; Morafka, 1977; Gehlbach, 1967.
Order Anura; Family Bufonidae:				
<i>Bufo cognatus</i> (Great Plains Toad)	Se. AB to w WI in the north, south through the Great Plains to nw. TX and into MX, west to s. NM, AZ, and se. CA, and north to parts of se. NV and c. UT.	Grasslands of the prairie and drier bushy areas.	Breeds in temporary pools. Egg strings are attached to debris on bottom of pools.	Cresere and Whitford, 1976; Tanner, 1989; Behler and King, 1992; Morafka, 1977.
<i>Bufo debilis</i> (Green Toad).	Sw. KS south through TX to the Gulf coast and into Mexico, north to se. areas of AZ, NM, and Co.	The shelter of rocks in semiarid regions. Also found in prairies.	Breeds in temporary pools. Egg strings attached to vegetation in pools.	Big Bend, 1989; Tanner, 1989; Creusere and Whitford, 1976; Behler and King, 1992; Morafka, 1977.
<i>Bufo punctatus</i> (Red-spotted Toad)	C. TX west into se. CA and south into MX.	Desert and rocky regions and prairie grasslands, usually near sources of permanent water or dampness, natural or man-made.	Breeds in temporary or permanent pools and streams. Lays eggs one at a time, not strings, on bottom of pools.	Big Bend, 1989; Tanner, 1989; Behler and King, 1992; Morafka, 1977.
<i>Bufo speciosus</i> (Texas Toad)	Extreme se. KS through OK, TX, and s. NM into MX.	Prairie grasslands and open woodlands, adapted for dry conditions.	Breeds in temporary pools or man-made waterholes and ditches.	Big Bend, 1989; Tanner, 1989; Behler and King, 1992; Morafka, 1977.

APPENDIX--Continued.

Species	Range	Habitat	Breeding	References
Order Anura; Family Bufonidae (Cont.):				
<i>Bufo valliceps</i> (Gulf Coast Toad)	Extreme s. MS, s. LA, e.c. and s. TX south to Costa Rica; disjunct pop. in Big Bend region of TX and on AR-LA border.	Humid locations, from roadside ditches and storm sewers, to the barrier beaches of the Gulf of Mexico.	Breeds in temporary pools or man-made waterholes and ditches.	Big Bend, 1989; Conant and Collins, 1991; Behler and King, 1992; Morafka, 1977; Porter, 1970.
<i>Bufo woodhousei</i> (Woodhouse's Toad)	Widespread throughout most of the U.S. and adjacent MX.	Sandy areas near marshes, irrigation ditches, backyards, and temporary rain pools.	Breeds in temporary or permanent pools and streams. Egg strings are attached to vegetation in shallow water.	Tanner, 1989; Big Bend, 1989; Behler and King, 1992; Morafka, 1977.
Order Anura; Family Hylidae:				
<i>Acris crepitans</i> (Northern Cricket Frog)	Southern NY to FL panhandle west to TX and se. NM, and adjacent MX, north to SD, WI, and MI.	Sunny ponds of shallow water with good growth of vegetation in the water or shore; slow moving streams with sunny banks.	Masses of eggs are laid in water.	Scudday, 1977; Behler and King, 1992; Conant and Collins, 1991; Morafka, 1977.
<i>Hyla arenicolor</i> (Canyon Treefrog)	S. UT to c. CO, south into MX. Isolated pop. in NM and the Big Bend region of TX.	Arid areas close rocky washes, streams, and permanent pools.	Masses of eggs are laid in water.	Tanner, 1989; Big Bend, 1989; Behler and King, 1992; Morafka, 1977.
<i>Hyla eximia</i> (Mountain Tree Frog)	The mountains of c. AZ, NM, and MX.	Slow water and shallow grassy pools in oak and conifer forests over 5,000 ft. Rarely seen high in tree tops.	Egg masses are attached to vegetation just below the water.	Tanner, 1989; Behler and King, 1992; Morafka, 1977.
Order Anura, Family Leptodactylidae:				
<i>Eleutherodactylus angusta</i> (Barking Frog)	C. TX to se. NM and n. Coahuila, MX north to extreme s. AZ.	Damp limestone caves and crevices.	Eggs are laid in limestone crevices, under rocks, and in moist soil. Tadpole stage occurs within.	Tanner, 1989; Morafka, 1977; Behler and King, 1992; Conant and Collins, 1991; Zweifel, 1967.

APPENDIX--Continued.

