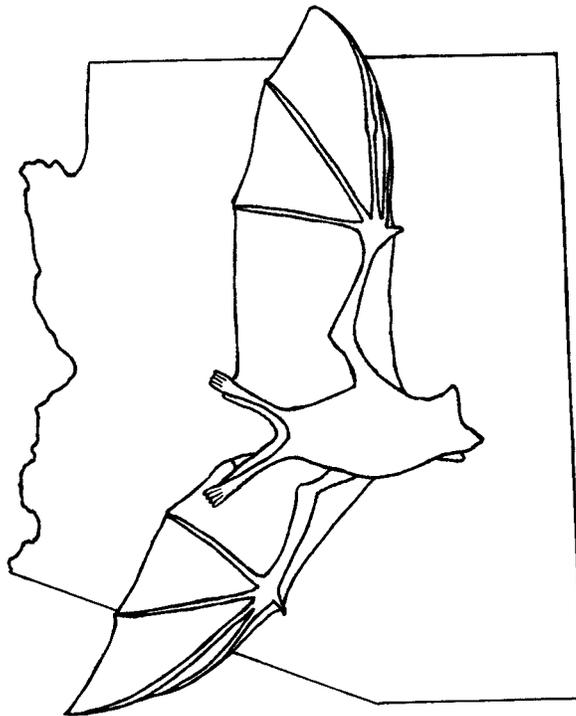


# ARIZONA BAT CONSERVATION STRATEGIC PLAN

Arizona Bat Resource Group

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## EXECUTIVE SUMMARY

### JUSTIFICATION

Declines in many bat populations at both the continental and local level have led to concern for the future of migratory and resident bats in Arizona. The reasons for declines are complex. Habitat loss, modification and fragmentation; loss of wintering and migratory habitat; roost disturbances; pesticide use; and vampire bat control have been implicated. In 1999, Bat Conservation International brought together federal, state, and local government agencies; foundations; conservation groups; and the academic community to organize a North American Strategic Plan for Bat Conservation to address these and other potential problems. Thus, the North American Bat Conservation Partnership (NABCP) was conceived as a voluntary, international coalition dedicated to “ensuring that bat conservation needs are adequately addressed” and that “the downward trends of declining species are reversed.” The Arizona Bat Resource Group, as part of the Coalition of North American Bat Working Groups, developed this plan in conjunction with the NABCP effort.

### ORGANIZATION

An introduction to bats and a description of past conservation and research actions in Arizona is followed by species accounts of the 28 bat species found in Arizona, as well as information about the major resources affecting these species. Management direction is described under 4 broad categories: 1) Research; 2) Inventory and Monitoring; 3) Management; and 4) Education. A parallel format is followed for each category, with an introductory problem statement followed by goal statements, a discussion of issues associated with each goal, and a list of priority actions to be addressed under each goal. Within each priority action, we have identified a list of conservation actions specific to Arizona that may be used as examples of projects needed to accomplish these goals. There are then habitat sections that outline the species, resources, and management goals and objectives relevant to 7 major habitat types within Arizona. Appendices outline guidelines for managers and researchers to use when carrying out recommended actions.

### SCOPE

This plan is intended to delineate specific areas of concern for management, research, inventory and monitoring, and education that should be addressed in Arizona by land managers, wildlife managers, and scientists. It is outside the scope of this plan to make detailed recommendations aimed at precluding possible listing of particular bat species, although attention to the goals and objectives outlined herein is important for any conservation action. All management direction is intended to apply to some extent for the entire state of Arizona. In addition, this plan is intended to be a dynamic document that will be revised as new information surfaces. Significant regional issues that are multi-state or multi-national in scope may be added following appropriate review and discussion among members of the NABCP Executive Committee and the Arizona Bat Resource Group.

## RELATIONSHIP OF THIS PLAN TO OTHER PLANS

This plan is intended to provide the framework and direction for other local, state, tribal, and federal bat conservation and management plans within Arizona. This plan is tiered directly to the NABCP Strategic Plan in an effort to facilitate communication and reporting of annual activities and accomplishments.

## LEVELS OF PLANNING

It is intended that there be only 2 levels of planning: 1) the NABCP Strategic Plan; and 2) all other local, state, tribal, provincial, and federal plans that will articulate site-specific projects and actions to address goals and priorities in the North American Plan. Regional working groups will play an essential role by facilitating communication and coordination of plans between the NABCP Plan and federal, tribal, state, and private agencies and other collaborators in their regions.

## PRIORITY RANKING

It is not intended that priorities be ranked between the goals or actions outlined in this strategic plan. For example, priorities will not be set that elevate management goals over research, education, or inventory and monitoring goals. These are considered to be equally important in providing guidance for bat conservation activities at state and local levels. Because many of the goals and priority actions identified apply to all 28 Arizona bat species, specific actions listed within this plan should be construed as examples of conservation measures needed and not necessarily an entire list of needed actions. It is at local levels that resource managers must: 1) assess which goals and actions apply within their areas of authority; and 2) set priorities for project specific actions that are most urgent.

## EVALUATION OF PROGRESS

Because of the lack of information and the difficulty in assessing population trends for bats, it is very difficult to set quantifiable targets with which to measure our progress. The time frame for reaching our objectives will vary depending on several factors including: the condition of the habitat necessary to sustain and enhance bat populations, the level of knowledge about species requirements, and the capability of the land owner or land manager to manage for bats. Conservation recommendations listed will provide direction for land managers to reach the conservation goals listed. All research and inventory and monitoring goals listed in the plan address information gaps that will have direct application to land managers, thus a constant feedback of new information will keep the plan current. The next step will be to develop an implementation schedule, including identification of possible partnerships for specific projects, providing timelines for when projects should be completed, and indicating budget estimates for each project. Planning, implementation, and evaluation will remain the most integral parts of our conservation process. In order to keep goals and objectives current, this plan should be reviewed and updated every 5 years.

## SOURCES OF INFORMATION USED

Along with cited references and publications, 3 sources of information were used to write this management direction: 1) The first draft of the NABCP Strategic Plan, written by Bat Conservation International and reviewed by the Executive Committee and Working Group leaders; 2) Species matrix and notes compiled during the Western Bat Working Group Meetings, in Reno, Nevada, February, 1998; and 3) Notes compiled during conference calls of the Arizona Bat Resource Group Steering Committee, September 1999.

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# ARIZONA BAT CONSERVATION STRATEGIC PLAN

Katharine E. Hinman and Tim K. Snow, editors

## INTRODUCTION

### BASIC NATURAL HISTORY

Worldwide, there are over 1000 species of bats. Of these, 148 are found in North America, 45 in the United States, and 28 in Arizona (accepted species counts will likely change within the next 2 years with the publication of the revised edition of Wilson and Reeder's *Mammal Species of the World* (in prep.); numbers in this plan are based on Nowak (1994)). However, despite their great diversity, bats have historically been poorly studied, misunderstood, and even persecuted. Unlike other mammals their size, bats are long-lived and slow at reproducing. Many species commonly form large colonies. All of these factors make bats vulnerable to disturbance and other threats. As well, even the most basic natural history information has not been investigated for many species worldwide, especially those that are tropical in distribution and those that are non-colonial. In the United States, more than half of bat species are endangered or in severe decline.

All bats belong to the order Chiroptera, which is divided into 2 sub-orders. The Megachiroptera, commonly called flying foxes, all belong to the family Pteropodidae, which has 42 genera and 173 species. They are found in the Old World tropics and subtropics and are generally fruit or nectar-feeders. The Microchiroptera are divided into 17 families and show a great diversity of feeding and roosting habits. Aside from insectivores, this sub-order also includes nectarivores, frugivores, carnivores, piscivores, and sanguinivores. The Microchiroptera occur worldwide except in the extreme polar regions and some isolated islands.

Although the Megachiroptera are in general larger than the Microchiroptera, there is considerable overlap in size, with the Megachiroptera ranging from 10 grams to more than 1.5 kilograms in weight with forearm lengths from 36 to 228 mm, and the Microchiroptera ranging from 2 grams to 196 grams with forearm lengths from 22 to 115 mm (Kunz and Pierson 1994).

Because of morphological and neurological differences between the 2 suborders of bats, some researchers suggest that the Megachiroptera and Microchiroptera evolved independently and that the shared ability to fly is simply convergent evolution (Pettigrew 1986, 1991a, 1991b, 1995). However, other morphological and molecular data seem to point to a single origin for flight in mammals (Baker and others 1991; Simmons and others 1991). The fossil record in bats, while dating back 50 million years before present, does little to illuminate this argument, since fossil bats are very similar to present-day bats. Most researchers believe that bats evolved from some type of arboreal insectivore (Norberg 1990).

Bats are the only mammals with true powered flight. Their wings are made up of thin elastic membrane stretched between elongated finger bones. This ability to fly has allowed them to become distributed worldwide and has probably contributed to their diversity in feeding, roosting habits, and other behaviors. A diversity of wing shapes in bats reflects this diversity of

behaviors: bats with long, narrow wings generally feed in open habits and fly fairly fast, whereas bats with short, broad wings are found in more cluttered environments where slower, more maneuverable flight is an advantage.

The hind limbs of bats are rotated 180° and allow the bats to roost head-down, which presumably makes them less vulnerable to predators as well as allowing them to occupy unique roost locations and take off easily.

Many bats have unique facial features, especially around the nose, mouth and ears. In the Microchiroptera many of these features and ornamentations are associated with echolocation abilities and prey detection, while in the Megachiroptera ornamentation is often associated with mate attraction.

### Echolocation

More than half of bat species, including all Microchiroptera and 1 genus of Megachiroptera (*Rousettus*), have the ability to echolocate, producing actively generated calls (often in the ultrasonic range) and listening for the echoes of those calls bouncing off obstacles and prey. The *Rousettus* produce these sounds by clicking the tongue, and appear to use echolocation only for navigation. However, the Microchiroptera produce these sounds in the larynx, emitting them either through the mouth or the nostrils. Fleshy facial ornamentation can then help focus these sounds, while specialized ear morphologies assist in reception of the echoes. Echolocation calls vary widely between Microchiroptera species, both in frequency and structure, and in many instances can be analyzed with bat detectors and used to identify flying bats to species. Calls may also vary intraspecifically depending on geographic area, foraging habitat, and other factors.

Not all Microchiroptera rely on echolocation for foraging, however. Many of the fruit and nectar feeding bats rely most heavily on olfaction and, in some cases, eyesight for finding food (this is also true of the Megachiroptera), while some insectivorous and carnivorous bats rely on hearing prey-generated sounds to detect their prey. Although no bats are blind, their nocturnal habits make vision of secondary importance for most of the Microchiroptera. However, it may still be useful for navigation and orientation, surveying for predators, and regulation of circadian rhythms (Kunz and Pierson 1994).

### Food Habits

Bats show a great diversity of food habits. Even among insectivorous bats, the variety of preferred food types is enormous. In general, nocturnal flying insects are the most commonly taken group of arthropods, including moths, beetles, flies, midges, mosquitoes, termites, ants, etc. These insects may be caught on the wing or may be picked off by roosting bats. Non-flying insects may also make up a large part of the diet of certain species of bats. These insects are gleaned off of foliage or the ground by bats relying mostly on hearing to detect their movements. Although there is some evidence of specialization in diet, many species are opportunistic foragers to some extent. There may be regional or seasonal specialization on one type or group of insects, but in a different geographic area or season, the apparent preference could be for something completely different.

In tropical regions, there are large numbers of “vegetarian” bat species that rely on fruit, nectar, and pollen for their diets. For this type of diet to be practical, appropriate food must be available year-round. Bats have been shown to be important pollinators and seed-dispersers of over 300 species of plants (Fleming 1993). Many of these plants show specializations for bat pollination, including large light-colored flowers, strong odor, and nocturnal nectar and pollen production. Some flowers may also have specialized “nectar guides” that reflect echolocation calls in a specific way to direct the bats to the flowers (von Helversen and von Helversen 1999). In the United States, there are only 4 species of nectar and fruit eating bats, and these are all migratory.

There are also carnivorous bats that eat small vertebrates, frogs, and even fish. These bats may rely on echolocation and/or prey-generated sounds to find their food. Only 3 species of bat in the United States, the hoary bat, the pallid bat (Johnston and Fenton 2001) and the California leaf-nosed bat (P. Brown, personal communication), have been documented exhibiting carnivorous behavior and this does not seem to be typical for these species.

The most famous of bat feeding habits is sanguivory, or blood feeding. There are only 3 species of vampire bat in the world and none occur in the United States (although 1 species has been documented in northern Mexico). These bats have become somewhat specialized on livestock blood, as farming has increased the supply of cattle and chickens within their habitat.

#### Reproduction / Life History

Mating systems in bats range from monogamy to polygyny, but for the most part mating and social organizations have only been studied in a few species. Even basic reproductive patterns are still unknown for many species. Some species give birth only once a year to a single young, while others may have multiple litters a year and/or multiple pups at a time. Even gestation can vary both between and within species. Delayed fertilization, delayed ovulation, delayed implantation of the blastocyst, and even arrested fetal development may be employed to synchronize birth with food availability. In general, in temperate areas females give birth once per year and most US bats have only 1 young a year (although some lasiurines may have multiple young). In tropical areas births may be asynchronous and may even be aseasonal. For bats in Arizona, mating usually occurs in the late summer or autumn, and the birthing season is usually in late May to July, with young becoming volant within 3 to 6 weeks. In general, parental care is solely the responsibility of the mother, with females often forming large maternity colonies while males form smaller geographically separate bachelor colonies.

Unlike other small mammals, reproduction in bats is a fairly slow process. Pregnancy lasts 3 to 9 months; in most species, only 1 or 2 large young are produced per year; and lifespans extend up to 34 years (Davis and Hitchcock 1995). This reproductive schedule is yet another factor that may make bats more vulnerable to extirpation than other small mammals. As well, it also means that factors affecting reproduction and life history may not be recognized for many years.

Mortality is probably highest in the first year, especially during the winter (Nagorsen and Brigham 1993; Sidner 1997). Juvenile bats must learn to fly and forage on their own and then build up enough fat reserves for hibernation or migration.

### Distribution and Seasonality

Due to their ability to fly, many bat species have much larger distributions than comparably sized nonvolant mammals. Unfortunately, this often means that bat species are overlooked in conservation planning efforts that rely partly on species distribution to prioritize actions (Pierson 1998). Overall species range may be deceptive as well, because many species are patchily distributed within their range due to specialized habitat requirements or may experience local population declines. In addition, the seasonal distributions of many species differ greatly throughout the year. Knowledge of seasonal habitat shifts is sorely lacking for most North American species (Pierson 1998), yet conservation strategies should include both summer and winter habitat.

Several species migrate during the winter to colder or warmer areas. These migrations may include distances of nearly a thousand miles or elevational changes of thousands of feet as species move to more suitable habitat for hibernation or over-wintering. Many species of bats are heterothermic, able to change their body temperature to lower their metabolism. This behavior can manifest itself on a daily basis, with some species entering torpor during the day to conserve energy, as well as on a seasonal basis during hibernation. Hibernation periods may last for 8 to 9 months at high latitudes or may be more sporadic in warmer areas. Before entering hibernation an individual must build up fat reserves sufficient to supply its energetic needs throughout the winter. Hibernacula generally maintain a stable temperature. Depending on the species of bat, preferred hibernacula temperatures may range from a few degrees above freezing to around 50°F (10°C). During hibernation, the bat's body temperature may drop to the ambient temperature of the hibernaculum, thus conserving energy that would otherwise have to be used to maintain a high body temperature. One Arizona species, the California leaf-nosed bat, selects warm caves and mines in the winter since they cannot lower their body temperature and enter torpor.

### Ecological and Economic Importance

Bats are essential to the health of many ecosystems and also contribute many economic benefits. As the primary consumer of night-flying insects, they are vital for the control of many agricultural and forest pests. In Texas, Kunz and others (1995) estimate that the 20 million Mexican free-tailed bats in Bracken Cave consume roughly 20 tons of insects nightly; a large portion of these insects rank among North America's most costly agricultural pests (McCracken 1996; Whitaker and others 1996). Big brown bats in Indiana consume crop pests such as cucumber beetles (Whitaker 1995). Even playing recordings of bat echolocation calls can deter major crop pests such as cotton bollworm, tobacco budworm, cabbage looper, granulate cutworm, army worm moths, and corn borer moths (Agee 1964; Belton and Kempster 1962). Bats are known to consume species of moths considered as major forest pests, including spruce budworm moths and oak moths (Pierson 1998). Many North American bat species also prey on mosquitoes (Anthony and Kunz 1977; Barclay 1985; Fascione and others 1991; Griffin and others 1960; Long and others 1998; Whitaker and others 1977).

Guano produced by insectivorous bats is rich in nitrogen and has long been used as a fertilizer. It may also be an important part of nutrient cycling in the natural ecosystem (Pierson 1998). In some caves, entire ecosystems exist that are dependent on bat guano.

Aside from the importance of insectivorous bats, several species of bats are also vital for the reproduction of plants. Bats are critical pollinators of tropical forest and desert plants. In Arizona, they are common visitors and pollinators of the saguaro and organ pipe cactus. As well, many species of century plants (agaves), the base for the tequila industry in Mexico, depend on bats for pollination (Howell and Roth 1981; Arizaga and Ezcurra 1995). Especially in tropical areas, bats are also crucial seed dispersers. Medellin and Gaona (1999) showed that bats disperse more seeds than birds in deforested areas, up to 10 seeds per square meter per night.

Because bats travel longer distances from their roosts to their foraging areas than other comparably sized animals (both volant and nonvolant) (see table in Pierson 1998), their ecologic and economic impacts may affect a large area, and may affect areas physically separated from their roosting environment. Greater knowledge of the impacts of bats and of their movement is needed to determine overall ecological and economic importance.

### Public Health

Misinformation spread about bats often cites propaganda about rabies and other diseases that these “vermin” may be carrying. In reality, bats are no more or less likely to have diseases than other animals. The 2 diseases most commonly associated with bats are rabies and histoplasmosis. Histoplasmosis is a fungal infection that results from inhaling the spores of a particular soil-dwelling fungus. This fungus grows especially well in the feces of birds and bats (Nagorsen and Brigham 1993). In areas where large numbers of bats roost, the fungus may be present and may be stirred up by disturbance of guano piles. While 60% of people have been exposed to histoplasmosis, very few develop difficulties from this exposure. Histoplasmosis may cause mild respiratory disorders, but is rarely fatal (Hutson 2001). Exposure can be limited by avoiding areas with large concentrations of bird or bat droppings and wearing a respirator with a 2-micron filter when entering such areas.

Rabies is a highly feared disease caused by a virus that infects the nervous system of an animal and is invariably fatal. All mammals can develop rabies, but bats have often been cited as major carriers because of misinformation spread in the 1960's that they were asymptomatic carriers of the disease and would not die from it. More recent work has not supported this (Brass 1994). Although 5-15% of bats submitted for rabies testing in North America are infected with the virus, this reflects the fact that animals submitted for testing are generally behaving abnormally or are already dead (the Arizona Department of Health Services [ADHS] reported 185 bats tested in 2001 of which 26 or 14% were positive for the virus, R. Cheshier, personal communication). Current estimates of rabies infection in wild populations of bats are from 0.1-0.5% (Nagorsen and Brigham 1993). Unlike many other mammals, bats generally develop the paralytic form of rabies rather than the furious form, which is likely why outbreaks of rabies have not been described in bats as they have been in other mammals such as skunks and foxes. Between 1929 and 1990, there were 499 cases of human rabies worldwide attributed to bats, of which 471 were attributed to vampire bats. In the United States, there are an average of 2.1 human deaths from rabies per year, with 1.3 of these attributable to a bat strain of the virus (Centers for Disease Control and Prevention 2002). In comparison, there are an estimated 30,000 human deaths per year of rabies from other sources worldwide, mostly domestic dogs (Hutson and others 2001).

Rabies is spread through a bite or exposure of an open wound to saliva or mucous membranes of an infected animal. A recent concern among public health workers is the lack of documented bite histories for humans who have died from bat strain rabies. This has led to speculation that these people were exposed through “cryptic” bites they did not know that they had received, increasing concern that people may not know they have been exposed to an infected animal. Such speculation has in some cases generated fear leading to recommendations of post-exposure treatment even when exposure has not occurred (for instance, when a bat is seen flying overhead outdoors). The conclusion that cryptic bites account for most cases of human rabies has been called into question by bat researchers and others who suspect that the lack of bite history is more likely a result of failure to diagnose rabies until after death, causing epidemiologists to have to rely on second-hand accounts of possible exposure (Mlot 2000; Tuttle 2000). Such discrepancies highlight the need for greater education of the public on the proper attitude toward all wildlife and the recognition of incidents that may constitute an exposure to rabies or other diseases.

## CONSERVATION OF BATS

By far the largest challenge to bat conservation is our lack of knowledge about most species. For many species, even the most basic natural history data is lacking. Consequently, developing management and conservation plans is very difficult. Even in Arizona, where a fair amount of work has been done on bats, we still do not have accurate current population estimates for many species, much less information on population trends. Research and surveys that focus on gaining this basic information are sorely needed and will help direct future management activities. However, the information we do have indicates that conservation actions should be of primary importance.

Despite their economic and ecological importance, bat populations are declining worldwide. Even species that are thought of as common have shown precipitous declines in population size. Arizona was once home to the largest known population of Mexican free-tailed bats, with a colony estimated at 25 million living in Eagle Creek Cave in 1963. Six years later, the population had dropped to only 30,000 (Cockrum 1970). It is unknown whether the population was extirpated or moved to another roost (although no other large roosts have been found in the area). More recent population estimates have indicated an increase in the population at the cave (Sidner 1986). However, in the winter of 2001, a fire that smoldered for several weeks in the guano deposits of the cave caused smoke damage to the cave and a June 2002 emergence count resulted in an estimate of less than 10,000 bats at this roost (D. Dalton, personal communication).

Other once-common bats have also shown large declines. Destruction of and eviction from roosts led to the loss of more than half of 23 known nursery colonies of little brown bats (*Myotis lucifugus*) in Indiana (Humphrey and Cope 1976). Both the gray bat (*Myotis grisescens*), which was once so abundant that flocks of hundreds of thousands were seen on summer evenings (Tuttle 1986), and the Indiana bat (*Myotis sodalis*) are now listed as federally endangered, following population declines of 76%-89% at gray bat maternity caves (Tuttle 1979; Rabinowitz and Tuttle 1980), and 73% at Indiana bat hibernacula (Humphrey 1978).

Roost disturbance from recreational caving and mine exploration, closure of abandoned mines for hazard abatement, renewed mining, deliberate vandalism, and exclusion of bats from roosting areas can be particularly devastating to colonial cave-dwelling bats. Management of roost sites should take into account the needs of the bats and the effects of disturbance on them. Hibernacula may be especially susceptible to disturbance. Colonies roosting in buildings may be subject to extermination attempts. Abandoned mines used by bats may be closed, collapse, or be reclaimed for use in further mining activities.

Forest harvesting regimes may have large impacts on forest-dwelling bats, especially since many of these species roost in large trees in older stands (Crampton and Barclay 1998; Kalcounis and Brigham 1997; Vonhof and Barclay 1996), which may be particularly targeted for harvest. Bats should be considered in forest management plans, due to their important role as predators of forest insects, but for the most part, the effects of forestry activities on bat populations remain uninvestigated (Humes and others 1999).

Loss of foraging areas may also have a large impact on bat populations. Even with adequate roost sites, bats may decline if there is not sufficient habitat in which to forage. For instance, in mining areas, roosts may be abundant for species such as the California leaf-nosed bat, but the desert-wash habitats where the bats forage for insects may have been destroyed (Brown and others 1993). Some bat species (cave myotis and Arizona myotis) have declined or disappeared from areas along the Lower Colorado River where habitat conversion and flooding due to dam construction have occurred over the past 60 years (P. Brown, personal communication). Loss of adequate water resources may also have negative impacts on bats. Nectar and fruit eating bats may suffer from the destruction of foraging plants by grazing, agricultural harvest, or development. Use of pesticides may not only deplete the prey base for insectivorous bats, but can cause poisoning to bats that consume sprayed insects.

In addition to these threats, bats suffer from poor public image. Fear of bats is still widespread. In Mexico, the spread of some livestock diseases by vampire bats have contributed to a rise in vampire bat control campaigns that are misdirected and have negatively affected beneficial bats, including insectivorous, nectarivorous, and frugivorous species (Clark and others 1994; Arita and Santos del Prado 1999). Since many of these bats are migratory, these activities affect not only the direct areas in which they occur, but also ecosystems hundreds of miles away.

Again, the lack of basic knowledge of previous distribution, population sizes and trends for most bat species is of primary concern. Therefore, determining threats to and conservation status of bat species is a continuous process. While records may exist for colonial cave-dwelling species, historic occurrence of most other species is often based on anecdotal evidence (Pierson 1998).

#### History of conservation actions: national

In response to research detailing the declines of cave-dwelling bats, a special symposium at the American Association for the Advancement of Science meeting in 1971 drafted several recommendations to encourage bat research and conservation and to coordinate efforts with and solicit support from government agencies, the media, public health officials, pest control officials, and the public (Mohr 1972). While bat biologists embraced the guidelines readily, a rabies scare coupled with sensationalized media reports severely damaged the public image of bats. People became frightened of bats, an attitude that was fed by exaggerated media reports and scare campaigns. In turn, the poor public attitude towards bats led many wildlife agencies and conservation organizations to ignore the AAAS recommendations.

Frustration with the situation grew within the scientific community and led to the founding of Bat Conservation International (BCI) by Merlin Tuttle in 1982. Education and outreach programs have begun to dispel the myths about bats and improve their image. As well, conservation, wildlife, and research organizations have begun to support increased work with bats and to include them in conservation and management recommendations. BCI has also collaborated with the National Pest Control Association and the Centers for Disease Control and Prevention to establish guidelines and educational programs dealing with nuisance bats and public health.

Although these efforts have been fruitful, bat conservation efforts are still hampered by the dearth of information about many bat species and their basic natural history. As well, there is still

widespread misinformation about bats. Continuing research, education and conservation activities must be initiated. These efforts must also include collaboration between agencies, regions, and countries. In 1995, the Partnership for the Conservation of Migratory Bats (PCMM) was established to coordinate conservation, education, and research activities affecting species of bats that migrate between Mexico and the United States. In April 1999, members of state and regional working groups, bat researchers, non-governmental organizations, and state and federal agencies from Mexico, Canada, and the United States joined to form the North American Bat Conservation Partnership (NABCP), to help unify efforts in bat conservation on a continent-wide scale.

#### History of conservation actions: Arizona

Arizona was the first state to have a full time position within its state wildlife agency specifically to work with bats. The Bat Management Project was created in 1990, when the Arizona Game and Fish Department (AGFD) began receiving Heritage Fund money from the Arizona Lottery. Originally the project employed 3 full time biologists. Their job was to survey bat habitat, identify important bat roosts (focusing especially on caves and mines), and recommend conservation and management actions for areas that were important to bats. The Bat Management Project also worked to increase grants to bat researchers statewide and to coordinate efforts with external scientists to maximize data collection. As well, they developed educational materials and programs, including a special edition of the AGFD's magazine, *Arizona Wildlife Views*, on the Bats of Arizona and a Bats of Arizona poster.

The Western Bat Working Group (WBWG) was formed as a coalition of state bat working groups from 13 western states and the Canadian provinces of British Columbia and Alberta. The WBWG steering committee includes a core group of individuals and representatives from each of the state working groups. The goals of the WBWG are to (1) facilitate communication among interested parties and reduce risk of species decline or extinction, (2) provide a mechanism by which current information regarding bat ecology, distribution, and research techniques can be readily accessed, and (3) develop a forum in which conservation strategies can be discussed, technical assistance provided, and education programs encouraged. Among its accomplishments, the WBWG was key in the development of a Memorandum of Understanding between the members of the Western Association of Fish and Wildlife Agencies to implement the "Conservation Assessment and Conservation Strategy for the Townsend's Big-eared Bat" (Pierson and others 1999) developed by the Idaho Conservation Effort.

In 1994, the Arizona Bat Resource Group (ABRG) was formed as part of the WBWG. The ABRG is comprised of agencies, organizations, and individuals interested in bat research, management, and conservation in Arizona. Through the ABRG, efforts have been made to develop statewide strategies for bat management and conservation. This plan has been developed by the ABRG for the purpose of outlining specific goals and objectives for bat work throughout the state and to delineate some of the resources needed by bats and the threats faced by bats.

Other agencies have also been proactive with regards to bat management and conservation in Arizona. For instance, Coconino National Forest joined with BCI and AGFD in the early 1990's to conduct the first habitat study of forest bats in Arizona (Murphy 1994).

All bats in Arizona are protected by law. Title 17 of the Arizona Revised Statutes authorizes the Arizona Game and Fish Commission to set hunting seasons and prohibits the taking of wildlife outside of its prescribed season (17-231, 17-234 and 17-309). As per Commission Order 14, there is no open hunting season on bats, meaning it is always illegal to take them. Article 17-101 defines “take” as “pursuing, shooting, hunting, fishing, trapping, killing, capturing, snaring or netting wildlife or the placing or using of any net or other device or trap in a manner that may result in the capturing or killing of wildlife.” Provisions for special licenses to take bats and other restricted live wildlife are given in Arizona Game and Fish Commission Rule 12, Article 4. Such licenses are administered by the AGFD. Cave dwelling bats are also protected under ARS 13-3702, which prohibits killing, harming, or disturbing any plant or animal life found in caves or caverns.

Because of this proactive stance by several groups and individuals in Arizona, bat awareness and conservation efforts in the state have been quite successful. However, increased coordination between state and federal agencies, land managers, researchers, and private individuals and companies will be needed to insure that bat management and conservation in Arizona continues. This plan will serve to outline the goals and priorities for education, research, management, and inventory and monitoring activities throughout the state and to identify Arizona’s efforts within the NABCP initiative. It will also serve as a resource and guideline for individuals and groups working with bats.

#### Vision Statement

Given the ecological and economic benefits provided by bats in North America, the NABCP aims to promote and coordinate a cooperative, continent-wide strategy for the conservation of bats, research into bat biology, and education regarding bat biology and conservation. This plan identifies Arizona’s efforts within this Partnership.

## BATS OF ARIZONA

### STATE OF KNOWLEDGE OF BATS IN ARIZONA

#### Overview of families found in Arizona

Four families of Chiroptera have been found in Arizona, although one of these families is represented by only 2 individuals captured in the 1950s (Hoffmeister 1986). The Mormoopidae (Ghost-faced bats) is made up of 8 species in 2 genera. Only one of these species, the ghost-faced bat (*Mormoops megalophylla*), has been identified in Arizona. These are insectivorous bats and are identified by expanded and ornamented lips, which form a “funnel” into the open mouth (Nowak 1994).

The Molossidae (Free-Tailed and Mastiff bats) is another insectivorous family, with 16 genera and 86 species. Bats in this family are characterized by a tail that projects one third or more of its length beyond the free edge of the tail membrane. There are 5 species of molossids in Arizona, in 3 genera: the Mexican free-tailed bat (*Tadarida brasiliensis*), the pocketed free-tailed bat (*Nyctinomops femorosaccus*), the big free-tailed bat (*Nyctinomops macrotis*), Underwood’s mastiff bat (*Eumops underwoodi*), and the greater western mastiff bat (*Eumops perotis*, the largest bat in the United States).

The Vespertilionidae (Vesper or Mouse-Eared bats) is the most diverse of the Microchiropteran families, with 42 genera and 355 species. It is 1 of only 3 families found in both the eastern and western hemispheres. These bats are also insectivorous, although there is some evidence of carnivory and perhaps even piscivory in a few species (Nowak 1994). Nineteen of the bat species of Arizona are vespertilionids, representing 9 genera: the pallid bat (*Antrozous pallidus*), Townsend’s big-eared bat (*Corynorhinus townsendii*), the spotted bat (*Euderma maculatum*), Allen’s lappet-browed bat (*Idionycteris phyllotis*), the hoary bat (*Lasiurus cinereus*), the western red bat (*Lasiurus blossevillii*), the western yellow bat (*Lasiurus xanthinus*), the silver-haired bat (*Lasionycteris noctivagans*), the big brown bat (*Eptesicus fuscus*), the western pipistrelle (*Pipistrellus hesperus*, the smallest bat in Arizona), the southwestern myotis (*Myotis auricolus*), the California myotis (*Myotis californicus*), the western small-footed myotis (*Myotis ciliolabrum*), the long-eared myotis (*Myotis evotis*), the Arizona myotis (*Myotis occultus*), the fringed myotis (*Myotis thysanodes*), the cave myotis (*Myotis velifer*), the long-legged myotis (*Myotis volans*), and the Yuma myotis (*Myotis yumanensis*).

While the Phyllostomidae (Leaf-nosed bats) is the second most diverse Microchiropteran family, with 48 genera and 148 species, they are found only in the New World and are generally tropical in distribution. There are only 3 species, however, that occur in Arizona. The phyllostomids show a great diversity in feeding habits and include species that feed on insects, fruit, nectar and pollen, blood, and small vertebrates. Of the Arizona species, only the California leaf-nosed bat (*Macrotus californicus*), is insectivorous while the lesser long-nosed bat (*Leptonycteris curasoae*) and the Mexican long-tongued bat (*Choeronycteris mexicana*) are primarily nectarivorous and frugivorous. The Mexican long-nosed bat (*Leptonycteris nivalis*) is also conjectured to occur in Arizona, since it is found in the extreme southwestern parts of New Mexico, but has never been positively identified in the state.

Status of Bats in Arizona

Species Name	USFWS	USFS	BLM	AGFD	WBWG	IUCN
<i>Mormoops megalophylla</i>	-	-	-	-	Medium	LR: lc
<i>Choeronycteris mexicana</i>	SC	Sensitive	Sensitive	Threatened	High	LR: nt
<i>Leptonycteris curasoae</i>	Endangered	Endangered	Endangered	Endangered	High	VU: A1c
<i>Leptonycteris nivalis</i> *	Endangered	Endangered	Endangered	Not listed	High	EN: A1c
<i>Macrotus californicus</i>	SC	Sensitive	Sensitive	Candidate	High	VU: A2c
<i>Myotis yumanensis</i>	SC	-	-	-	Low	LR: lc
<i>Myotis velifer</i>	SC	-	Sensitive	-	Medium	LR: lc
<i>Myotis occultus</i>	SC	-	Sensitive	-	Medium	LR: lc
<i>Myotis evotis</i>	SC	-	Sensitive	-	Medium	LR: lc
<i>Myotis auriculus</i>	-	-	-	-	Medium	LR: lc
<i>Myotis thysanodes</i>	SC	-	Sensitive	-	Medium	LR: lc
<i>Myotis volans</i>	SC	-	Sensitive	-	Medium	LR: lc
<i>Myotis californicus</i>	-	-	-	-	Low	LR: lc
<i>Myotis ciliolabrum</i>	SC	-	Sensitive	-	Medium	LR: lc
<i>Lasionycteris noctivagans</i>	-	-	-	-	Medium	LR: lc
<i>Pipistrellus hesperus</i>	-	-	-	-	Low	LR: lc
<i>Eptesicus fuscus</i>	-	-	-	-	Low	LR: lc
<i>Lasiurus blossevillii</i>	-	Sensitive	-	Candidate	High	LR: lc
<i>Lasiurus xanthinus</i>	-	Sensitive	-	Candidate	High	LR: lc
<i>Lasiurus cinereus</i>	-	-	-	-	Medium	LR: lc
<i>Euderma maculatum</i>	SC	Sensitive	Sensitive	Candidate	Medium	LR: lc
<i>Idionycteris phyllotis</i>	SC	Sensitive	Sensitive	-	High	LR: lc
<i>Corynorhinus townsendii</i>	SC	Sensitive	-	-	High	VU: A2c
<i>Antrozous pallidus</i>	-	-	-	-	Low	LR: lc
<i>Tadarida brasiliensis</i>	-	-	-	-	Low	LR: nt
<i>Nyctinomops femorosaccus</i>	-	-	Sensitive	-	Medium	LR: lc
<i>Nyctinomops macrotis</i>	SC	-	Sensitive	-	Medium	LR: lc
<i>Eumops perotis</i>	SC	-	-	-	Medium	LR: lc
<i>Eumops underwoodi</i>	SC	-	Sensitive	-	Medium	LR: nt

<sup>1</sup> Sources for status determination are as follows:

USFWS = U.S. Fish and Wildlife Service's Endangered Species Act listing. SC refers to Species of Concern. These are currently all former Category 2 species. These are species whose conservation status may be of concern to the US Fish and Wildlife Service, but do not have official status.

USFS = U.S. Forest Service (Region 3) Sensitive Species list. Taxa on this list are species proposed for the list currently undergoing revision.

BLM = Bureau of Land Management's Sensitive Species list (October 2000). Categories similar to the USFS list.

AGFD = Arizona Game and Fish Department. In prep. Wildlife of Special Concern in Arizona. Arizona Game and Fish Department Publication. Phoenix, Arizona. 32 pp.

WBWG = Western Bat Working Group *The Western Bat Species: Regional Priority Matrix*. High priority species may be imperiled or at risk of imperilment, medium priority indicates a level of concern, but information regarding the species and perceived threats is lacking, and low priority indicates that most of the existing data suggests species' populations are stable and the potential for major changes in status is considered unlikely.

IUCN = The World Conservation Union conservation status. EN=endangered, VU=vulnerable, LR:nt=lower risk, near threatened, LR:lc=lower risk, least concern. Red list (EN and VU) subcategories include A=threshold levels of population reduction either in the past (1) or predicted for the future (2), c=reduction based on decline in area of occupancy, extent of occurrence or quality of habitat (Hutson and others 2001).

\*Historical records of Greater long-nosed bats in Arizona refer to *L. curasoae*. However, records of *L. nivalis* from the Peloncillo Mountains near the New Mexico/Arizona border indicate this species may occur in Arizona.

### Historical perspectives

Due to the great diversity of bat species in the state of Arizona, coupled with recent support from AGFD for bat work, there has been a considerable amount of research done on bats in Arizona. Much of this work, however, has been done by government agencies or under contract to these agencies, and is thus not readily available in the literature. The “Further References and Gray Literature” section of this plan lists many resources and papers in the gray literature that address bat issues and research in Arizona. It is outside of the scope of this plan to comprehensively review all research that has been done on bats in Arizona.

A large proportion of the projects that have been done on bats in Arizona have been inventories of bat occurrence in different areas. Some areas, such as the Chiricahua Mountains, where the Southwestern Research Station of the American Museum of Natural History is located, have a history of extensive study, while other areas have only recently been surveyed. Surveys have included mist-netting and harp-trapping, observations with night-vision equipment, exit counts from roosts, interior examination of possible roost sites, and, more recently, acoustic surveys using bat detectors. Each of these techniques has advantages and disadvantages and may be skewed toward detecting certain species more frequently than others.

Research efforts have tended to focus on some species more than others. In general, colonial species often receive greater attention due to their gregarious nature and the relative ease of finding study animals. Large colonies of Mexican free-tailed bats have been studied for information on migration and population status. Interest in the lesser long-nosed bat has been great, due to its listing as an endangered species as well as its importance as a pollinator to many distinctive desert plants, such as the saguaro and organ pipe cactus and several species of agave. Research on forest-dwelling bat species has primarily been focused on roost and habitat selection. Behavioral studies, including descriptions of mating behavior, roosting behavior, and foraging behavior, have become more common with the advent of more sophisticated equipment for observing and tracking bats.

Recently, some research has focused on human-mediated effects on bats. This has included studies on the effects of toxins and pesticides on bat colonies, as well as the use of bridges, buildings, and other manmade structures as roosts by bats.

Although bats in Arizona have received a fair amount of attention in comparison to bats in other areas, there are still large gaps in our knowledge of these species. In particular, we lack good estimates of population sizes and trends for many species. As well, lack of information on habitat and diet preferences can make management recommendations difficult. In the following species accounts, we summarize known information for each species, and outline specific areas where more research is needed.

BAT SPECIES OF ARIZONA

SPECIES LIST

Family Mormoopidae

Ghost-faced bat, *Mormoops megalophylla*

Family Phyllostomidae

Mexican long-tongued bat, *Choeronycteris mexicana*

Lesser long-nosed bat, *Leptonycteris curasoae yerbabuena*

California leaf-nosed bat, *Macrotus californicus*

Family Molossidae

Greater western mastiff bat, *Eumops perotis*

Underwood's mastiff bat, *Eumops underwoodi*

Pocketed free-tailed bat, *Nyctinomops femorosaccus*

Big free-tailed bat, *Nyctinomops macrotis*

Mexican free-tailed bat, *Tadarida brasiliensis*

Family Vespertilionidae

Pallid bat, *Antrozous pallidus*

Townsend's big-eared bat, *Corynorhinus townsendii*

Spotted bat, *Euderma maculatum*

Allen's lappet-browed bat, *Idionycteris phyllotis*

Silver-haired bat, *Lasionycteris noctivagans*

Western red bat, *Lasiurus blossevillii*

Hoary bat, *Lasiurus cinereus*

Western yellow bat, *Lasiurus xanthinus*

Western pipistrelle, *Pipistrellus hesperus*

Big brown bat, *Eptesicus fuscus*

Southwestern myotis, *Myotis auriculus*

California myotis, *Myotis californicus*

Western small-footed myotis, *Myotis ciliolabrum*

Long-eared myotis, *Myotis evotis*

Arizona myotis, *Myotis occultus*

Fringed myotis, *Myotis thysanodes*

Cave myotis, *Myotis velifer*

Long-legged myotis, *Myotis volans*

Yuma myotis, *Myotis yumanensis*

## SPECIES ACCOUNTS

These species accounts are modified from unpublished abstracts compiled and edited by AGFD's Heritage Data Management System (HDMS).

## RANGE MAPS

The range maps included in these species accounts were developed by the HDMS using the vertebrate distribution map layers from the United States Geological Survey (USGS). Vertebrate distribution coverages were created by L.A. Graham, V.J. Ackerson, and V.J. Meretsky. Species distributions were modeled, in part, on their association to vegetation type or types. When appropriate, masks based on geographic range, elevation, expert opinion, or other variables may have been applied. Thus, the shaded areas on the maps represent primary and secondary habitat for the species involved. The points on the maps represent species occurrences recorded in the HDMS. Criteria for recording occurrence differ between species and are indicated in the figure labels. Neither of these 2 mapping methods is exhaustive, but they may be used to identify the predicted and known distribution of the species.

GHOST FACED-BAT – *MORMOOPS MEGALOPHYLLA*

*Description.* -- The ghost-faced bat is a medium-sized bat (forearm 46-56 mm) with long, lax fur that is brownish to reddish brown above. It has prominent leaf-like folds of skin that extend from ear to ear across chin; the central fold, in front of lower lip, is covered with small wart-like prominences. The face is short and the forehead high; the rostrum sharply upturned. Its ears are small, round and connected across the forehead and its lower part forms a pocket below the eye. The tragus is complexly folded. The end of the tail projects upward from near the middle of the interfemoral membrane. There is no other bat in the U.S. with these characteristics.

*Distribution and habitat.* -- The ghost-faced bat has been found only once in Arizona, in June, 1954, when 3 females were taken near Patagonia in the southern foothills of the Santa Rita Mountains on the Coronado National Forest (Fig. 1). The individuals were caught in a mist net over a waterhole in a riparian community of mature cottonwood, sycamore, and willow at an elevation of 4450 ft (1356 m), in oak woodland. Nothing further is known about its distributional status in Arizona. The nearest known colonies are in Sonora about 150 mi (240 km) south of where they were netted in Arizona. Species range is from southwestern and southern Texas and southern Arizona, southward through Mexico (including southern Baja California, the Mexican Plateau, and Yucatan Peninsula) into Central America as far as eastern Honduras and El Salvador. In South America, the ghost-faced bat is known from several widely separated localities along the Caribbean coast of Colombia, Venezuela, Trinidad, and the Dutch West Indies, and also is known from the arid upper Patia Valley in northern Ecuador.

In Texas, the ghost-faced bat has been captured in both lowland and upland areas but is most common in desert scrub and river floodplain habitats. Specimens have been collected or individuals observed in all months except December; thus the ghost-faced bat appears to be resident in some part of its Texas distribution year around. There is a strong correlation between the Trans-Pecos, Texas, distribution of this bat and areas having annual precipitation of 10 to 12 inches and average annual temperatures above 64°F (18°C).

*Biology.* -- This is a colonial, cave dwelling bat whose distribution is closely correlated with the distribution of caves, crevices and abandoned mine tunnels which serve as daytime roosts. Rarely, buildings and railroad tunnels may be used for day roosts. Although they may be found roosting in numbers of several thousand to a half million, ghost-faced bats do not cluster in compact groups as do most other cave dwelling bats, but rather roost singly, spread out over the ceiling about 15 cm apart. Maximum sizes of colonies reported from Texas are 3000-4000 and 6000.

The ghost-faced bat is believed to be non-migratory and spends its life in one general locality. However, the species may be unpredictably nomadic with colonies being found in a cave for a period of time, then suddenly disappearing, apparently shifting to new living quarters in some other cave. This species is not known to hibernate. During the winter it may gather in caves, or parts of caves, where the air is considerably warmer than outside the cave. In Texas during January a cave contained a colony of 1550 in a room with a temperature of 80°F (27°C). In Nuevo Leon, Mexico, during November about a half million individuals were found in cave with relative humidity of 86% and temperature of 70°F (21°C); outside temperature was 59°F (15°C).

From what little is known about the reproductive biology of ghost-faced bats, it appears that the period of reproduction is confined to late winter and early spring, even in the tropics, and there is only 1 offspring each year. In the northern part of its range (Mexican states of Coahuila and Nuevo Leon bordering Texas) pregnant females have been reported in March, April and May, each with a single embryo. In Arizona 1 female was found to be pregnant with 1 fetus in June. Elsewhere, in Mexico and Central America, sexually mature females taken between January and June are likely to be gravid or lactating. Young are normally born in June. No nursery colonies have been found in the United States.

The food of this bat appears to consist entirely of flying insects. The only specific item reported from study of stomach contents is wing scales of Lepidoptera. This bat is thought to forage high above the ground since it is seldom caught in mist nets. It is a strong, swift flier, seems unable to detect mist nets, and thus flies into a mist net with considerable force, which suggests that it forages in areas unobstructed by tall vegetation. However, in Tamaulipa one was shot about 6 ft (2 m) above the ground, in Yucatan 18 were caught in mist nets set "in or near forests," and 3 were taken in southern Chiapas, Mexico in nets set across a tree-bordered, shallow stream where about a dozen species of bats came to drink.

*Population trends.* -- Population trends of this species are unknown.

*Management factors.* -- Arizona is at the extreme northwestern edge of the ghost-faced bat's range. No nursery colonies are known north of central Sonora. Studies of the distribution, habitat, population, and life history are needed for this species. However, given the limited occurrence of this species in Arizona, specific management actions for this species are not recommended at this time.