Species	Range	Habitat	Breeding	References
Order Anura, Family Leptodactylidae (Cont.):				
<i>Eleutherodactylus guttilatus</i> (Spotted Chirping Frog)	Big Bend area of w. TX and south into MX.	Near springs and moist areas of caves and ravines.	Fewer than 15 eggs are laid on land.	Big Bend, 1989; Behler and King, 1992; Conant and Collins, 1991.
<i>Eleutherodactylus marnocki</i> (Cliff Chirping Frog)	C. to w. TX: San Antonio to Big Bend.	Crevices and caves of limestone hills.	Female may lay eggs three times a year on land.	Morafka, 1977; Behler and King, 1992; Conant and Collins, 1991.
Order Anura, Family Microhylidae:				
<i>Gastrophryne olivacea</i> (Great Plains Narrow-Mouthed Toad)	Se. NE and MO south to Tamaulipas and San Luis Potosi; west through most of TX and n. MX to w.c. Chihuahua and nc. Durango; s.c. AZ south to Nayarit; isolated records in w. TX and sw. NM.	Montane woodlands, grasslands, and desert from sea level to 4,000 ft. Moist or damp areas from marshes to leaf litter and rodent burrows.	Breeds in temporary ponds. Eggs are laid in water as a surface film.	Big Bend, 1989; Tanner, 1989; Behler and King, 1992; Morafka, 1977; Conant and Collins, 1991; Nelson, 1972.
Order Anura, Family Pelobatidae:				
<i>Scaphiopus bombifrons</i> (Plains Spadefoot)	The Great Plains from s AB and SK se. through MT to MO and c. OK, south through w. TX and c. AZ and into MX. Separate pop. in extreme s. TX.	Shortgrass prairie where soil is loose and dry, rainfall low. Likes sandy and gravelly soils.	Eggs in masses of 10-200 are attached to submerged vegetation in shallow temporary ponds.	Creusere and Whitford, 1976; Behler and King, 1992; Tanner, 1989; Morafka, 1977; Conant and Collins, 1991.
<i>Scaphiopus couchi</i> (Couch's Spadefoot)	Extreme se. CA, s. AZ and NM, and sw. OK south into MX.	Shortgrass prairie, mesquite savannah and creosote bush desert.	Eggs are laid on plant stems in temporary pools.	Tanner, 1989; Creusere and Whitford, 1976; Big Bend, 1989; Behler and King, 1992; Morafka, 1977; Conant and Collins, 1991; Wasserman, 1970

APPENDIX--Continued.

Species	Range	Habitat	Breeding	References
Order Anura, Family Pelobatæ (Cont.):				
<i>Scaphiopus multiplicatus</i> (Southern Spadefoot)	Se. AZ, NM, parts of s. CO, and w. OK south into MX.	Shortgrass plains and sandy gravelly areas such as alkali flats, washes, and river floodplains.	Breeds in temporary ponds. Eggs are laid in cylindrical masses attached to vegetation in water.	Creusere and Whitford, 1976; Big Bend, 1989; Behler and King, 1992; Morafka, 1977.
Order Anura, Family Ranidae:				
<i>Rana berlandieri</i> (Rio Grande Frog)	Sw. AZ and s. NM to c. TX, south into MX.	Any water or moist conditions, natural or artificial.	Egg masses are attached to submerged vegetation.	Behler and King, 1992.
<i>Rana blairi</i> (Plains Leopard Frog)	Se. SD and w. IA to e. NM and c. TX; e. CO to c. IN and c. OK; extends west in NM.	In prairie and desert grassland, oak-pine woodland and farmland. It frequents prairie pools, ponds, and streams, including temporary water sources where the water is muddy.	Eggs in clusters containing 200-600 eggs; deposited in temporary or permanent pools, usually attached to plants in shallow water.	Stebbins, 1985; Brown, 1992.
<i>Rana catesbeiana</i> (Bullfrog)	Eastern and central U.S.; also New Brunswick and parts of Nova Scotia. Extensively introduced in the west.	Ponds, lakes, and slow-moving streams large enough to avoid crowding and with sufficient vegetation to provide easy cover.	Egg masses are attached to submerged vegetation.	Tanner, 1989; Behler and King, 1992; Morafka, 1977; Conant and Collins, 1991.
<i>Rana chiricahuensis</i> (Chiricahua Leopard Frog)	Mountain regions of c. and sw. AZ, sw. NM, and the Sierra Madre Occidental, to s. Durango in MX.	Oak and mixed oak and pine woodlands and pine forests in rocky streams with deep rock-bound pools; also ranges into chaparral, grassland, and desert in river pools, permanent springs and ponds, and stock tanks.	Breeding; eggs may resemble those of the Northern Leopard Frog.	Stebbins, 1985; Platz and Mecham, 1984.

APPENDIX--Continued.

Species	Range	Habitat	Breeding	References
Order Anura, Family Ranidae (Cont.):				
<i>Rana pipiens</i> (Northern Leopard Frog)	Throughout northern North America, except West Coast. Along the upper Rio Grande in NM and south to El Paso.	From fresh water sites with profuse vegetation to brackish marshes and moist fields; from desert to mountain meadows.	Egg masses are in firm globular clusters of up to 6,500 eggs; attached to submerged vegetation in quite waters of ponds, lake margins, reservoirs, canals, and streams.	Behler and King, 1992; Morafka, 1977; Conant and Collins, 1991; Stebbins, 1985.
<i>Rana</i> <i>yavapaiensis</i> (Lowland Leopard Frog)	Colorado River drainage from the Virgin River in extreme nw. AZ and the Hoover Dam area to Yuma and Somerton; w. and c. AZ below 4,800 ft. south of Mogollon Rim; sw. NM; n. Sonora and nw. Chihuahua.	Desert, grassland, oak and oak-pine woodland, entering the permanent pools of foothill streams, and stock tanks	Breeding; eggs may resemble those of the Northern Leopard Frog.	Stebbins, 1985.