### Ghost-faced Bat *Mormoops megalophylla*

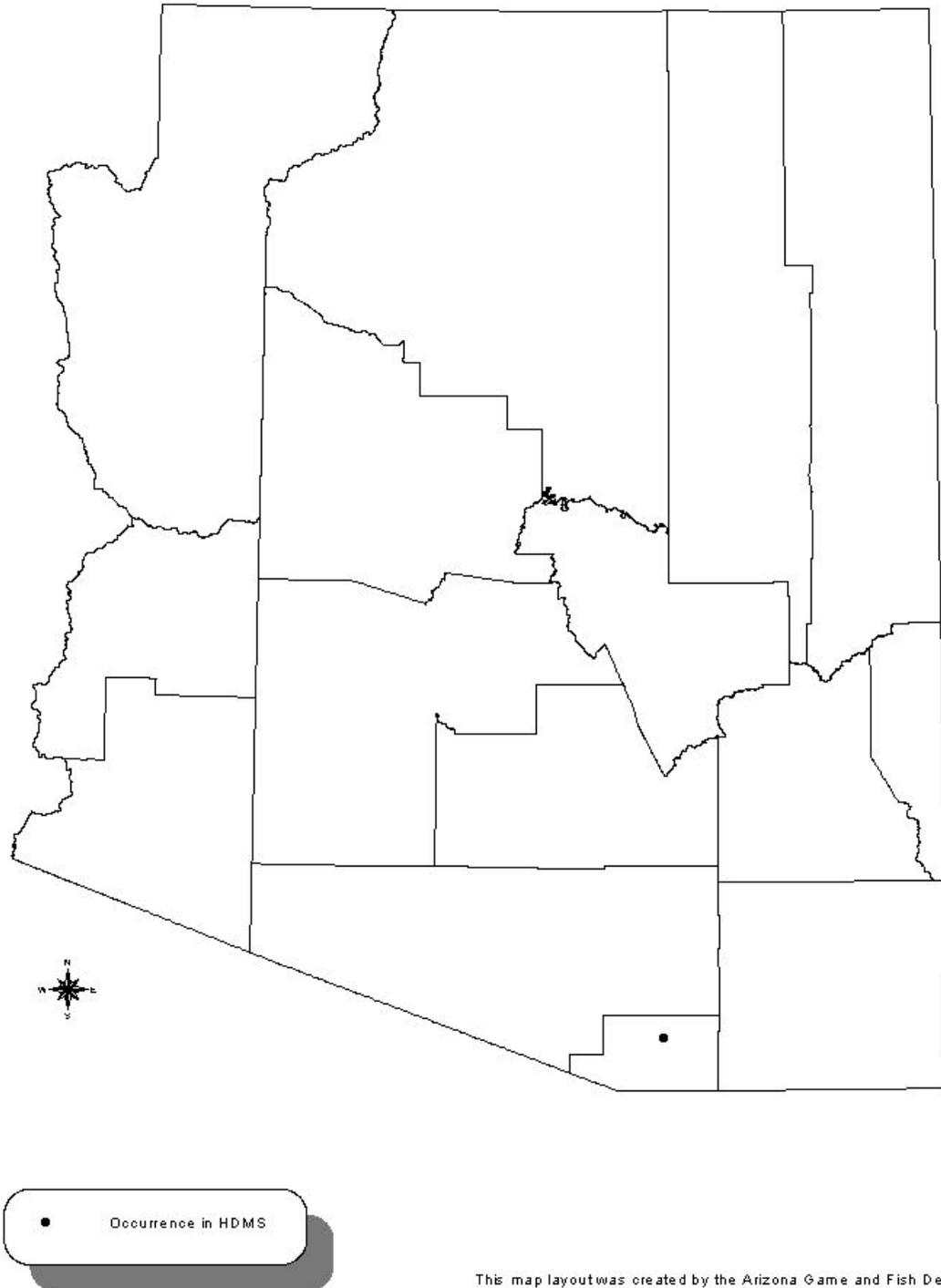


Figure 1: Occurrence of the ghost-faced bat in Arizona. Points represent all occurrences of 1 or more individuals, including netting records.

MEXICAN LONG-TONGUED BAT – *CHOERONYCTERIS MEXICANA*

*Description.* -- The Mexican long-tongued bat has a long and slender nose with a noseleaf that is broad at the base, pointed at the tip, and about 5 mm high. Its forearm is 42-48 mm. The tail is approximately 10 mm in length, about one-third the length of interfemoral membrane. Dorsal pelage varies from buffy brown to dark grayish-brown, paler on shoulders and palest on the venter, and the ears are pale brownish gray. The tongue is long and extendable. Upper incisors are small and do not fill space between canines. There are no permanent lower incisors, but 1 to 4 deciduous teeth may persist in adults.

The Mexican long-tongued bat may be distinguished from the lesser long-nosed bat, which is larger (forearm 51-55 mm) and has no visible tail. The only other phyllostomid in Arizona, the California leaf-nosed bat is also easily differentiated from the Mexican long-tongued bat by its much larger ears (29-38 mm).

*Distribution and habitat.* -- Within Arizona, the Mexican long-tongued bat is found in the southeastern parts of the state, from the Chiricahua Mountains, extending as far north as the Santa Catalina Mountains and as far west as the Baboquivari Mountains (Fig. 2). Recently, this species has also been reported from Grand Canyon National Park (E. Leslie, Grand Canyon National Park, personal communication). The species range also includes southern California, southwestern New Mexico and much of northern and central Mexico.

Mexican long-tongued bats are often found in canyons of mixed oak-conifer forests in mountains raising from the desert; in Mexico, its preferred habitat includes arid thorn scrub, and tropical deciduous forests. There is some range overlap with lesser long-nosed bats, but it is not great (see Hevly 1979). Mexican long-tongued bats usually arrive at higher elevations than lesser long-nosed bats when they arrive in spring. There are occurrence records for this species from 3200 – 7320 ft (976 – 2233 m), but most are from 4000 - 6000 ft (1220 - 1830 m).

*Biology.* -- The Mexican long-tongued bat is less gregarious than other colonial bats and less inclined to roost with other bat species. In roosts, they do not cluster closely together but hang 2 to 5 cm apart, usually by only one foot so they can swivel 360 degrees to watch any intruder. Populations consist of 15 or fewer individuals. Caves and abandoned mines are favored daytime retreats, where this species prefers to roost in the dimly lit areas often near the entrance. They are also often found in shallow caves or rock shelters. A few have been found in palo verde-saguaro areas.

This species is migratory, spending the winter in Mexico where it does not hibernate. Southern Arizona, where it is found in sexually segregated and nursery colonies during the summer, it is at the extreme northern edge of its range. It had been thought that only adult females moved north from Mexico into the United States with the males remaining in the southern part of the range, but recently, some adult males have been found in the Chiricahua Mountains. The young are born mid to late June and early July. Young grow rapidly and can probably fly within 2-3 weeks. After the young fledge, these bats move about opportunistically in search of food.

The Mexican long-tongued bat feeds on the nectar and pollen of paniculate agaves, and occasionally on the fruit of columnar cacti (these bats are not typically found in low desert situations). Its bristle-like tongue and lack of lower incisors aid in lapping up flower nectar and pollen. Insects are also probably taken. This species is also frequently seen visiting hummingbird feeders in the Huachuca, Chiricahua, and Santa Catalina Mountains. During the winter, some individuals have been reported feeding at hummingbird feeders in the Tucson areas. It is not known if they are feeding on other things at that time.

*Population trends.* -- Populations in Arizona appear to be highly variable.

*Management factors.* -- Mexican long-tongued bats are very wary of humans and are easily disturbed. Human disturbance to roost sites should be restricted. Surveys for this species may be difficult because it roosts in small (5-15 individuals) colonies. The development of improved survey methods could greatly increase knowledge of population trends. Studies to determine food habits, range, population densities, and migration and roosting patterns are also needed.

### Mexican Long-tongued Bat *Choeronycteris mexicana*

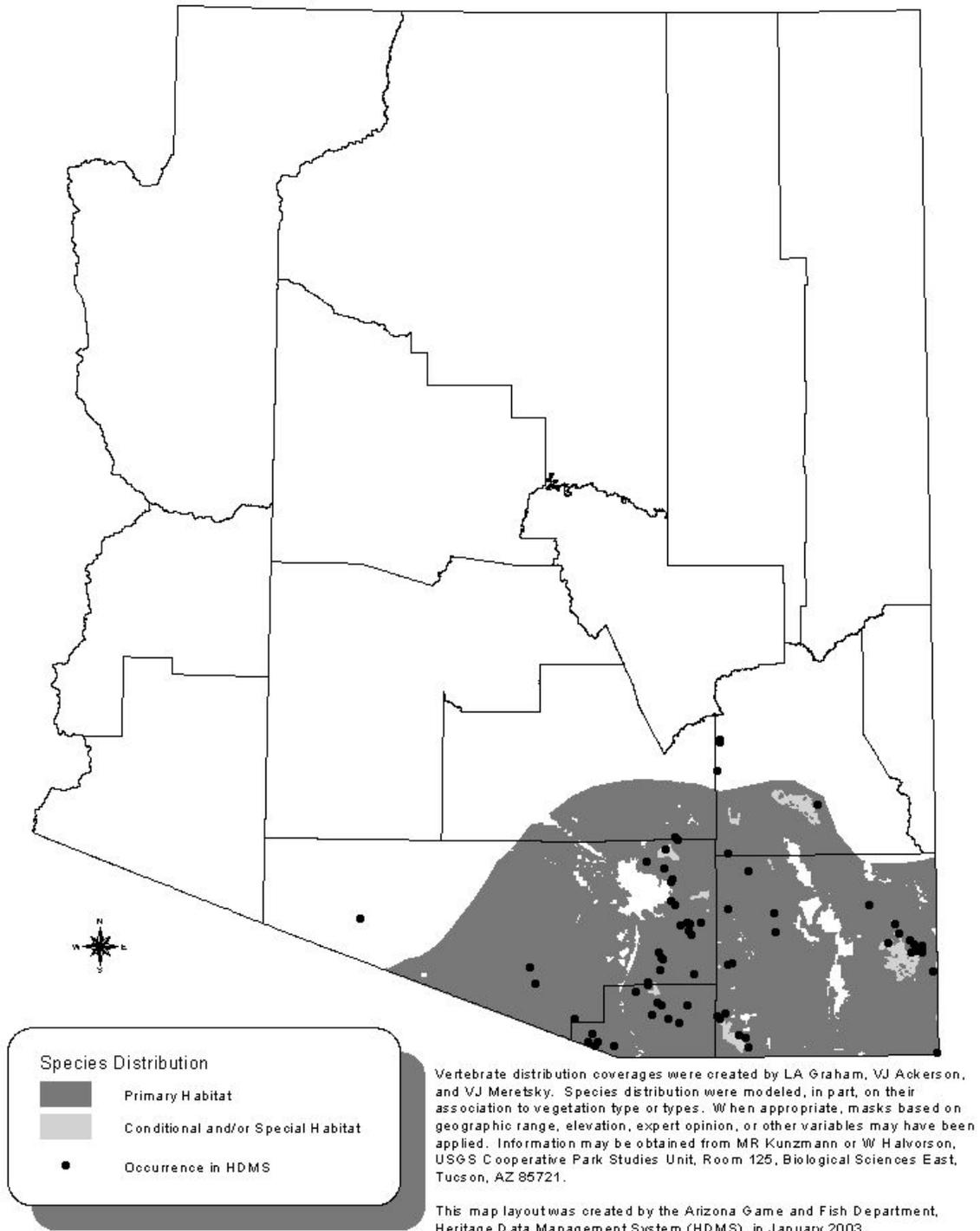


Figure 2: Habitat range and occurrence of the Mexican long-tongued bat in Arizona. Points represent all occurrences of 1 or more individuals, including netting records (map does not include recent records from the Grand Canyon).

LESSER LONG-NOSED BAT – *LEPTONYCTERIS CURASOAE YERBABUENAE*

*Description.* -- The lesser long-nosed bat is a medium-sized bat, with a forearm of 51-56 mm. Fur is gray in young and reddish-brown in adults. The lesser long-nosed bat has an elongated snout and a nose-leaf, an erect triangular flap of skin at the tip of the snout. There is no tail, and the interfemoral membrane is reduced to a narrow band along each hind leg. These bats have large eyes and reduced ears compared to other bats in Arizona. This species is generally smaller in length of head and body, forearm, skull, and upper tooth row than the closely related Mexican long-nosed bat (*Leptonycteris nivalis*). It is also more brownish below and more reddish above than the Mexican long-nosed bat.

The lesser long-nosed bat may be distinguished from the other 2 phyllostomids in Arizona by its greatly reduced tail membrane and complete lack of a tail. Additionally, the lesser long-nosed bat has much smaller ears than the California leaf-nosed bat and is larger with a shorter snout than the Mexican long-tongued bat.

*Distribution and habitat* -- In Arizona, the lesser long-nosed bat is found from the Picacho Mountains to the Agua Dulce Mountains in the southwest and the Galiuro and Chiricahua mountains in the southeast (Fig. 3). There are also 2 late-summer records of immature individuals from the Phoenix area and 1 from the Pinaleno Mountains. The species is not present in Arizona in winter. The total species range varies somewhat depending on which classification is used. *Leptonycteris sanborni* (the former species name for the lesser long-nosed bat) is listed as occupying the lowland deserts of Mexico from Oaxaca and Veracruz through western Mexico to Baja California, and northward to south-central and southeast Arizona and southwest New Mexico. *L. curasoae* is listed as occupying essentially the same range but extending southeasterly through Guatemala to El Salvador. The closely related Mexican long-nosed bat is found farther to the east, from the Big Bend area of Texas south through eastern Mexico to central Mexico where its range overlaps with that of the lesser long-nosed bat.

Lesser long-nosed bats are found in desert grassland and shrubland up to oak transition. They forage in areas of saguaro, ocotillo, paloverde, prickly pear and organ pipe cactus and later in the summer, among agaves. There appear to be both sexual and seasonal differences in the Arizona range of the lesser long-nosed bat. During the early part of their stay (late April to late July) pregnant females congregate at traditional roost sites, give birth, and raise their young at lower elevations (below about 3500 ft (1068 m)) within the range of columnar cacti. Males and perhaps nonreproductive females may be found at this time in roosts in the eastern part of the state. By late July most females and young have dispersed from the maternity colonies and some have moved to higher elevations (up to about 5500 ft (1678 m)) where they are found feeding on agave flowers. By late September or October all of these bats migrate south to Mexico, although exactly where is not known.

*Biology.* -- Lesser long-nosed bats do not hibernate and cannot withstand prolonged exposure to cold. They migrate in September/October to Mexico, where they breed and spend the winter. Females arrive in Arizona pregnant and as early as the second week in April. They join other females in maternity colonies late in pregnancy sometime in April or early May. Maternity colonies may number in the hundreds to the thousands and in a few places in the tens of

thousands. Males form separate, smaller colonies. One young per year is born during May. Young can fly by the end of June. Maternity colonies break up by the end of July. Neither maximum nor mean lifespan are known; however, 1 banded individual when recaptured was a minimum of 4 years old.

In Arizona, lesser long-nosed bats feed on nectar and pollen from flowers of saguaro and organ pipe cactus in early summer and agave later in the summer and early autumn. They may feed on ripe cactus fruits at the end of the flowering season. They may also take a few insects incidentally when taking nectar. Lesser long-nosed bats also take sugar water from hummingbird feeders at night in the Huachuca, Chiricahua, and Santa Rita Mountains. During winter in Mexico, primary food plants, as identified by their pollen, appear to be *Ceiba*, *Bombax*, and *Ipomoea*. Their spring migration from central Mexico northward is thought to follow the sequential blooming of certain flowers from south to north.

They leave daytime roosts to feed about an hour after sunset. After filling their stomachs, sometimes to the point of appearing pregnant, they go to night roosts, which may be different from day roosts, to rest and groom. As they groom themselves they remove the pollen sticking to their fur with their claws and then lick it off their claws. This ingested pollen provides proteins and other nutrients not obtainable from nectar.

The lesser long-nosed bat is considered an important pollinator of various agave species, columnar cacti and other Mexican plant species. Pollen collects on their heads and shoulders (sometimes making them look yellow) when they stick their head into a flower to get nectar. As they go from plant to plant pollen is rubbed off on the pistils at each flower thus pollinating them. It is not yet clear just how important this bat is as a pollinator of saguaro and the agave species with which it is associated in Arizona since some populations of these plants also exist well outside the known range of this bat. The tongue is long and tipped with brush-like papillae that help mop up nectar. Like most nectar feeders, the teeth are much modified, having lost the cutting and crushing cusps of the insect feeding species of bats. Its diet of nectar enables this bat to be essentially independent of free water.

The lesser long-nosed bat roosts in caves, mine tunnels, and occasionally in old buildings. Spatters of thin yellow material on the floor or walls of a cave or mine likely indicate the recent presence of this bat or the Mexican long-tongued bat (the other of the 2 nectar/pollen eating bats in Arizona). The yellow material is guano colored yellow by pollen the bats have ingested from plants visited for nectar.

These bats are strong flyers capable of flight speeds of up to about 14 mph (22.5 km/hr). They are also highly maneuverable which allows them to hover at flowers and often to evade both hand and mist nets. In a roosting area they can often be identified by a distinctive roaring sound made by the wings as they fly.

*Population trends.* -- The lesser long-nosed bat is currently federally listed as endangered. Populations are presumed to have declined significantly, and listing was based on the reduction of the number of maternity colonies and declines in the size of remaining maternity colonies in Arizona and Sonora due to exclusion and disturbance. Additionally, lesser long-nosed bats are

thought to be negatively affected by large reductions in acreage of native agaves over large areas of northern Mexico due to excessive harvesting for local manufacture of mescal and tequila. Excessive browsing on newly emergent flower stalks of agaves, by both cattle and deer has also been suggested as possibly decreasing foraging opportunities and thus contributing to declines among these bats. Recent surveys, however, have indicated that population sizes are much larger than those reported in the 1980's.

*Management factors.* – Arizona is at the extreme northern edge of the lesser long-nosed bat's distribution, yet it contains at least 3 large maternity colonies. Over-harvesting of native (as opposed to cultivated) agaves in northern Mexico may reduce foraging habitat for this species. Other threats to this species include exclusion from some roost sites and disturbance at others.

Lesser long-nosed bats have been designated as endangered by the federal government and by the state of Arizona. A recovery plan was adopted by the USFWS in 1997. Studies have been initiated of agave ecology, including fire relationships, on the Fort Huachuca military reservation; of foraging ecology in Sonora by researchers from BCI; and of the effects of low-flying supersonic aircraft on the Barry M. Goldwater Air Force Range. In addition annual surveys of known roosts are being conducted in Arizona and parts of Sonora by biologists from universities, federal and state agencies, and private organizations.

Biologists and others also continue searching for new colonies. Several caves and mine adits in southeastern Arizona have been gated with interpretive signs placed nearby by the Coronado National Forest and are monitored by forest and other biologists. At Colossal Cave, developed for tourism, at the base of the Rincon Mountains some obstacles have been removed and attempts have been made to return parts of the cave to pre-disturbance conditions in hope of attracting lesser long-nosed bats to use it as a maternity roost as they did until the 1960s.

In 2002, the *Leptonycteris curasoae* Recovery Cooperative (LcRC) was formed, with members from AGFD, USFWS, BCI, and the Arizona Sonora Desert Museum, to encourage implementation of the 1997 recovery plan.

In addition to continuation of those activities noted above information is needed on dates of occurrence at specific localities and roosts, the variety and relative importance of food plants, the bat's migration routes, plant species and phenology along such routes, winter roost sites, and abundance of these bats at winter roosts. Because dates of presence and roost occupation can vary with season, with elevation and habitat, and with locale, surveying for this bat must be carefully planned. Population trend and presence surveys should coincide with known dates of occupation for particular roosts or localities. Although times of occupation or presence are known for some sites, they may be only partially known or remain to be determined for others.

*Additional information.* -- This species was previously known as *Leptonycteris sanborni*. Some researchers support the raising of *Leptonycteris curasoae yerbabuena* to specific status as *Leptonycteris yerbabuena*.

### Lesser Long-nosed Bat *Leptonycteris curasoae yerbabuenae*

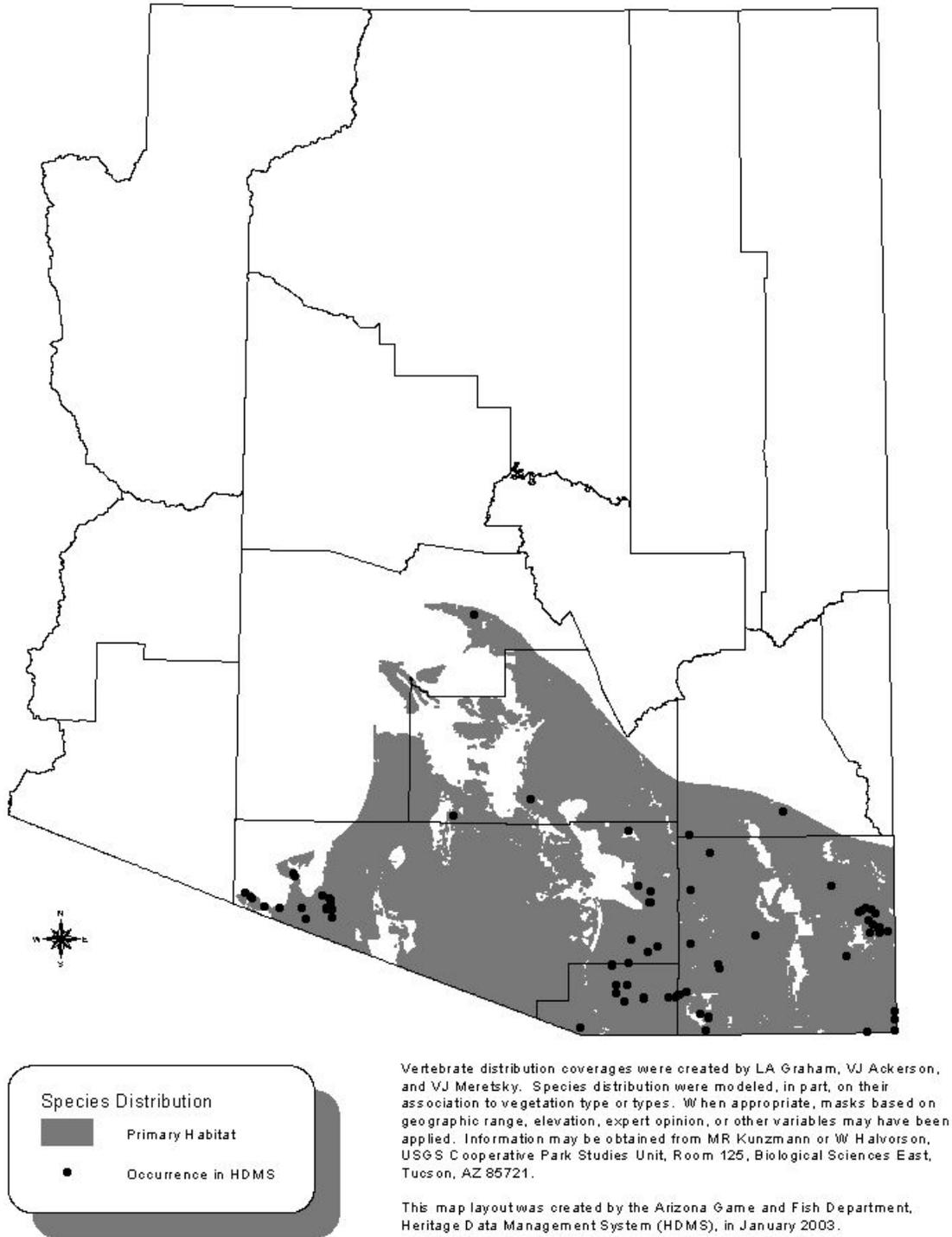


Figure 3: Habitat range and occurrence of the lesser long-nosed bat in Arizona. Points represent all occurrences of 1 or more individuals, including netting records.

CALIFORNIA LEAF-NOSED BAT – *MACROTUS CALIFORNICUS*

*Description.* -- The California leaf-nosed bat is a large-eared, leaf-nosed bat in which the nose-leaf is erect and lanceolate. Its ears are large (29-38 mm) and joined together near base. The tail extends free beyond edge of uropatagium for 5 to 10 mm. Forearm length is 47-55 mm.

The California leaf-nosed bat may be identified by the combination of large ears and nose-leaf. It is easily distinguished from the Mexican long-tongued bat and the lesser long-nosed bat, both of which have much smaller ears. Roosting California leaf-nosed bats generally hang from the ceiling of caves and mines in groups of a few up to several hundred. Although they roost close to each other they are not usually touching or tightly packed as are the individuals of many other colonial bat species. They typically pivot as they hang and watch an approaching person prior to flying. California leaf-nosed bat guano is reported to have a distinctive odor that may be used to help identify a roost.

*Distribution and habitat.* -- In Arizona, California leaf-nosed bats are primarily found south of the Mogollon Plateau in Sonoran and Mohave desert scrub, and occasionally in Chihuahuan and Great Basin desert scrub (Fig. 4). They are also known from southeastern and, in summer, extreme northwestern Mohave County. They are year-round occupants of some roosts, with summer and winter ranges essentially the same. The species range extends through southern California, southern Nevada, across the southwestern half of Arizona and southward to the southern tip of Baja California, northern Sinaloa, and southwestern Chihuahua, Mexico. May be found at elevations up to 5160 f (1560 m), but most records are from below 2500 ft (757 m).

*Biology.* -- California leaf-nosed bats remain active year-round and are not known to hibernate or migrate, though they may not occupy the same roost year round. Sustained exposure to low temperatures, which could be lethal, is largely avoided in the desert conditions in which they live and by selection of warm roost sites. They primarily roost in mines, caves, and rock shelters. Day roosts in mines are usually within about 80 ft (24 m) of the entrance. They prefer roost sites with large areas of ceiling and flying space. In colder parts of their range, during winter, they are found in mines where temperatures are well above external ambient temperatures. During this time they are found in roosts with temperatures near 80°F (27°C) and are usually found 100 ft (30 m) or more back from the entrance.

Kidney anatomy indicates that the California leaf-nosed bat is better able to concentrate urine and thus conserve water than its closest relative Waterhouse's leaf-nosed bat (*Macrotus waterhousii*), which occupies a wetter habitat. Some individuals in captivity have been reported to go for at least 6 weeks without drinking water (Lu and Bleier 1981). However, Bell and others (1986) suggest that these bats are able to exist in temperate desert areas because they minimize energy expenditure by using geothermally-heated winter roost sites with stable year-round temperatures of about 84°F (29°C) and an "energetically frugal pattern of foraging that relies on visual prey location" and detection of prey-produced sounds.

Females produce 1 young per year and can breed during their first autumn. Males, however, do not breed until their second year. Females congregate in maternity colonies to give birth during May and June. The young are nursed during the following month after which they are able to fly

and begin foraging for themselves. Nursery colonies are in roost sites with temperatures of about 90°-95°F (32°-35°C) and located near the entrance to the roost. Some nursery colony sites are occupied year round. During spring and summer males roost separately, then join the females in late summer and early autumn, and they are found together during winter. Fertilization takes place in early autumn with embryological development greatly slowed through the winter until March when it proceeds normally. Maximum life expectancy is greater than 15 years.

The California leaf-nosed bat primarily takes prey while hovering close to the ground or by gleaning from vegetation often within 3 feet (1 m) of the ground, although it is also capable of taking prey in flight. It feeds on large, flying insects such as grasshoppers, moths and flying beetles. Insect larvae, especially Lepidoptera, and other flightless, or daytime active prey are taken from bushes and off the ground. Daytime insects are especially important during winter months. Hoffmeister (1986) reports that California leaf-nosed bats may also feed on fruits, including those of cacti.

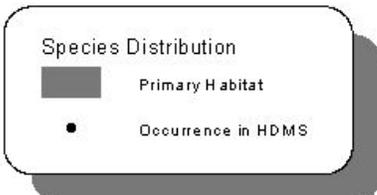
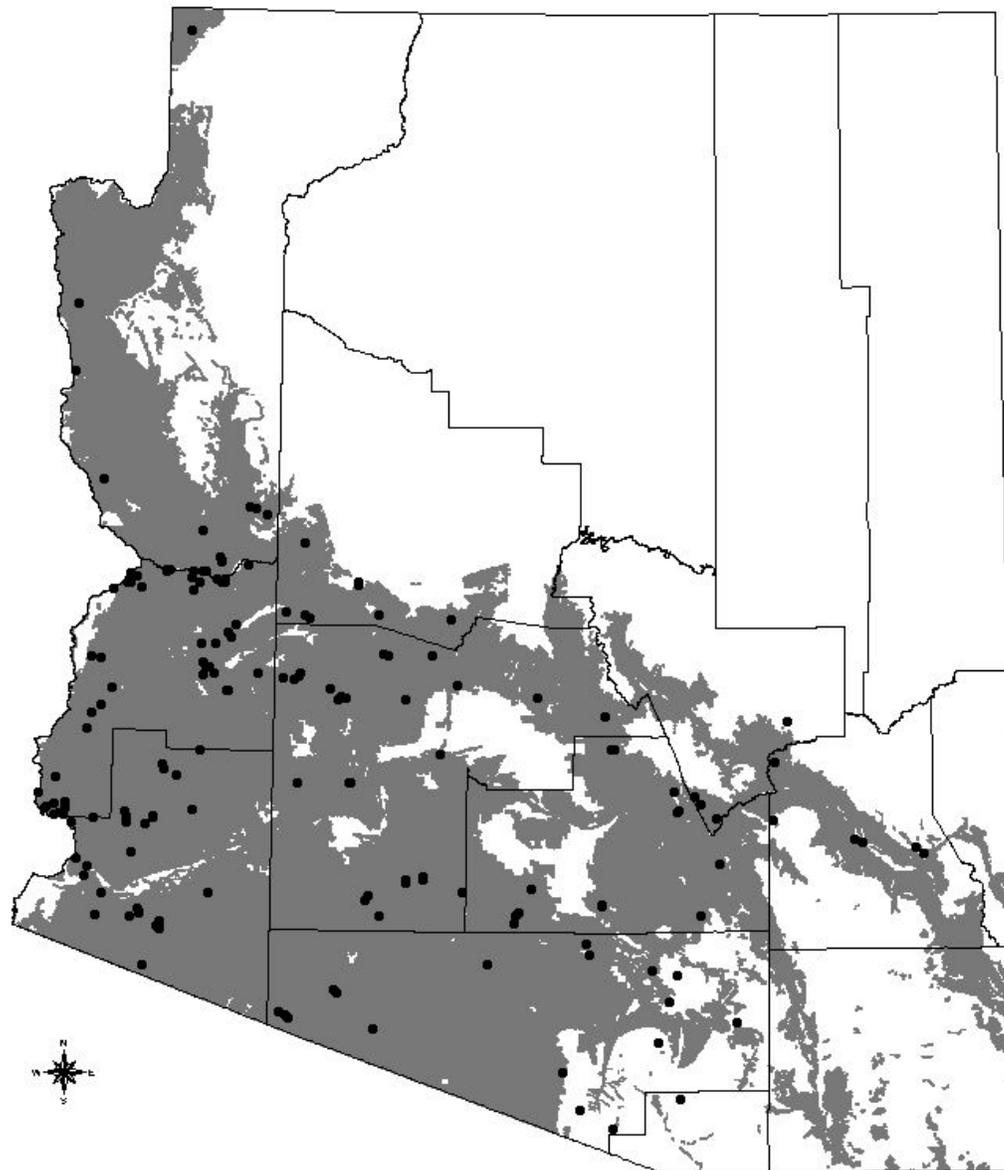
The California leaf-nosed bat commonly night roosts in places that provide overhead protection and an adequate flight approach. Such places include a variety of manmade structures, rock shelters and mines. Large insects may be brought to the night roost to eat and insect wings and other discarded body parts may be found below the roost site.

*Population trends.* -- Population trends are poorly known, but concerns have been expressed regarding roost abandonment and reduced numbers as a result of disturbance by both recreationists and scientists at a number of well known and accessible roost sites.

*Management factors.* -- The California leaf-nosed bat is susceptible to human disturbance, which may cause abandonment of roosts. Loud noises in roosts may disorient the bats and also negatively affect reproductive success. Habitat destruction (closure by dynamiting, bulldozing, or otherwise blocking caves and mines) and modification (altering air movement, humidity, temperature, or interfering with bat access) by partial blocking or improper gating are all potentially serious concerns. Mine closure for hazard abatement and renewal of mining activity at previously abandoned mines both present threats to existing colonies. However, California leaf-nosed bats have been shown to accept properly designed gates at roost sites. Studies to determine home range, foraging areas and distances, and local, seasonal movements are needed, as well as historical studies of roost site use and disturbance. Differential habitat use by bachelor and maternity colonies should also be studied, and lek sites should be identified and monitored.

*Additional information.* -- These bats are seldom netted over water or even in flyways; thus surveying for California leaf-nosed bats seems to be most efficiently done at roosts using exit counts or other estimation methods. Most individuals leave day roosts within 1 to 3 hours after sunset.

### California Leaf-nosed Bat *Macrotus californicus*



Vertebrate distribution coverages were created by LA Graham, VJ Ackerson, and VJ Meretsky. Species distribution were modeled, in part, on their association to vegetation type or types. When appropriate, masks based on geographic range, elevation, expert opinion, or other variables may have been applied. Information may be obtained from MR Kunzmann or W Halvorsen, USGS Cooperative Park Studies Unit, Room 125, Biological Sciences East, Tucson, AZ 85721.

This map layout was created by the Arizona Game and Fish Department, Heritage Data Management System (HDMS), in January 2003.

Figure 4: Habitat range and occurrence of the California leaf-nosed bat in Arizona. Points represent maternity colonies, roosts of 5 or more individuals, and sites where 3 or more pregnant or lactating females have been netted.

GREATER WESTERN MASTIFF BAT – *EUMOPS PEROTIS CALIFORNICUS*

*Description.* -- The greater western mastiff bat is the largest bat in the United States, with a forearm of 73-83 mm and weight of 53-61 g. Its wings are long and narrow, with a wingspan of 530-570 mm. The ears protrude forward and are large (~40 mm) and joined at base with a broad, square tragus. The distal half of the tail is free from the interfemoral membrane. Pelage is dark gray or brownish gray and slightly lighter underneath; hairs are bicolored, nearly white at base. This bat has a strong odor partially due to a gland on the throat that exudes an oil.

The genus *Eumops* is distinguished from the other 2 genera (*Tadarida* and *Nyctinomops*) of Molossidae found in Arizona by a smooth upper lip which lacks vertical creases or wrinkles and lack of anterior emargination of the palate, both of which characteristics are found in both of the other genera. The greater western mastiff bat is larger than Underwood's mastiff bat (*Eumops underwoodi*) and is darker in color, lacking the long guard hairs on the rump, which Underwood's mastiff bat possesses. The greater western mastiff bat makes a distinctive, piercing, high-pitched 'cheep' every 2 to 3 seconds during flight. The call is louder than that of any other U.S. bat and, unlike other bats, it is emitted almost continuously while flying. The calls are not as intense as those of Underwood's mastiff bat. Once learned, detection of the greater western mastiff bat's call can be used to determine its presence in an area (Cockrum 1960). Another possible means of identification is the sharp, swishing sound made by the wings during flight. It is reported that these sounds can be heard up to about 100 ft (30 m) away. At roost sites, the massive, yellow urine stains and the large droppings are distinctive.

*Distribution and habitat.* -- The greater western mastiff bat is found in all Arizona counties except Yavapai, Navajo, Apache and Santa Cruz (Fig. 5). It is considered a year-round resident in Arizona based on collections or calls heard in every month except January. The species range extends from northern California south through Las Vegas, Nevada, across the southern half of Arizona to Big Bend, Texas, and south to Sinaloa in northwestern Mexico and Zacatecas in central Mexico. This population is 1 of 3 widely separated populations; the other 2 are in South America and Cuba.

This species is found in lower and upper Sonoran desertscrub near cliffs, preferring the rugged rocky canyons with abundant crevices. They prefer crowding into tight crevices. Entrances to roosting crevices are usually horizontal but facing downward which facilitates entry and exit. The large body and narrow wings make ground launching difficult. According to Barbour and Davis (1969), they regularly use roosts allowing them a vertical drop of 10 or more feet ( $\geq 3$  m). Elevational range for this species is from 240 – 8475 ft (73 - 2583 m).

*Biology.* -- Whether or not this bat hibernates during winter is unclear. Limited evidence suggests that during winter months it goes into torpor every day, but arouses and leaves the roost to forage at night when temperatures at dusk are above 41°F (5°C). This bat can tolerate ambient temperatures of 100°-102°F (38°-39° C) without undue heat stress (Barbour and Davis 1969).

The hind legs of this bat are not as reduced as in other bats allowing it to crawl rapidly. When crawling the tail is extended at about a 45° angle and may serve as a tactile organ when in a crevice. These bats are active within their roosts throughout the day. They are capable of fast and

prolonged flight but may have difficulty getting airborne from the ground and often roost at some height. If grounded, they may scramble up a post or a tree in order to achieve a height of around 5m for launching into flight.

The greater western mastiff bat most likely breeds in early spring when male's testes are enlarged. The odiferous gland at the base of the throat is most active in males in March and is thought to be related to reproduction. Parturition time varies more in this bat than in any others in the United States. Young have been found as early as June and as late as August. Gestation is 80-90 days, and litter size is 1 young per year. The timing and degree of separation of the sexes is unclear. While both sexes have been found together throughout the year, males are found less commonly in maternity colonies. These bats may roost singly, in groups of 2 or more, but usually in colonies of up to 100 individuals. Many roost sites do not seem to be occupied year-round, although they are likely to be occupied periodically. They often move around among several roost sites even when they have young. This is thought to be influenced by temperature as well as human disturbance.

The greater western mastiff bat feeds on insects, especially Hymenoptera (bees, wasps, ants and sawflies). They forage at considerable heights (100 to 200 ft (30 to 61 m); sometimes to 1000 ft (305 m) or more) over extensive areas for long (about 6½ hours) periods during the night. They are known to forage at least 15 mi (24 km) from the nearest likely roosting sites. They may forage on rainy nights and have even been heard during a thunderstorm. This bat also prefers to feed over large open bodies of water (e.g. ponds, reservoirs, etc), making them difficult to net.

*Population trends.* -- Population trends for the greater western mastiff bat are poorly known. Some historical roost sites are no longer occupied.

*Management factors.* -- A factor of concern for the greater western mastiff bat is the vulnerability of maternity colonies. As well, according to Acker (*in* Chebes 2000) the species uses only select drinking sites and is severely limited by the availability of drinking water. Because its wing structure is adapted for fast and straight-line flight, it is unable to drink from water sources less than 100 ft (30 m) long. As a consequence, greater western mastiff bats are no longer found in many previously occupied areas and populations may be in decline. According to the Texas Parks and Wildlife Department they are also threatened by urban/suburban expansion and by activities that disturb or destroy cliff habitat (e.g. water impoundments, highway construction, quarry operations). Recreational climbing is another potential threat. Pest control operations have eliminated most known building colonies in the Los Angeles basin. Grazing and pesticide applications in agricultural areas may impact foraging habitat.

Status surveys, as well as surveys to locate maternity and winter roosts, are needed to determine population status and trends.

*Additional information.* -- These bats are seldom netted over water or in flyways and their roosts are difficult to find or get to. However, since their echolocation calls are distinctive and field workers can be trained to identify them surveys may be most efficiently conducted by listening for their calls at selected localities.

### Greater Western Mastiff Bat *Eumops perotis californicus*

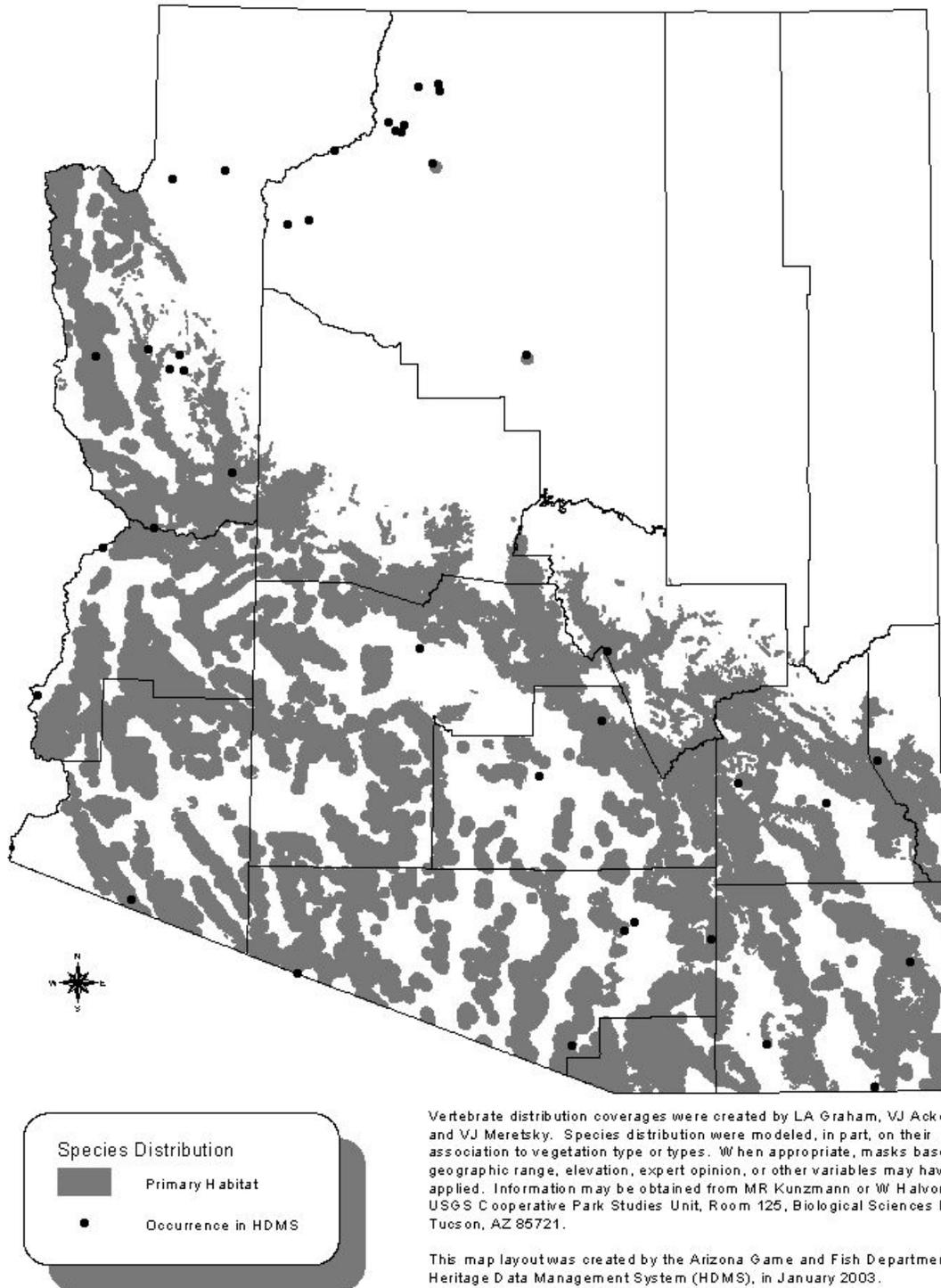


Figure 5: Habitat range and occurrence of the greater western mastiff bat in Arizona. Points represent all occurrences of 1 or more individuals, including netting records.

UNDERWOOD'S MASTIFF BAT – *EUMOPS UNDERWOODI*

*Description.* -- Underwood's mastiff bat is a large bat with a forearm length of 65-74 mm, and a weight of 45-65 g. It has long, narrow wings, with a wingspan of 500-540 mm. The ears are 28-33 mm, and meet at the midline, projecting forward. The ears just reach to tip of nose when laid forward. The tragus is small and rounded. The distal half of the tail is free from the interfemoral membrane. The fur is a rich, dark brown above, somewhat grayish below, and is bicolored, lighter at the base. A few long guard hairs on rump extend 7-10 mm beyond rest of fur. Males have a well-developed gular gland (as in all Molossidae). The skull is short, wide, and unusually strongly ridged.

Underwood's mastiff bat is superficially similar to all other free-tailed bats, but larger than the Mexican free-tailed bat (*Tadarida brasiliensis*), the pocketed free tailed bat (*Nyctinomops femorosaccus*), and the big free-tailed bat (*Nyctinomops macrotis*). Unlike *Tadarida* and *Nyctinomops* the upper lips of *Eumops* species are smooth. Underwood's mastiff bat is most similar to the greater western mastiff bat (*Eumops perotis*) with which it may be sympatric in Arizona. The greater western mastiff bat is slightly larger (forearm 73-83 mm) and has much longer ears (36-47 mm), reaching beyond nose when laid forward, with a broad, square tragus. As well, the greater western mastiff bat lacks the long guard hairs on the rump.

*Distribution and habitat.* – Within Arizona, Underwood's mastiff bat is known from 4 localities near Sasabe and the vicinity of the Baboquivari Mountains; and from Organ Pipe Cactus National Monument, Pima County (Fig. 6). The species is found primarily in Sonora, Mexico, reaching the most northern part of its range just north of the US/Mexico border in Arizona.

Very little is known about the preferred habitat of this species. It has been netted over waterholes in Sonoran desert scrub and mesquite/grassland situations. It has been found at 1000 ft (305 m) at Organ Pipe Cactus National Monument and at 4000 ft (1220 m) near Sasabe.

*Biology.* -- Despite their great size, and formidable dentition, these bats seem rather gentle. Their presence can be detected by their characteristic high pitched "peeps" emitted several times a minute when flying. These "peeps" are quite intense and may actually hurt the ears of an observer if the bat passes too close. Underwood's mastiff bat probably roosts in crevices along steep cliffs, perhaps in cracks of buildings. According to Cockrum (1981) the "day roosts are probably in high (30-40 ft (9-12 m) or more above ground level) rock crevices in steep cliffs." However, they have also been found roosting in saguaro boots (T. Tibbitts, personal communication). The narrow wings provide poor maneuverability, and this bat cannot take off from a flat surface. Water sites for drinking must provide a large open-water surface (15 to 30 ft (4 to 9 m) or more) for the long gliding approach of this bat.

Underwood's mastiff bat is presumably a year-round resident in Arizona. It is active during the warm months and hibernates in high rock crevices during the winter, although it may occasionally be active during the winter. Cockrum (1981) reports male and female bats active at Organ Pipe Cactus National Monument during the months of January, March, May, June, August and September.

These bats apparently have a single young born in late June or July. A female gave birth on July 5 to a normal young which was successfully raised in captivity (Constantine 1961).

Underwood's mastiff bat feeds on night flying insects 6 to 60 mm in length. Ross (1967) found it to take 13% short-horned grasshoppers and 47% scarab beetles. Very little is known about its natural feeding habits.

*Population trends.* -- Population trends for Underwood's mastiff bat are unknown.

*Management factors.* -- Arizona is at the extreme northern edge of the species range for Underwood's mastiff bat. They have a limited United States distribution and few individuals. Life history studies as well as work on distribution, habitat, and populations are needed.

## Underwood's Mastiff Bat *Eumops underwoodi*

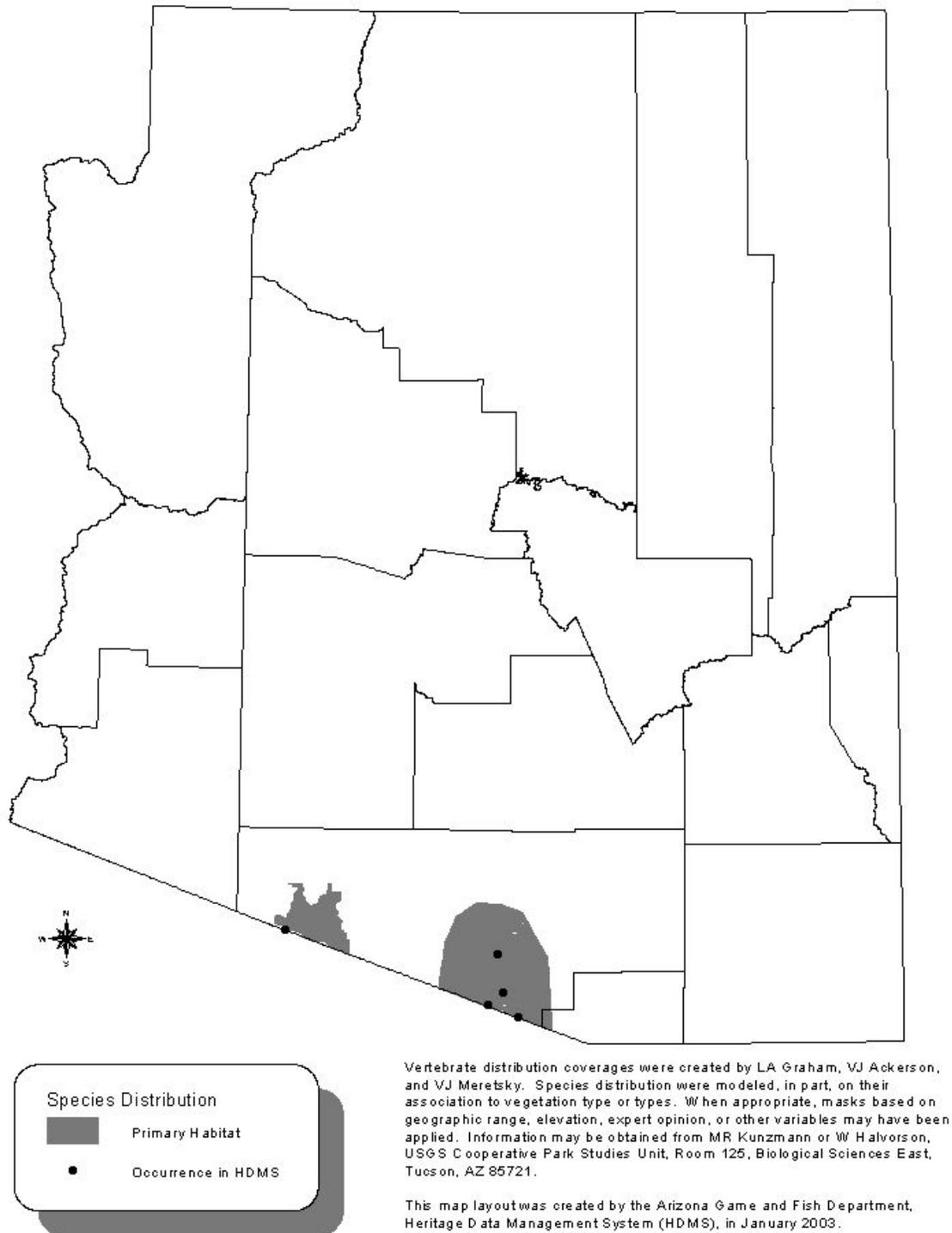


Figure 6: Habitat range and occurrence of Underwood's mastiff bat in Arizona. Points represent all occurrences of 1 or more individuals, including netting records.

POCKETED FREE-TAILED BAT – *NYCTINOMOPS FEMOROSACCUS*

*Description.* -- The pocketed free-tailed bat is a small to medium sized bat with long narrow wings (wingspread 330-360 mm) and a forearm length of 44-50 mm. The tail protrudes free from the interfemoral membrane. The ears are joined at the base. Long hairs protrude from the toes. The color is from dark brown to gray, sometimes reddish with underparts pale with the basal half of hairs nearly white.

The pocketed free-tailed bat may be distinguished from the Mexican free-tailed bat (*Tadarida brasiliensis*) by the ears, which do not join at the midline in the Mexican free-tailed bat. All other free-tailed bats in the United States are larger than the pocketed free-tailed bat, with adults having forearm measurements greater than 55 mm.

*Distribution and habitat.* – Within Arizona, the pocketed free-tailed bat is found from Lake Mead southward below the Mogollon Rim (Fig. 7). Overall species range is from southern California to the Big Bend area of Texas, south through Baja California and central-western Mexico to central Mexico.

Elevation range for the pocketed free-tailed bat is from 190 to 7520 ft (58-2294 m), but it is usually found in arid lower elevations around high cliffs and rugged rock outcrops.

*Biology.* -- Females produce 1 young, late June and early July in Tucson, Arizona. Pregnant and lactating females have been captured in June and July in Texas. Colonies usually consist of less than 100 individuals. This species roosts in rock crevices during the day and may also use human built structures. Pocketed free-tailed bats can be very noisy during day, and may draw attention to their hiding place.

The pocketed free-tailed bat is insectivorous and feeds primarily on large moths. It usually leaves its daytime roosts in the evening, well after dark.

*Population trends.* -- Population trends for the pocketed free-tailed bat are unknown.

*Management factors.* -- Surveys should be conducted to locate roost and to ensure that they are protected from human disturbance. Although this species is found frequently in southern Arizona, information on natural history and habitat requirements is sorely lacking. Research on these factors, as well as information on population sizes and trends, is needed to make specific management recommendations.

### Pocketed Free-tailed Bat *Nyctinomops femorosaccus*

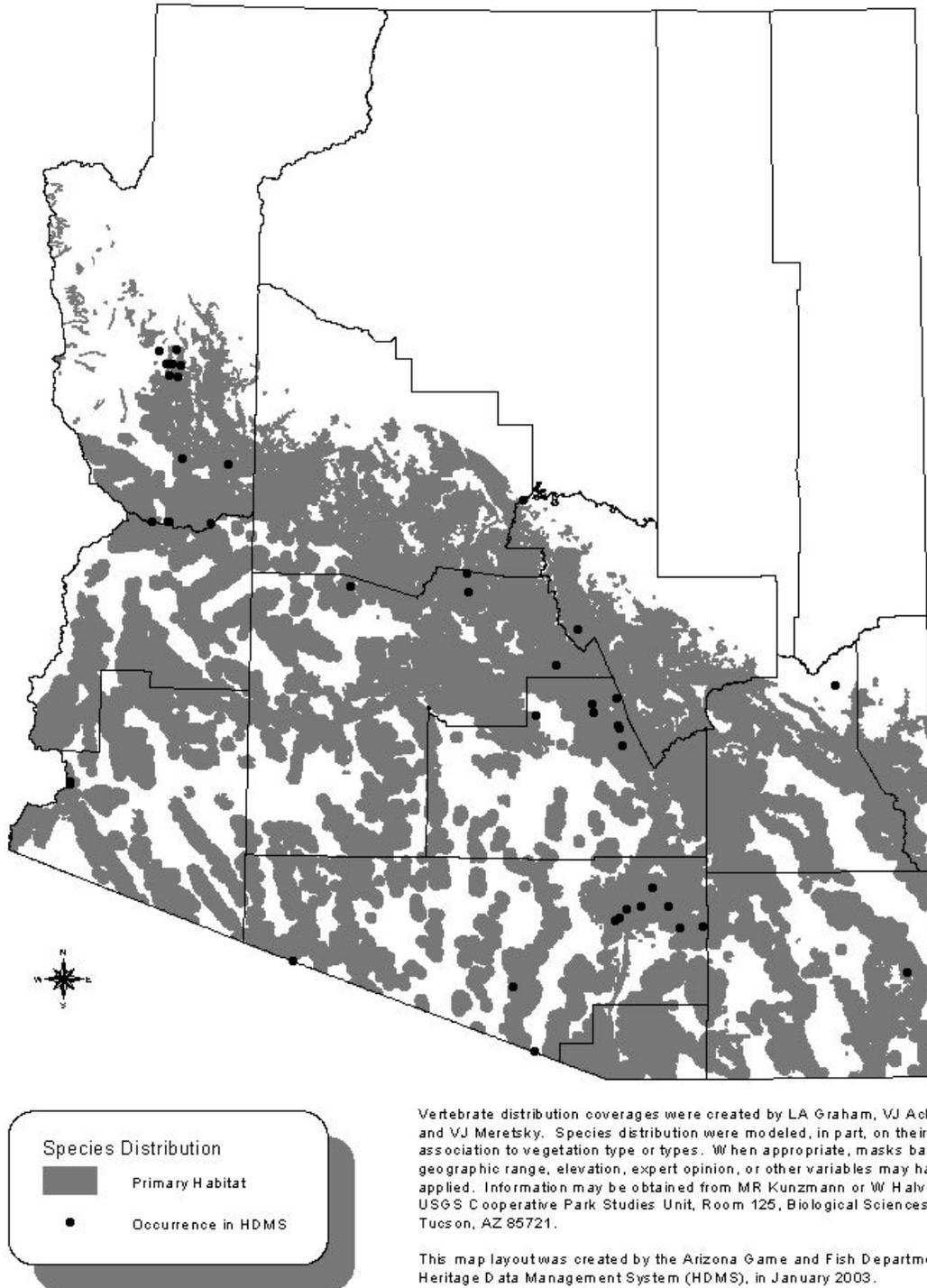


Figure 7: Habitat range and occurrence of the pocketed free-tailed bat in Arizona. Points represent all occurrences of 1 or more individuals, including netting records.

BIG FREE-TAILED BAT – *NYCTINOMOPS MACROTIS*

*Description.* -- The big free-tailed bat is a rather large bat, with a forearm length of 58-64 mm, a wingspread of 417-436 mm, and weighing 22-30 g. Its tail extends 10-15 mm beyond the interfemoral membrane. The ears are joined basally in midline and are large, extending well beyond end of rostrum when laid forward. Ears have wart-like bodies on anterior edges (Ingles 1954). The big free-tailed bat's fur is glossy with dorsal color varying from light reddish brown to dark brown and underparts similarly colored but paler. The hair is bicolored with the basal portion being white.

The big free-tailed bat is larger than both the Mexican free-tailed bat (*Tadarida brasiliensis*) and the pocketed free-tailed bat (*Nyctinomops femorosaccus*). The greater western mastiff bat (*Eumops perotis*) and Underwood's mastiff bat (*Eumops underwoodi*) are both larger than the big free-tailed bat. The big free-tailed bat is most similar to Wagner's mastiff bat (*Eumops glaucinus*), but in the United States, Wagner's mastiff bat is restricted to southern Florida whereas the big free-tailed bat is found only in the west.

*Distribution and habitat.* -- The big free-tailed bat is widely spread throughout Arizona, but probably absent from the Mogollon Plateau (Fig. 8). In winter, it is found in southern Arizona. Overall species range is from northern South America and the Caribbean Islands northward into the western United States. Breeding populations are common in New Mexico, Arizona, Texas, and Utah, and big free-tailed bats have been reported as far away from brood sites as Iowa and British Columbia. Throughout September and October of 2000 and 2001, the big free-tailed bat was a common migrant along the Muddy River in southern Nevada (Williams 2001). Northern limits of this species's winter range have yet to be determined.

The big free-tailed bat primarily inhabits rugged, rocky country and riparian areas at elevations of 1810 - 8475 ft (552 - 2585 m). Associated plant species include creosote bush, blackbrush, sandsage, snakeweed, salt cedar, water willow, mesquite, and rabbitbrush.

*Biology.* -- Big free-tailed bats apparently spend the day in crevices in rock cliffs. However, only 1 day roost was known as of 1969. In spite of local abundance, this species is not found in many places where habitat seems suitable, although this observation could be a result of poor sampling strategies. Big free-tailed bats are unpredictable in abundance. They emerge for feeding relatively late, about 40 minutes after the pipistrelles, and leave the roost in small groups.

Females have 1 young. It is assumed that females form nursery colonies based upon observations of a number of females being caught in a single area during birthing season in June. One description of a probable maternal roost site is a crevice "about 20 ft [6 m] long and 6 in [15 cm] wide on the side of a cliff some 40 ft [12 m] above a talus slope" (Barbour and Davis 1969).

Big free-tailed bats feed almost exclusively on large moths but crickets and long horned grasshoppers are occasionally taken.

*Population trends.* – Big free-tailed bat populations appear to be stable although the species is not common except sometimes locally, and even then, not consistently.

*Management factors.* -- This species is readily captured in mist nets. They apparently commonly impale themselves on cactus while in pursuit of insects.

Needed projects include surveys for maternity colonies and other day roosts, as well as determination of the species's winter range.

## Big Free-tailed Bat *Nyctinomops macrotis*

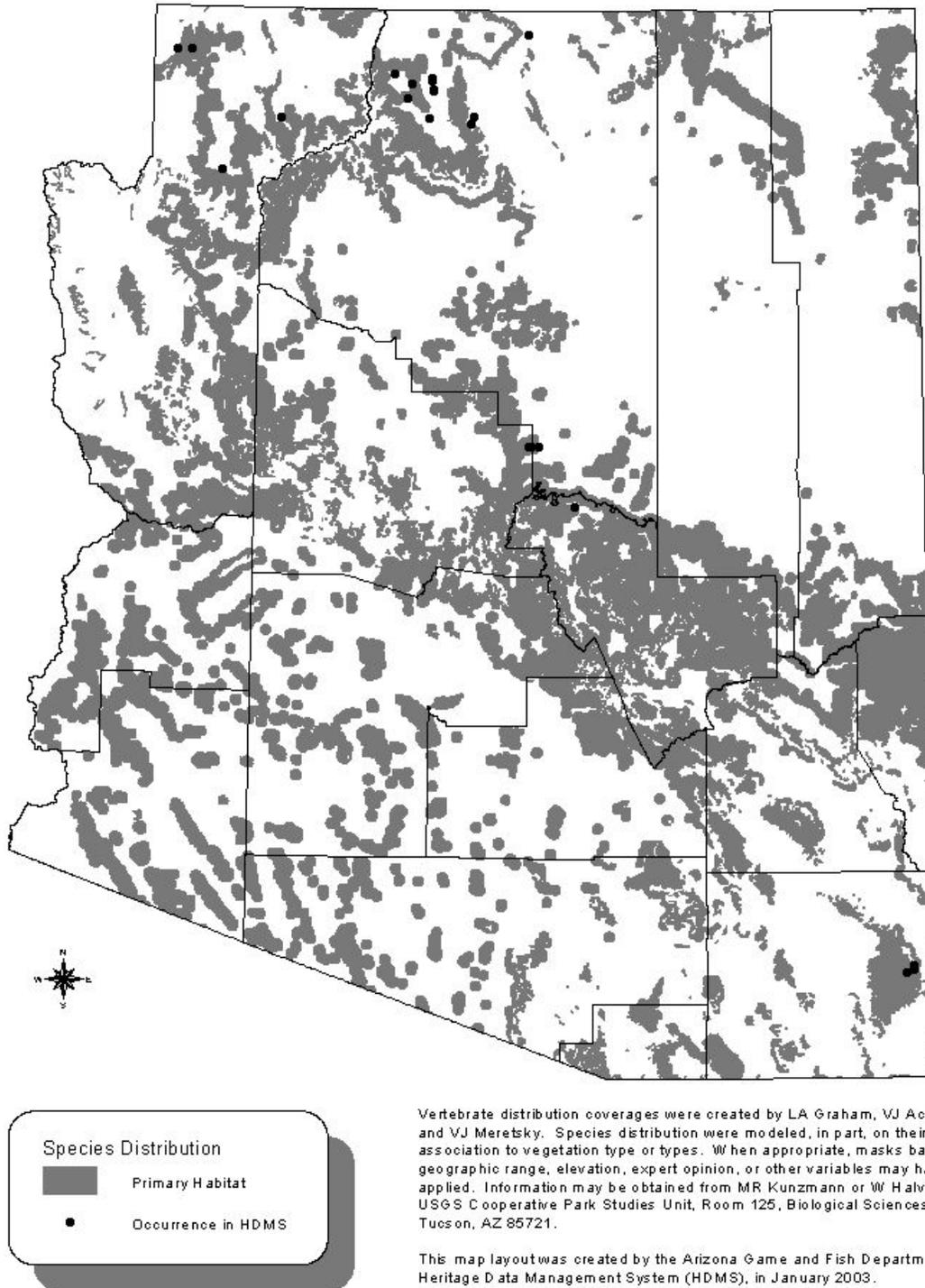


Figure 8: Habitat range and occurrence of the big free-tailed bat in Arizona. Points represent all occurrences of 1 or more individuals, including netting records.

MEXICAN FREE-TAILED BAT – *TADARIDA BRASILIENSIS*

*Description.* -- The Mexican free-tailed bat is small to medium-sized, with a forearm length of 36-46 mm, and a wingspread of 290-325 mm. It is dark gray to smoky brown, with hair of uniform color. It has short velvety fur with nearly black muzzle and membranes. Its leathery wings are long, slender, and pointed. The tail extends noticeably beyond trailing edge of interfemoral membrane. Large, round ears bear a series of small papillae on leading edge and lie forward along head, above eyes. This bat is snub-nosed with wrinkled upper lips.

The deep vertical grooves on the upper lip aid in identification. When its ears are laid forward, they do not extend appreciably beyond muzzle. It may be distinguished from the pocketed free-tailed bat (*Nyctinomops femorosaccus*) by its ears, which do not join at the midline.

*Distribution and habitat.* – The Mexican free-tailed bat is found throughout Arizona in the summer (Fig. 9), but in the winter is found in lesser numbers in only the southern half of the state. The northern range of this species extends to southern Oregon, Nevada, northern Utah, northern Nebraska into Arkansas, northern Alabama, Mississippi, and Georgia, and southern North Carolina. It ranges southward through most of Central America and into at least 7 South American provinces and into the Caribbean islands.

These migratory bats move northward from southern Arizona and Mexico in the spring to the Lower Sonoran and Upper Sonoran life zones. Considered primarily a lowland species, they do sometimes range into the highlands. Overall elevational range is from 450 to 8437 ft (137-2573 m). Associated plant communities include desert scrub and coniferous forests.

*Biology.* -- The Mexican free-tailed bat has been found roosting in caves, mine tunnels, and crevices in bridges, parking garages, and buildings. Some of these roosts are used only in the spring and autumn by bats as transient or resting roosts on their annual migrations north and south. According to Bailey (1971), the odor of musk that these bats emit is so strong that from outside a building, a colony can be detected. Avian predators on Mexican free-tailed bats include American kestrels, Mississippi kites, red-tailed hawks, roadrunners, and Great horned owls.

Mexican free-tailed bats probably breed in the lower latitudes in late February and early March. Ovulation occurs in late March. In Texas, the gestation period appears to be about 90 days; in California, 100 days. One or 2 young per female born in mid-June to early July. Births may occur over long period of time. However, the majority take place within 10 days of each other. During the day, young hang in dense groups away from females. Each mother locates and nurses her own young in the large colonies. Young are nursed in the afternoon, and again when females return from foraging in the night. Young develop rapidly and are flying in about 5 weeks.

Adult Mexican free-tailed bats emerge about sundown to feed. According to Barbour and Davis (1969), "The stream of bats is shaped like an undulating tube with a diameter of about 30 ft [9 m]. The column slopes gradually upward to a height of about 500 ft [152 m] where it divides into small flocks of bats." They feed primarily on moths (90%) and numerous other insects in small amounts. They probably hunt in groups. It is estimated that where there are nurseries with

populations into the multimillions, the annual consumption of insects would be about 40,000,000 lbs (18,144,000 kg).

*Population trends.* -- Mexican free-tailed bat populations appear stable. However, recent surveys in Arizona indicate that numbers have severely declined at several important roosts. Whether this reflects actual population decreases or merely relocation has not yet been determined.

*Management factors.* -- Pesticides may constitute a large threat to this species, especially since they frequently eat crop pests. Pesticides have been blamed for the decline in numbers at Eagle Creek Cave in the 1960's, although this has not been confirmed. Fat-soluble pesticide use should be restricted in areas where Mexican free-tailed bats are foraging.

Mapping of migration routes is sorely needed, as is identification and protection of maternity roosts.

Mexican free-tailed bats are commonly found in urban roosts, such as bridges and buildings. Where possible, these roosts should be protected. Such roosts may also provide the opportunity for bat-watching areas and interpretive signs.

### Mexican Free-tailed Bat *Tadarida brasiliensis*

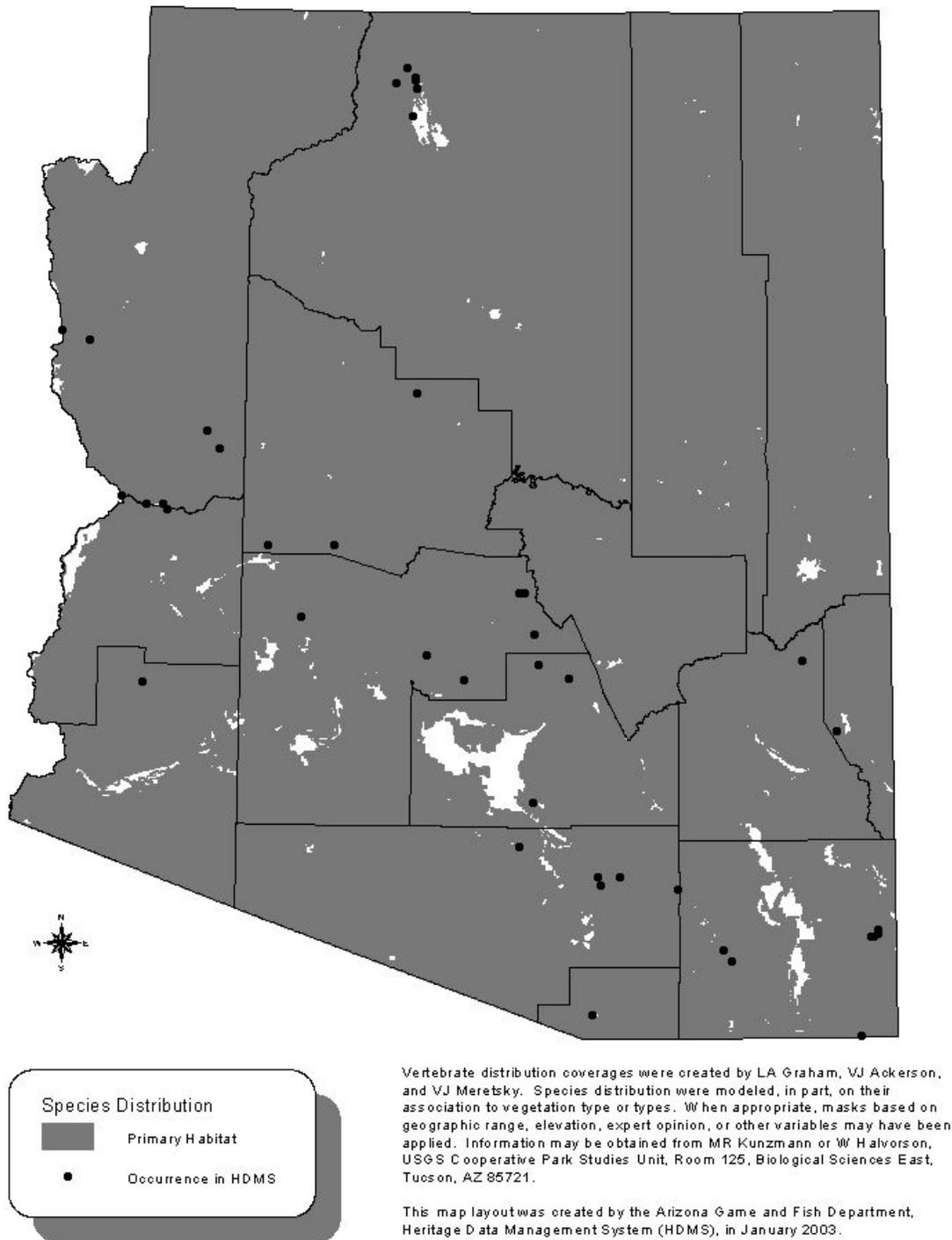


Figure 9: Habitat range and occurrence of the Mexican free-tailed bat in Arizona. Points represent maternity colonies, roosts of 10 or more individuals, and sites where 3 or more pregnant or lactating females have been netted.

PALLID BAT – *ANTROZOUS PALLIDUS*

*Description.* – The pallid bat has a forearm length of 48-60 mm, with a wingspread of 360-390 mm. It has large ears (31-36 mm) in which the tragus has a wavy edge. Pallid bats weigh 21.4-22.2 g. The fur is light yellow, washed with brown or gray with underparts pale cream, almost white. Females are larger than males.

The ears are grayish-tan, separated at base, and reach far beyond the muzzle when laid forward. This is the only bat which has distal tips of dorsal hairs darker than base. All other bats have opposite coloration. The pallid bat has scent glands on each side of the muzzle, when excited it will secrete a few drops of an odoriferous material unique to this species.

*Distribution and habitat.* -- Pallid bats are found throughout the state in the summer (Fig. 10) and in the southern part of the state in the winter. The species range includes western North America from south-central British Columbia south through the western United States to central Mexico. This species is also known from 2 recent localities in Cuba.

Pallid bats are found in a variety of habitat types including coniferous and non-coniferous forests, brushy terrain, rocky canyons, scrub grassland, open farmland, and deserts where suitable roosts exist. Elevational range is less than 8000 ft (2440 m) and generally from 210 – 6850 ft (64 – 2089 m).

*Biology.* -- The pallid bat prefers to roost in rock crevices, buildings and occasionally in mines, caves, and hollow trees during the day. A suitable site must provide protection from precipitation, inaccessibility to predators, a microenvironment with moderate daily temperature changes, shelter from direct sunlight, a space large enough for more than 2 dozen bats, and an unobstructed entrance at least 5 ft (1.5 m) above the ground to allow the bat to drop for flight. Night roosts include buildings, bridges, rock overhangs, and other sheltered places that are open and offer easy accessibility by flight. Pallid bats often roost with bats of different species. If the bat becomes too warm, it may salivate and pant to cool itself.

This species is a slow flyer without especially good maneuverability. However, pallid bats are able to walk on the ground with a variety of strides and gaits, and they can hover or glide momentarily. Pallid bats emit a skunk-like odor that may be used as a defense mechanism.

Breeding does not begin until after the summer colonies have dispersed in autumn. Breeding then occurs sporadically throughout the winter. Sperm is retained within the female through the winter with delayed fertilization taking place in the spring. Nursery colonies begin forming in April. Males, with the exception of some young of the previous year, are excluded from these colonies. Young are born over a 2 week period beginning in late May or June. Adult females usually give birth to 2 young, while yearling females give birth to only 1 young. During parturition, the females hang upright by their thumbs with their uropatagium curled upright forming a basket. Young are born breech first. As soon as the feet are free, the baby aids itself in birth by pushing against the mother. The young then attach themselves to the mother's teat with the help of the mother who then covers the young with her wing. Females apparently nurse only their own young. The young's eyes open in 2-5 days, ears open in 5-14 days, hair develops in 14-

21 days and it is flying in 33-36 days. Young bats reach adult size in 5-7 weeks, but do not attain adult weight until the following year. Pallid bats become sexually mature at about 2 years of age. Cockrum (1973) has a record of a Pallid bat banded in Arizona that lived 9 years.

The pallid bat feeds less on the wing than other bats, consuming a large variety of ground-dwelling insects. Aside from a size preference of insects larger than 17 mm, it selects no particular species as prey. In addition to moths, crickets, beetles, and antlions, this species will also feed on scorpions and centipedes. They have also been found to consume lizards and rodents (Harvey and others 1999). The Pallid bat can consume up to half its weight in insects every night. After catching prey the bats return to their night roost to eat their catch. Foraging peaks at the beginning and the end of the nocturnal activity cycle. They use passive sound in addition to echolocation to home in on their slow moving targets on the desert floor or in low brush. Pallid bats are known to visit flowers and are pollinators of several species of cactus. However, the bats do not appear to be feeding on the nectar, rather the insects found within. The pallid bat is considered a legitimate pollinator of bat-adapted CAM plants (Herrera and others 1993).

*Population trends.* -- Pallid bat populations appear to be stable.

*Management factors.* -- Pallid bats may be susceptible to disturbances at the roost (Hoffmeister 1986). More information on winter roosts and habits in Arizona will increase the effectiveness of management activities, as will research on differential resource use in diverse habitats (desertscrub, grasslands, woodlands).

### Pallid Bat *Antrozous pallidus*

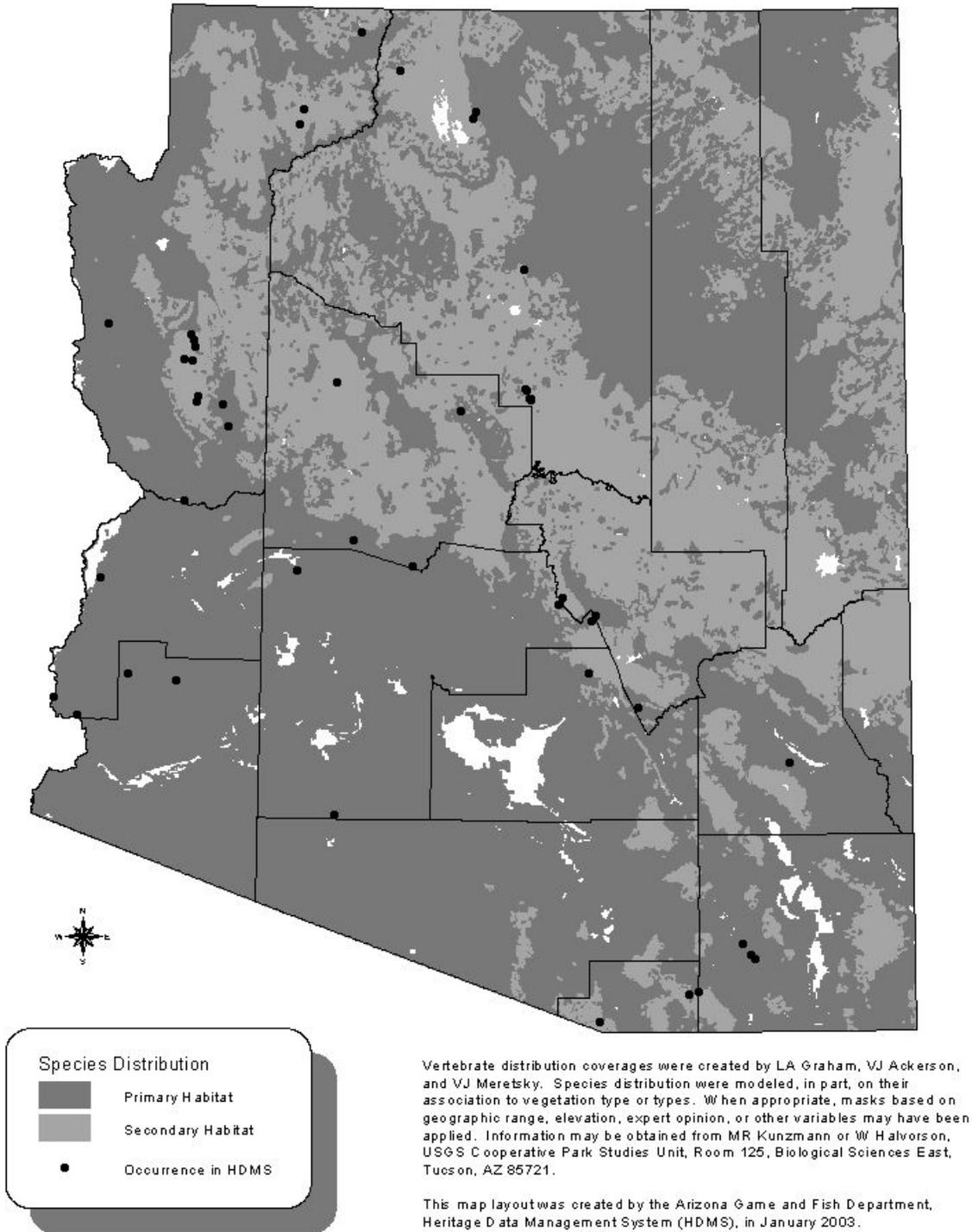


Figure 10: Habitat range and occurrence of the pallid bat in Arizona. Points represent maternity colonies, roosts, and sites where 3 or more pregnant or lactating females have been netted.

TOWNSEND'S BIG-EARED BAT – *CORYNORHINUS TOWNSENDII*

*Description.* -- Townsend's big-eared bat is a medium-sized bat, with a forearm length of 39-47 mm, weighing 9-12 g. It is pale, yellowish-brown in color. Ears are large and hairless ears (30-39 mm in length), and there is a large glandular lump on each side of the nose.

Townsend's big-eared bat is distinguished from all but 4 species of Arizona bats by its large ears. The presence of a pair of glandular lumps on the nose distinguishes Townsend's big-eared bat from the other 4 big-eared species: the California leaf-nosed bat (*Macrotus californicus*), the spotted bat (*Euderma maculatum*), Allen's lappet-browed bat (*Idionycteris phyllotis*), and the pallid bat (*Antrozous pallidus*). Townsend's big-eared bat can be distinguished by its unicuspid first upper incisor from the Mexican big-eared bat (*Corynorhinus mexicanus*, a Mexican species whose range in northeastern Sonora extends to within a few miles of Arizona's southeastern border), which has a bicuspid first upper incisor. Additionally when compared with the Mexican big-eared bat, Townsend's big-eared bat is distinguished by its dorsal hairs having bases much lighter than tips rather than bases and tips being almost the same color; crossribs in tail membrane usually >9.0 mm rather than fewer; tragus usually >13.0 mm rather than less.

At day roosts this species may be suspected when guano is found in circular patches in open areas. The California leaf-nosed bat may be suspected if the guano is found at the edges of open areas (i.e. near the base of the sides or walls of a mine or other roost).

*Distribution and habitat.* -- Townsend's big-eared bat is widespread in Arizona, although it is not considered common anywhere, and is least common in northeastern grasslands and southwestern desert areas (Fig. 11). The species ranges throughout western North America from southern British Columbia south through the Pacific Northwest and southern California on the west and the Black Hills of South Dakota and West Texas on the east through the Mexican uplands to the Isthmus of Tehuantepec in southern Mexico. It is not known from the Baja California peninsula. Isolated occurrences in the southern Great Plains, Ozark Mountains and Appalachian Mountains are considered to be relict populations.

In Arizona, summer day roosts are found in caves and mines from desertscrub up to oak woodlands, and oak / pine, pinyon / juniper, and coniferous forests. Night roosts may often be in abandoned buildings. In winter, they hibernate in cold caves, lava tubes and mines mostly in uplands and mountains from the vicinity of the Grand Canyon to the southeastern part of the state. Townsend's big-eared bat has been found from 550 to 7520 ft (168 - 2294 m). Most records, however, seem to come from above 3000 ft (915 m).

*Biology.* -- These bats prefer to hang from open ceilings at roost sites and do not use cracks or crevices. At maternity roosts these bats apparently prefer dim light near the edge of the lighted zone. In Arizona, emergence times and especially return times and patterns probably vary as they do elsewhere depending on insect activity and development stage of young.

Winter roosts generally contain fewer individuals (usually singles or small groups and in Arizona occasionally as many as 50) than summer roosts. For hibernation they prefer roost sites with temperatures between about 32° and 54°F (0° and 12° C). These may be near entrances and in

well-ventilated areas of the roost. The bats may arouse and move to other spots in the roost during the winter so as to be in areas of more stable cold temperatures. The ears are erectile and can be collapsed and rolled up while at rest and expanded to usual size when alert.

Males and females congregate separately in summer. Although the males are thought to be mostly solitary, the females form maternity colonies of 12 to about 200 in the western United States. In Arizona, 5 to 7 maternity colonies have been found with numbers from about 100 to several hundreds. In Arizona females are pregnant in April and maternity colonies have been reported in late April. Indirect evidence (near term embryos and presence of newborns) indicates the single young are born in June in Arizona. Dates of birth vary considerably throughout their range being reported from late April to mid July. In Arizona most young are flying by the end of July. Elsewhere young are weaned at about 6 to 8 weeks. Nursery colonies begin to disperse during August. Following mating in autumn and winter (when it sometimes takes place while the female is torpid) sperm is stored in the female's reproductive tract until spring. Fertilization occurs when ovulation takes place.

Males in their first autumn produce few sperm and are thus thought to be essentially sterile and probably nonbreeding. Females in their first autumn do breed and bear young the following summer. Gestation varies from 56 to 100 days after fertilization depending on climatic conditions and the resultant metabolic rates of the females (i.e. development slows when females go into daily torpor). Band recoveries in California suggest a maximum longevity of 16+ years.

Small moths, 3-10 mm (average ~ 6 mm), are the primary food of these bats. Neuropterans, coleopterans, dipterans and hymenopterans are also sometimes taken. They are reported to take prey from leaves and while in flight along forested edges. Following a late night peak of activity they usually go to a night roost. They may forage again in the early morning since they are reported not to return to their daytime roosts until shortly before sunrise. They may forage 4-5 miles from the roost site.

*Population trends.* -- Population trends for Townsend's big-eared bats are unclear, though there have been losses or reductions of maternity colonies reported.

*Management factors.* -- Maternity colonies are easily disturbed resulting in abandonment. Surveys need to be carried out to locate, census, and monitor maternity colonies, and to determine patterns of movement and roost-switching. Studies should also be carried out to identify habitat needs and differential habitat use by bachelor and maternity colonies.

In 1999, the Idaho Conservation Effort produced the "Species conservation assessment and conservation strategy for the Townsend's big-eared bat" (Pierson and others 1999). A memorandum of understanding between the members of the Western Association of Fish and Wildlife Agencies adopted implementation of this strategy and specific conservation actions on behalf of this species in 2001.

*Additional information.* -- These bats are versatile in their flight. They may dart swiftly from place to place, fly slowly and deliberately, or even hover. This maneuverability can make them difficult to capture with hand or mist nets or to corner in enclosed mine tunnels or buildings.

### Townsend's Big-eared Bat *Corynorhinus townsendii*

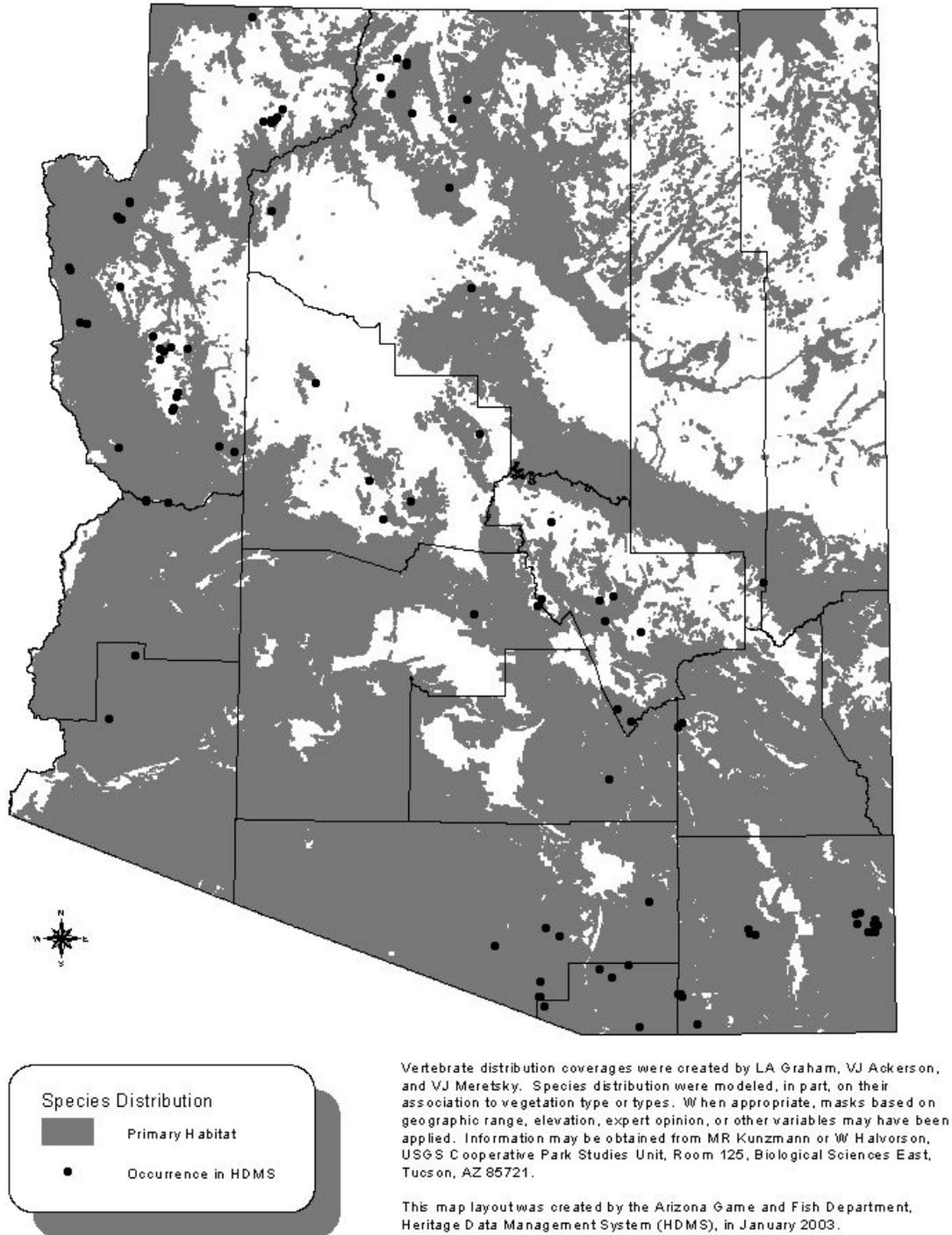


Figure 11: Habitat range and occurrence of Townsend's big-eared bat in Arizona. Points represent maternity colonies, roosts of 5 or more individuals, sites where 5 or more males have been netted, and sites where pregnant or lactating females have been netted.

SPOTTED BAT – *EUDERMA MACULATUM*

*Description.* -- The spotted bat is a medium sized bat with a forearm length of 48-51 mm. Dorsal fur is black with 3 large white spots, 1 on each shoulder and 1 at base of tail. All hairs black at base, but those on underparts are white tipped and conceal black bases. Ears pinkish-red and long (51 mm, largest of any North American bat). Ears curled at rest but erect and pointing forward when alert. Circular, bare throat patch is distinctive.

Black and white color pattern and enormous pink ears are unique and unmistakable. Researchers report that its voice is distinctive and that workers can learn to recognize it in the field. Its voice is described as a series of soft but high-pitched, metallic squeaks. Its voice has also been reported as similar to Allen's lappet-browed bat (*Idionycteris phyllotis*) but higher pitched.

*Distribution and habitat.* -- In Arizona, specimens have been found near Yuma, Roll, Maricopa Junction, Tempe and Littlefield. They have also been recorded from the Kaibab Plateau (Berna 1990), and southeast of Seligman (M. Senn, AGFD, personal communication) (Fig. 12). There appears to be a substantial population in Fort Pierce Wash area on the Utah-Arizona border, with 2 individuals netted nearby in Arizona (M. Herder and R. Price, BLM, personal communication). Two individuals were captured at a known roost near Marble Canyon (AGFD 1996). Aural records exist for eastern Arizona. The species is locally distributed throughout central western North America from southern British Columbia and Montana, south through California and Big Bend, Texas to Durango and Queretaro in Mexico.

Habitat associations vary over this species's range. In Arizona it is mostly collected in dry, rough desertscrub with a few captured or heard in ponderosa pine forest. This bat has been found from low desert in southwestern Arizona to high desert and riparian habitats in northwestern Arizona and Utah, and conifer forests in northern Arizona and other western states. One specimen in New Mexico was found in spruce-fir. The spotted bat is considered by some biologists to be an elevational migrant. Roost site characteristics and site localities are poorly known, but limited observations suggest that they prefer to roost singly in crevices and cracks in cliff faces. Cliffs and water sources are characteristic of localities where it occurs. Observations from British Columbia suggest that *Euderma* may change roost sites after July.

Williams (2001) collected 616 minutes of *E. maculatum* activity during a year-long intensive acoustic based habitat preference study in the upper Moapa Valley, southern Nevada. In the study region, *E. maculatum* is primarily found over mesquite bosque habitat (62%, n= 381), secondarily over riparian marsh habitat (28%, n = 172), infrequently over riparian shrubland habitat (10%, n = 61), and avoids palm grove habitat (0.3%, n = 2). The only specimen captured was via mist net and was approximately 15 cm above riparian marsh habitat.

Specimen localities in Arizona range from elevations of 110 to 8670 ft (34 - 2644 m). Over its whole range it has been found at localities ranging from 180 ft (55 m) below sea level in California to 10,600 ft (3230 m) above sea level in New Mexico.

*Biology.* -- This species may be active in winter under some conditions. Netting in southwestern Utah from November to March, Poche (no date) captured 7 spotted bats on 2 occasions in

January and February at ambient temperatures of -25° to -23°F (-5° to -4°C) and relative humidities from 41% to 76%. In 2000, the spotted bat was a common species in the upper Moapa Valley, southern Nevada, from late spring through autumn, and absent by the end of November (Williams, 2001). The spotted bat is apparently relatively solitary but may hibernate in small clusters (Whitaker 1980). In British Columbia, roosted solitarily during active season; appeared to maintain exclusive foraging areas (Leonard and Fenton 1983); foraged up to 3.7-6.2 mi (6-10 km) from day roost each night (Wai-Ping and Fenton 1989). Apparently this bat is a rapid flyer. Many of them are injured in the mist nets, indicating a high rate of speed at the collision (Snow 1974).

Reproductive behavior for spotted bats is relatively unknown. Limited observations indicate 1 young per female per year. Young are apparently born from late May to early July elsewhere, but no records exist from Arizona. Lactating females have been captured in June, July and August.

Limited evidence suggests that moths (5-11 mm in size) are the dominant food item. These are usually taken by bats hunting alone, using echolocation calls of moderate intensity in the range of 8000 to 15,000 cycles per second. Sounds in this frequency range are audible to humans, but are of too low a frequency for detection by tympanate moths. These moths have evolved thoracic "ears" which enable them to detect the higher frequency echolocation calls emitted by other insectivorous bats, and subsequently evade them. Other occasional prey items include June beetles and sometimes grasshoppers taken while on the ground.

The spotted bat makes a wide variety of sounds in communicating and foraging. The voice has been described as sounding like a soft, extremely high-pitched metallic squeak; a hissing noise and a rat like squeak; and a typical bat chirp. This bat has also been heard clicking the teeth together and making grinding noises by gnashing the teeth. Previous to taking flight, the spotted bat makes clicking or ticking notes (Snow 1974).

The low frequency of the echolocation call is useful in both hunting and communications. Due to reduced attenuation and good propagation qualities, the call is good for long-range detection of prey and an increased range of audibility by other bats. The bat is also able to approach the moth more closely and enhance the chance of a successful pursuit due to the moth not being able to detect the low intensity of sound (van Zyll de Jong 1985). Similar calls are made by Allen's lappet-browed bat (*Idionycteris phyllotis*), the big free-tailed bat (*Nyctinomops macrotis*), and the greater western mastiff bat (*Eumops perotis*) (Snow 1974).

Monitoring of echolocation calls indicate this bat forages throughout the night in British Columbia and Colorado even though capture records from earlier years indicate late-night activity. It has also been seen in these areas foraging at about 33 ft (10 m) above the ground. In Colorado it was heard foraging over pinyon-juniper, riparian vegetation, sand-and-gravel bars, over a river in a deep, steep-walled canyon, and campgrounds. In British Columbia they were documented foraging over marsh areas. According to NatureServe (2001), the spotted bat hunts alone, and at least sometimes appears to maintain an exclusive foraging area (Leonard and Fenton 1983). Neighboring bats show evidence of mutual avoidance and have been observed to turn away when encountering one another near the boundaries of their hunting areas. This mutual avoidance has been interpreted as a mechanism to avoid competition. When the neighbor is

absent, an individual may show no hesitation in flying into an area avoided earlier. It is believed that a combination of the bat's echolocation call and conspicuous color pattern are used to maintain the spacing between bats (van Zyll de Jong 1985).

*Population trends.* -- The spotted bat was not encountered by biologists until 1891 and then only as dead specimens. No specimens were taken alive until the early 1960s. This species was initially thought to be extremely rare and in very low numbers. Increasing numbers of field workers focusing on the species and slowly improving understanding of habitat and roost occurrences have increased reports and captures. Spotted bats are now known to occupy a wider total range than initially thought and do not appear to be as rare as initially thought. Population abundance and densities are very poorly known.

*Management factors.* -- Numbers of this species seem to be limited, and natural history requirements are poorly known. According to NatureServe (2001), they are moderately threatened range-wide. Because of the lack of sufficient information, only speculations can be made about threats. Habitat destruction, such as construction of dams that inundate high cliffs and canyon walls, possibly is a threat (Snow 1974). Fenton (*in* NatureServe 2001) stated that the 2 highest threats to spotted bats appeared to be collection of specimens by humans, and the use of pesticides that the bats may accumulate through their diet and that kill their prey.

Suggested projects for this species include determining the summer and winter distribution, roost characteristics, and foraging areas. According to NatureServe (2001) the following is recommended: determine the presence of the spotted bat by surveying likely habitat, establish and maintain waterholes in likely spotted bat habitat (it is well known that the bat will fly for several miles to find water, and a water hole will benefit many species), support and cooperate in studies to determine more about the impacts by humans. Also of interest is research into differential resource use by the spotted bat in different habitat types (forests, riparian areas, grasslands).

### Spotted Bat *Euderma maculatum*

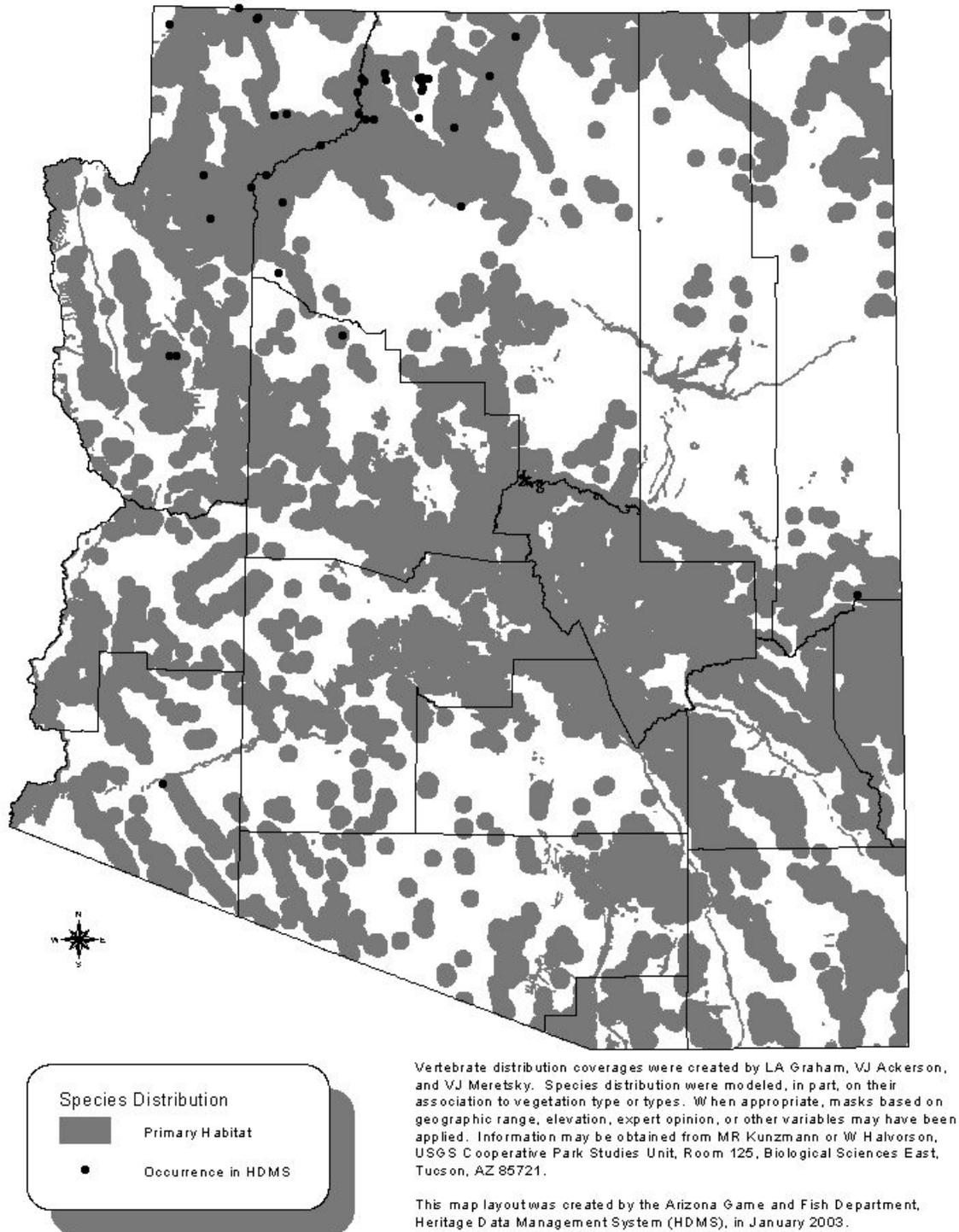


Figure 12: Habitat range and occurrence of the spotted bat in Arizona. Points represent all occurrences of 1 or more individuals, including netting records.

ALLEN'S LAPPET-BROWED BAT – *IDIONYCTERIS PHYLLOTIS*

*Description.* -- Allen's lappet-browed bat is a medium-sized bat. Fur is tawny on the back with hairs dark brown at base; underparts slightly lighter. It has no fur on its wings or membranes. It has large ears (40 mm long, tragus-16 mm), with 2 flaps (lappets) projecting forward from the base of the ears. The ears are often protected by folding and coiling them into "rams' horns," which lay along the sides of the bat's neck. There are no glandular enlargements on muzzle. The calcar is keeled.

The presence of the forward-projecting lappets at the base of the ears distinguish Allen's lappet-browed bat from the other 4 big-eared bats with which it may be confused: the spotted bat (*Euderma maculatum*), the pallid bat (*Antrozous pallidus*), the California leaf-nosed bat (*Macrotus californicus*), and Townsend's big-eared bat (*Corynorhinus townsendii*). Its call is a loud, distinctive "peep" at about 1 second intervals, similar to the spotted bat but lower in pitch. They also emit a "rapid clicking" or "low, barely audible cheeping" much like Townsend's big-eared bat.

*Distribution and habitat.* -- Allen's lappet-browed bat specimen locations range across most of Arizona, but it is not known from the southwestern deserts of Arizona. Most Arizona specimens have been taken from the southern Colorado Plateau, the Mogollon Rim and adjacent mountain ranges (Fig. 13). Species range is from the central highlands of Mexico from the Distrito Federal, San Luis Potosi, Tamaulipas and Durango northward into west-central New Mexico to the Colorado River Valley, Arizona, mostly at higher elevations (Barbour and Davis 1969). Typically found in mountainous regions. Seasonal movements and cold season whereabouts unknown.

In Arizona, this species is taken most often in ponderosa pine, pinyon-juniper, Mexican woodland and riparian areas of sycamores, cottonwoods and willows. It has also been collected in white fir and in Mohave desertscrub. There are boulder piles, cliffs, rocky outcrops or lava flows at or near most collection locations. It is typically netted along streams or over ponds where the bats may be seeking insects, water or both. Elevation range is from 1320 ft (403 m) to 9800 ft (3225 m), but most specimens are at altitudes of 3500-7500 ft (1100 –2500 m).

*Biology.* -- Allen's lappet-browed bat is capable of highly maneuverable flight; it can hover and even fly vertically. Flight is characterized by "swift, direct flights from one place to another, interspersed with slower flights and by occasional near hoverings, as if the bat were carefully seeking an exit" (Barbour and Davis 1969). This species roosts in caves and abandoned mine shafts, and their roosts are often loosely associated with roosts of Townsend's big-eared bat, the California myotis (*Myotis californicus*), and the fringed myotis (*Myotis thysanodes*). Allen's lappet-browed bat is also fairly common in tree roosts on the Coconino and Apache-Sitgreaves National Forests, in Arizona (AGFD 1996). There is no information on male or winter roosts, with the exception of 1 individual observed in February, 1992, in a through and through adit in the Union Pass area near Kingman (B. Spicer, AGFD, personal communication).

Reproduction in this species is very poorly known. Females form maternity colonies in the early summer. Males are possibly solitary roosting during this time. Young are born mid to late June in

Arizona, and begin to fledge by late July. Arizona maternity roosts are known from the Kingman area and the Aravaipa Canyon area at the north end of the Galiuro Mountains. Lactating females have been captured in the vicinity of Flagstaff.

A fragile skull and jaw suggest that Allen's lappet-browed bat feeds primarily on soft-bodied insects. This is supported by diet studies, which have found the main food to be small moths (Microlepidoptera, 6-12 mm in size). There are also records of this bat feeding on soldier beetles (Cantharidae), dung beetles (Scarabeidae), leaf beetles (Chrysomelidae), roaches (Blattidae) and flying ants (Formicidae). Food is gleaned from surfaces or pursued and taken in flight.

*Population trends.* -- Population trends for Allen's lappet-browed bat are very poorly known. Barbour and Davis (1969) and Hoffmeister (1986) point to the paucity of pre-1955 records for Arizona and discuss the possibility that this species has only recently expanded its range into Arizona, Nevada, Utah and New Mexico.

*Management factors.* -- Maternity colonies are easily disturbed, often resulting in abandonment. Further information on movement patterns and roost-switching behavior must be collected before the full impact of disturbance on this species is known.

Little is known about habitat needs for this species. Surveys for maternity and hibernaculum roost sites should be carried out, and research should be done on differential resource use in diverse habitats.

*Additional information.* -- Allen's lappet-browed bats are readily taken in mist nets; they do not seem as adept at avoiding them as some of the other big-eared bats, such as Townsend's big-eared bats. They are most often netted 1½ - 2 hours after dusk. These bats are fairly docile and seldom attempt to bite when captured.

### Allen's Lappet-browed Bat *Idionycteris phyllotis*

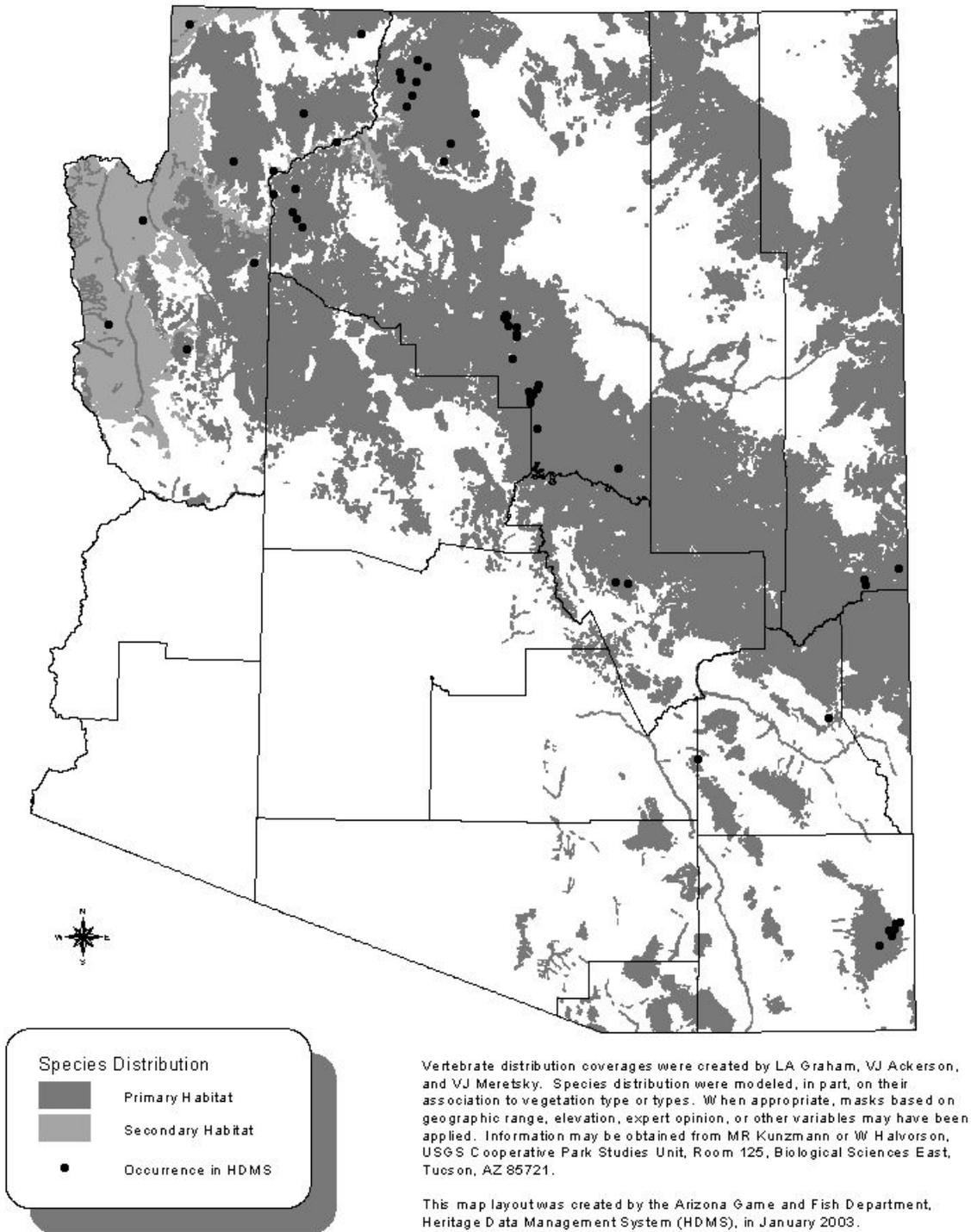


Figure 13: Habitat range and occurrence of Allen's lappet-browed bat in Arizona. Points represent all occurrences of 1 or more individuals, including netting records.

SILVER-HAIRED BAT – *LASIONYCTERIS NOCTIVAGANS*

*Description.* -- The silver-haired bat is a medium-sized bat with a forearm length of 37-44 mm. Dorsal fur is darkish-brown or black with silver tips, with ventral fur slightly lighter, giving a salt and pepper appearance. The tail and wings are dark brown to black in color. Color distinguishes this bat from all others. The ears are short, rounded and naked with a short, blunt tragus. The skull is broad and flat with rostrum markedly broad with reference to braincase. Unlike other bat species, fur covers the proximal half of the upper side of the tail membrane.

*Distribution and habitat.* -- The silver-haired bat is found in eastern Arizona, mostly in the higher mountains, through the northwestern corner of the state (Fig. 14). It is probably a year-round resident in southeastern Arizona and a summer resident farther north. The species is found throughout most of North America from southeastern Alaska across the southern half of Canada, southward in the United States into Georgia, westward into Arizona, and southward into Mexico.

This bat lives in broad-leafed riparian and coniferous woodlands near streams and ponds. Associated plants include Douglas fir, Engelman spruce, blue spruce, white fir, and aspen. Based on records in the Heritage Data Management System, the species's elevational range is from 1810 to 9200 ft. (552 - 2806 m) (AGFD, unpublished data accessed 2001).

*Biology.* -- Silver-haired bat roosts are usually in crevices in trees, however, during migration roosts are less carefully selected. They have been recorded to roost in woodpiles, open sheds, outbuildings, and garages and to hibernate in New York skyscrapers, warehouses, trees, and ship hulls. More commonly, they roost in the space left under the bark of an exfoliating tree with a large circumference. Typically, silver-haired bats roost alone or in small groups of 2-6, rarely in contact with each other. They fly fairly slowly, reaching speeds of only 11.2 mph (18 km/hr). Migrating south in the winter, it appears that females will travel further north than the males in the summer. They fly in small groups, and are preyed upon primarily by owls. Their lifespan is at least 12 years.

Copulation begins in late September and possibly continues throughout the winter. Females store sperm during the winter. Ovulation peaks in late April and early May. Gestation takes 50-60 days. The young, usually 2, are born blind and naked in June and July.

Silver-haired bats are insectivorous, emerging early in the evening to forage. They consume mostly Tricoptera and Coleoptera, however a variety of other insects are included in their diet. Each individual bat has its own feeding route covering about 495-980 ft<sup>2</sup> (46-91 m<sup>2</sup>). They often forage in or near coniferous and/or mixed deciduous forests.

*Population trends.* -- The silver-haired bat population appears to be stable, but fluctuates greatly from year to year in all known localities. According to Barbour and Davis (1969) "this bat is erratic in abundance, being scarce throughout much of its wide range."

*Management factors.* -- Because this is assumed to be a tree roosting bat, deforestation could be detrimental to this species.

### Silver-haired Bat *Lasionycteris noctivagans*

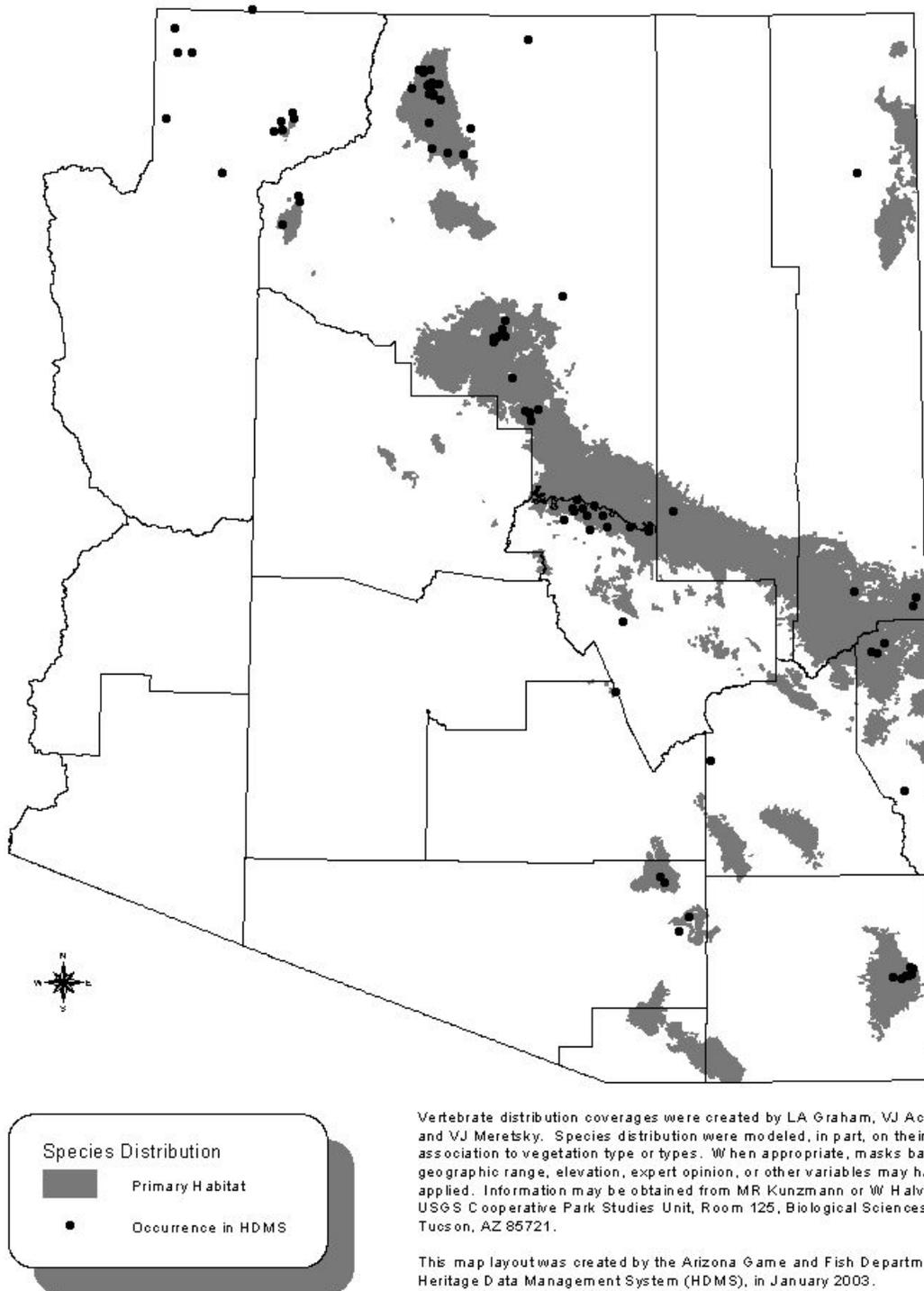


Figure 14: Habitat range and occurrence of the silver-haired bat in Arizona. Points represent all occurrences of 1 or more individuals, including netting records.

WESTERN RED BAT – *LASIURUS BLOSSEVILLII*

*Description.* -- The western red bat is a medium-sized bat (forearm 38-43 mm, weight 7-15 g), with long, narrow and pointed wings and a wingspan of 290-332 mm. Its ears are short and rounded, 11-13 mm in length. The interfemoral membrane (uropatagium) is completely furred on the dorsal surface. Fur color ranges from bright orange to yellow-brown with white-tipped hairs and whitish patches near the shoulder. Wing membranes are black. Males are usually more brightly colored than females. There is a distinct white bib under the neck in striking contrast to the black wing membrane.

Lasiurine bats are distinguished from other bats in Arizona, except the silver-haired bat (*Lasionycteris noctivagans*), by their short, round ears and their long tail membrane with at least the anterior portion well furred. The western red bat is distinguished from the silver-haired bat by fur color, which in the silver-haired bat is black with silver tips. The fur of the western red bat is never black, although some hairs may be silver-tipped. Compared to the western red bat, the hoary bat (*Lasiurus cinereus*) is larger (forearm 50-54 mm), has an edging of black fur around the ears, and is grayish in color. The western yellow bat, (*Lasiurus xanthinus*) is larger (forearm 45-50 mm), yellowish in color, and only the anterior half of the uropatagium is furred.

*Distribution and habitat.* -- The AGFD Heritage Data Management System contains thirty records of western red bats (as of 2001) scattered throughout the state, except in desert areas (Fig. 15). This species appears to be a summer resident only, as records range from May 30 to September 30 (E.L. Cockrum, University of Arizona, personal communication). The species range is from extreme southern Canada through the western United States south to Panama and South America.

Western red bats are found in broad-leaf deciduous riparian forests and other wooded areas, at elevations of 1900 - 7200 ft. (580 - 2196 m).

*Biology.* -- The western red bat is generally solitary, though it seems to migrate in groups and forage in close association with others. Males and females migrate at different times and have different summer ranges. This species may migrate to the southern part of its range and/or hibernate in the winter, sometimes emerging to feed on warm days (air temperatures 55°-65°F (13°-18°C)). It responds to subfreezing temperatures by raising its metabolism to maintain body temperature above the critical low limit of 23°F (-5°C). The interfemoral membrane may be wrapped over the body to provide additional insulation. Western red bats are migratory and winter status in Arizona is unknown. In the southern part of their range they are thought to migrate altitudinally (E.L. Cockrum, personal communication).

Western red bat day roosts are among dense foliage, the hanging bat resembling a dead leaf. Summer roosts may also be in leafy shrubs or herbs, and they are often found in trees of fruit orchards. Roost sites are from a few feet to more than 40 ft (12 m) high and heavily shaded from above but open below to allow the bat to drop into flight. Western red bats may also roost in saguaro boots and occasionally in cave-like situations (E.L. Cockrum, personal communication), although they generally avoid caves and buildings during both summer and winter. Solitary females roost with their young in tree foliage.

The western red bat copulates between August and October. General observations suggest that copulation may be initiated in flight. The female stores the sperm until spring when fertilization occurs. The gestation period is 60-70 days. Females give birth to 1 litter of 2 (range: 1-5, higher than any other bat) each year in late May to mid-June. Lactation lasts 5-6 weeks. Like other species of *Lasiurus*, females of this species have 2 pairs of mammae instead of the single pair found in most other species of bats. It is estimated that young fledge between their third and fourth week.

Predators of western red bats include birds of prey and opossums. Humans and human constructions have also taken their toll on red bats in general. There have been documented cases of these bats being impaled by barbed wire, entrapped on road surface oil, flying into lighthouses and the radiator grills of automobiles (Myers and Hatchett 1999).

The western red bat emerges to forage 1 to 2 hours after dark and may forage well into the morning. It may hunt 1800-3000 ft (550-915 m) from its roosting site. Foraging flight pattern begins with slow, fluttering, erratic flight high in the air. After 15 to 30 minutes they may begin flying in straight lines or wide circles over the same ground between tree top level and a few feet above ground level.

It is unclear whether western red bats feed mainly on certain groups of insects or on any insect within a certain size class. Moths seem to be one of the more important prey items; they also take flies, bugs, beetles, cicadas, ground dwelling crickets, and hymenopterans. They are commonly drawn to feed around city streetlights and floodlights on barns. The western red bat catches insects using its wing membranes and, less often, its interfemoral membrane. Occasionally, it will land on vegetation to capture prey. There is a distinct body and head posturing change in this bat when in pursuit of prey. It has been said that if you observe a rural street light and see a bat dipping and diving, that you are most likely viewing a red bat.

*Population trends.* -- The status and trends of the western red bat population in Arizona are unknown.

*Management factors.* -- Western red bats generally occur in low numbers. Loss of riparian or other broad-leaved deciduous forests and woodlands probably has had a negative effect on these bats. Greater understanding of habitat utilization in riparian areas will help direct management actions.

Status surveys are needed to determine population status. This will require the development of effective survey methods. Also needed is life history information, especially as it relates to roost site selection, and information on population structuring.

*Additional information.* -- The western red bat has been timed in flight at 40 mph (64 km/hr). This species was formerly considered synonymous with *Lasiurus borealis*.

### Western Red Bat *Lasiurus blossevillii*

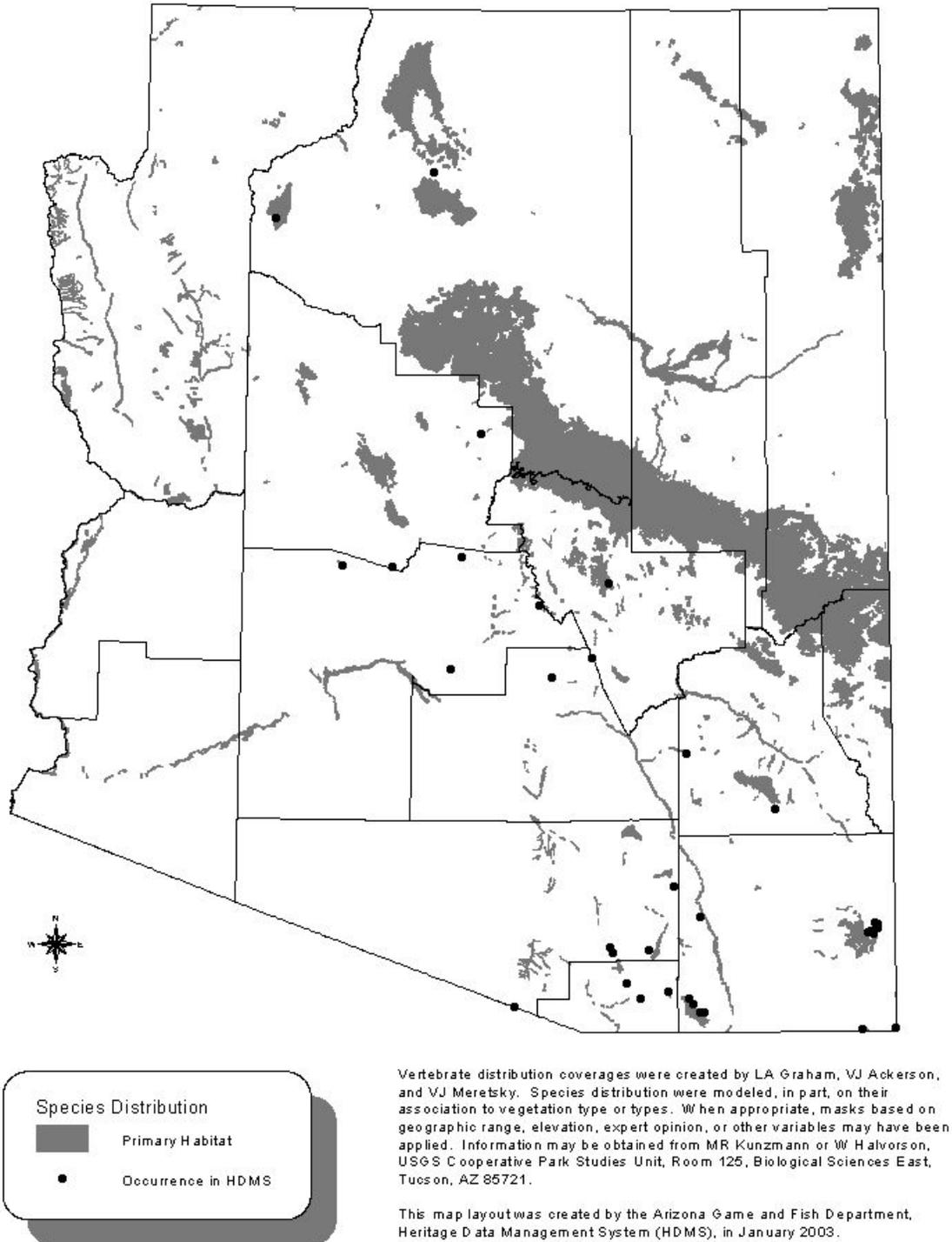


Figure 15: Habitat range and occurrence of the western red bat in Arizona. Points represent all occurrences of 1 or more individuals, including netting records.

HOARY BAT – *LASIURUS CINEREUS*

*Description.* -- The hoary bat is large with a forearm length of 46-58 mm, wingspread of 380-410 mm, and a weight of 20-35 g. The hoary bat has a heavily furred interfemoral membrane. Ears are 17 mm long, rounded, edged with black, and do not reach as far as the nostrils when laid forward. The tragus is short and broad. Teeth are large and strong. The coat is mixed dark brownish and gray, tinged with white-tipped hairs producing a frosty or hoary effect. Wrist and shoulder patches are whitish, and the throat patch is yellowish.

Minute upper molars are proportionally smaller than those in the western red bat (*Lasiurus blossevillii*) and are occasionally absent. The swift and direct flying style can distinguish the hoary bat from any other bat in the United States, except where the largest of the free-tailed bats occur. This is only vespertilionid producing audible sound during flight other than the big brown bat (*Eptesicus fuscus*) (Barbour and Davis 1969). The hoary bat is not easily confused with other lasiurines because of large size and distinctive color (Shump and Shump 1982).

*Distribution and habitat.* -- The hoary bat is found statewide in Arizona (Fig. 16). It is the most widespread of all American bats. Hoary bats range near the limit of trees in Canada, southward to at least Guatemala, and in South America from Brazil to Argentina and Chile. They are also found in Hawaii. The hoary bat is uncommon throughout most of the eastern United States and in the northern Rockies, but common in the prairie states and the Pacific Northwest. Hoary bats winter in southern California, southeastern United States, Mexico, and Guatemala.

The hoary bat is a solitary tree-roosting species and, in Arizona, is found in juniper scrub, riparian forest, and desert habitats. Based on records in the Heritage Data Management System, elevation ranges from 485 to 8800 ft (148 - 2684 m) (AGFD, unpublished data accessed 2001).

*Biology.* -- Although there is much circumstantial evidence to support the assumption that hoary bats migrate, wintering sites are not well documented and no specific migration patterns have been plotted. Nevertheless, large groups have been spotted in spring and autumn, when they would be expected to be migrating or breeding. The swift (about 13.2 mph (21.3 km/hr)) direct flight makes them readily identifiable on the wing anywhere in the United States. They are quite active 40 minutes to 1 hour after sunset.

The hoary bat is a solitary bat that roosts primarily among foliage in trees, although unusual roosts include a woodpecker hole, the nest of a grey squirrel, under driftwood, and clinging to the sides of buildings. By day, hoary bats generally roost 10-16 ft (3-5 m) above the ground in trees such as elm, black cherry, plum, box elder, and osage orange, where they are well hidden from above but visible from below.

In the Trans-Pecos area, parturition occurs in the middle of May into July with a litter size of 2 (Schmidly 1977).

Little is known of hoary bat food habits, but they appear to have a strong preference for moths. It is believed that the bat approaches a flying moth from the rear, engulfs the abdomen-thorax in its mouth and then bites down, allowing the sheared head and wings to fall to the ground. These

bats are also known to eat beetles, grasshoppers, termites, dragonflies, and wasps with foraging behavior extremely flexible. According to Furlonger and others (1986), hoary bats were significantly more active over sites with cover than those without cover and were positively associated with edge situations. Barclay (1984) states that foraging activity appears to be variable with adults and juveniles foraging continuously for 1-4 hours beginning 30-45 minutes after sunset. The first foraging period may involve flights up to 25 mi (40 km) round trip, followed by several shorter flights ending about 1 hour before sunrise. Shump and Shump (1982) state that, according to Bishop (1947) and Orr (1950), "even during times of presumed insect abundances, they have been seen attacking pipistrelles."

*Population trends.* -- Population trends for the hoary bat are unknown.

*Management factors.* -- No important predators are known for hoary bats, although hawks and owls probably take some from time to time. Accidental impalement on barbed wire fences is a common occurrence.

Research to identify habitat requirements and resource utilization, especially in riparian areas, is needed to guide management actions.

*Additional information.* -- The hoary bat has a relatively high incidence of rabies. In Indiana, 25% of the hoary bats collected from 1965 to 1968 were found to be rabid. They are extremely aggressive when captured in mist nests.

### Hoary Bat *Lasiurus cinereus*

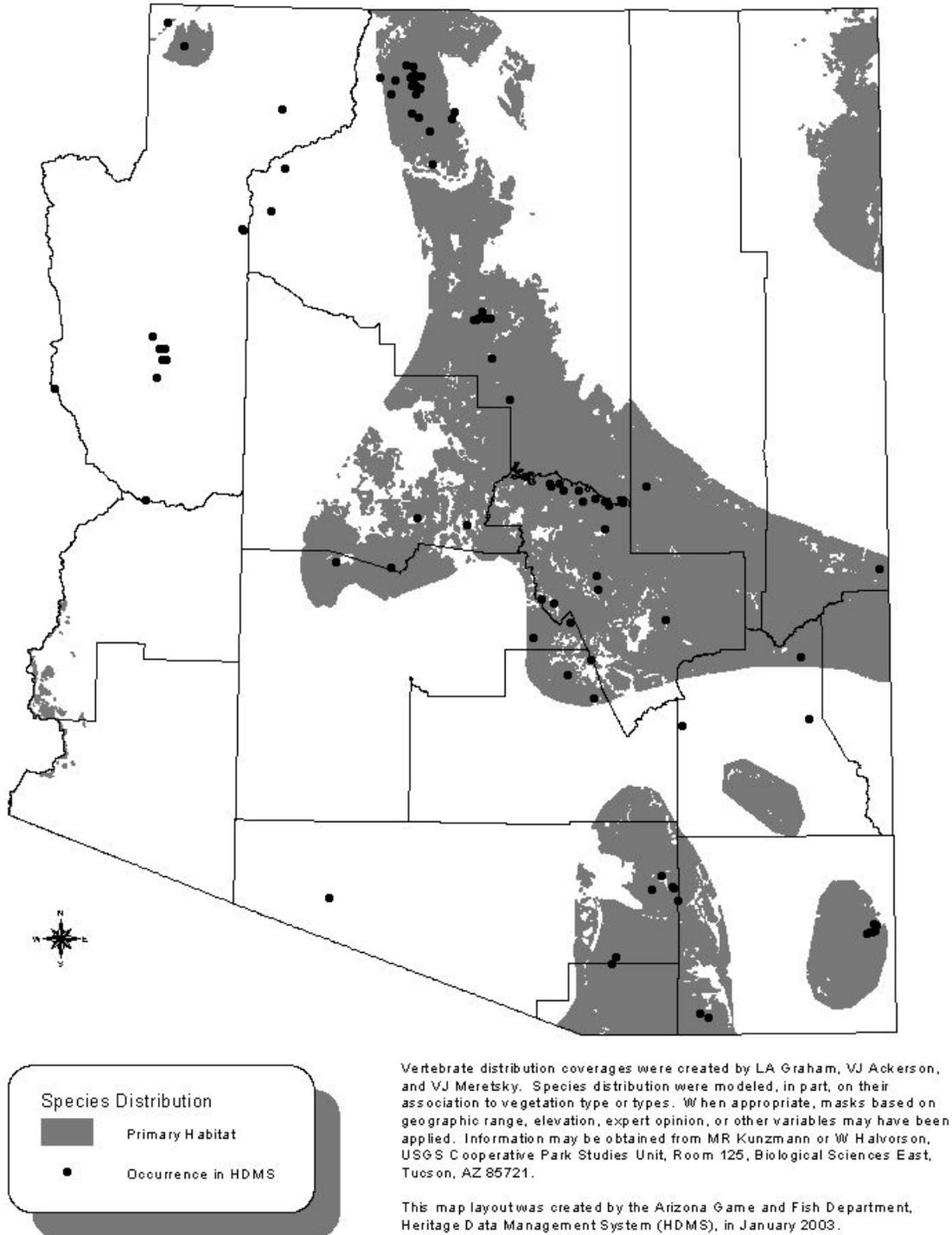


Figure 16: Habitat range and occurrence of the hoary bat in Arizona. Points represent all occurrences of 1 or more individuals, including netting records.

WESTERN YELLOW BAT – *LASIURUS XANTHINUS*

*Description.* -- The western yellow bat is a medium to large sized bat with a forearm of 41.5-50 mm, weighing 9.2-22.5 g. The fur is yellowish-buff / light brownish tipped with gray or white (color slightly darker than the pallid bat (*Antrozous pallidus*)). The wings are long, with a wingspan of 335-355 mm. Ears are short, longer than wide (17 mm long). The anterior half of the dorsal surface of the interfemoral tail membrane (uropatagium) is well furred, while the posterior half is bare or with scattered hairs.

Lasiurine bats are distinguished from other bats in Arizona, except the silver-haired bat (*Lasionycteris noctivagans*), by their short, round ears and their long tail membrane with at least the anterior portion well furred. The western yellow bat can be distinguished from the silver-haired bat by fur color, which is never black although some hairs may be silver-tipped. The uropatagium is completely furred in the other species of *Lasiurus* found in Arizona. The western yellow bat is smaller than the hoary bat (*Lasiurus cinereus*), which has a forearm length of 50-57 mm and mahogany brown pelage with hairs distinctively silver tipped. The ears of the western yellow bat are not edged in black as in the hoary bat. The western yellow bat is larger than the western red bat (*Lasiurus blossevillii*), which has a forearm length of 38-43 mm and red pelage.

*Distribution and habitat.* -- In Arizona, the western yellow bat is known primarily from Tucson and Phoenix (Fig. 17). It has also been taken at Yuma (including the Yuma Proving Ground), Sasabe, along the Bill Williams River and in the Chiricahua Mountains. It has also been found in Guadalupe Canyon, Peloncillo Mountains, Hidalgo County, New Mexico, extremely close to Arizona. The species range includes South America, from Uruguay and Argentina north through Central America and Mexico into southwest United States (southern California, Arizona, extreme southern Nevada, extreme southwest New Mexico and southern Texas).

Habitat requirements for western yellow bats are not clearly understood. They may be associated with Washington fan palm trees, other palms or other leafy vegetation such as sycamores, hackberries and cottonwoods, which provide roost sites, and low-elevation riparian areas with broad-leaf deciduous trees. Individuals have been found roosting about 15 ft (4.5 m) above the ground in a hackberry and sycamores. They have also been netted over a water hole in a Guadalupe Canyon, New Mexico, and over a swimming pool in oak woodland in the Chiricahua Mountains. The elevational range for the yellow bat is 550-6000 ft (168-1830 m) in Arizona.

In the upper Moapa Valley, southern Nevada, the western yellow bat is clearly associated with exotic California fan palms. Of 4 habitats (riparian marsh, mesquite bosque, California palm groves, and riparian shrubland) investigated acoustically in the study area, this species was detected in exotic California palm groves 80% of the time (Williams 2001). Several observations have been made of western yellow bats roosting in the dead leaf skirts of palm trees. There is also 1 record of a male roosting in a yucca reported in Texas (Higginbotham and others 2000).

*Biology.* -- Western yellow bats are presumably year-round residents in Arizona. They are solitary roosting. It has been suggested that in Tucson they hibernate among dead palm fronds (Barbour and Davis 1969); however E.L. Cockrum (personal communication) considers this questionable although they may roost on the trunk or at the base of a frond during the day. Like

the hoary bat and the western red bat, western yellow bats wrap themselves into their tail membrane for added thermal regulation while roosting. Western yellow bats may be migratory in at least part of its range. Williams (Nevada Division of Wildlife, personal communication) suggests that this species is migratory in southern Nevada, as populations drastically decline during the winter months in the upper Moapa Valley, southern Nevada. Moderate trimming of palm trees in the study area in November 2001 uncovered only a few individuals, none of which were hibernating, further suggesting partial migratory status.

In 1992 a tally of records found only 18 records for Arizona: males in spring and summer and females from midwinter to mid spring (Cockrum, personal communication). Williams (personal communication) states that of the reduced winter population in the upper Moapa Valley, southern Nevada, individuals captured during winter months are almost always males. Western yellow bats are sexually dimorphic in size, with females being larger.

The litter of 1 or usually 2 is born in early June. Like other species of *Lasiurus*, females of this species have 2 pair of mammae instead of the single pair found in most other kinds of bats. Although both males and females have been taken in Arizona, no pregnant, lactating females or young have yet been reported from the state although 1 juvenile male was netted in 1994. Gravid females were captured June 4-7, 1962, in Guadalupe Canyon in the Peloncillo Mountains, New Mexico. In southern Nevada, sex ratios are typically 2:1 favoring males, and reproductive females are not uncommon (Williams, personal communication).

The western yellow bat emerges at dusk. Mumford and Zimmerman (1963) report that this species flies steadily, in a straight line with slow wing beats. A variety of insects including Hymenoptera, Diptera, Lepidoptera, and Coleoptera were found in the feces of a single specimen (Higginbotham and others 1999).

*Population trends.* -- The western yellow bat is apparently expanding its range into the southwestern United States.

*Management factors.* -- Low numbers of western yellow bats may be a cause for concern. The most obvious threat to this species is the loss of roosting habitat. This species roosts in the dead leaf skirts of palm trees. Trimming of palm trees for aesthetic or fire management purposes in most cases completely removes viable roosting habitat. Woodland habitats, primarily palm tree groves, likely play a substantial factor in determining the range of this species (Williams 2001).

Survey methods need to be developed in order to conduct effective status surveys of this species. As well, research needs to be done to determine life history, ecological relationships, and habitat requirements. More sampling is needed to better determine the demography of the western yellow bat in Arizona.

*Additional information.* -- This species was not reported from Arizona until 1960. Barbour and Davis (1969) suggest that the western yellow bat seems to be extending its range northward into the United States from Mexico. Spencer and others (1988) attributes the northward expansion of this species into southern Texas to the introduction of ornamental palms. In Arizona, western yellow bats are most often found within the metropolitan Tucson and Phoenix areas.

### Western Yellow Bat *Lasiurus xanthinus*

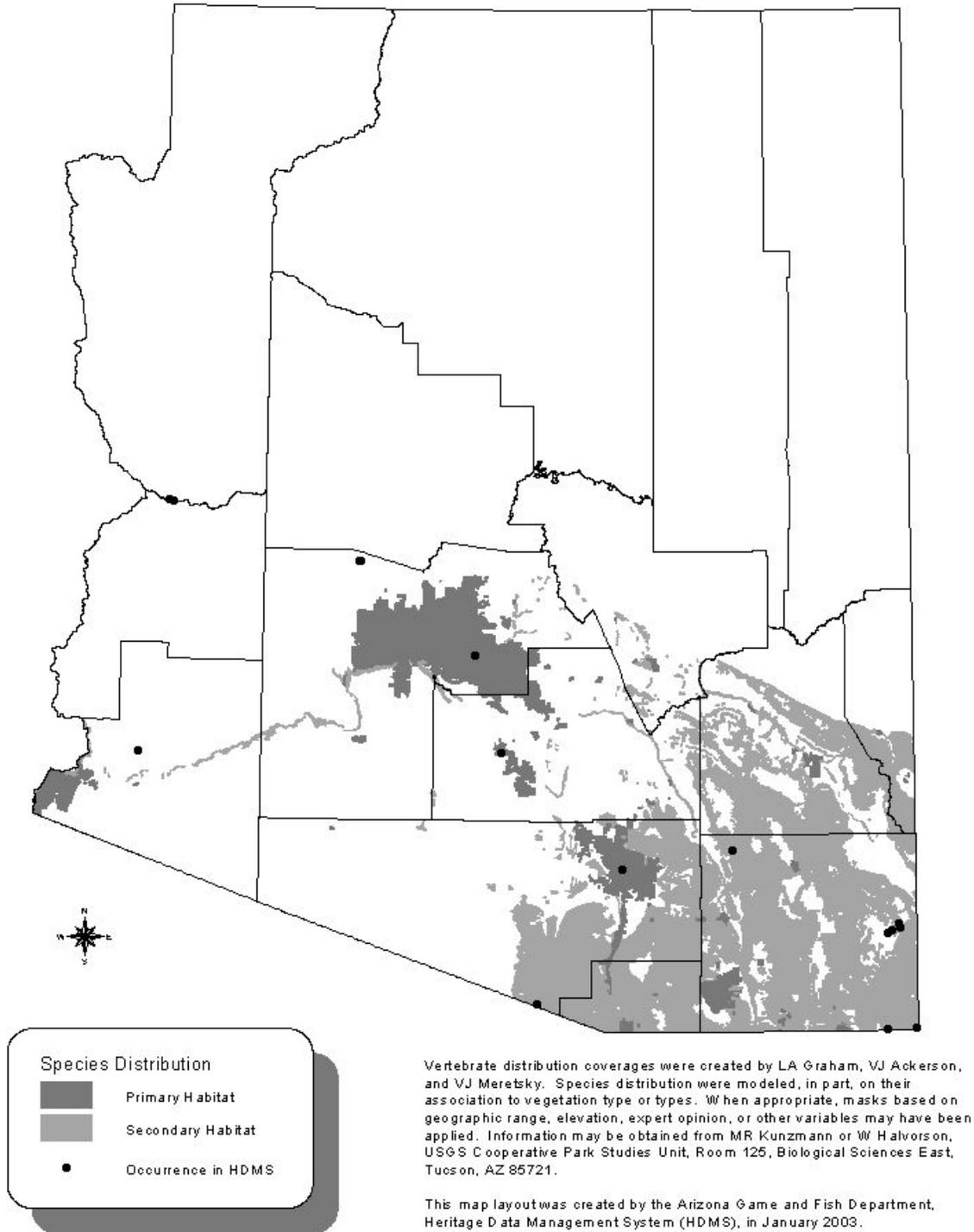


Figure 17: Habitat range and occurrence of the western yellow bat in Arizona. Points represent all occurrences of 1 or more individuals, including netting records.

WESTERN PIPISTRELLE – *PIPISTRELLUS HESPERUS*

*Description.* -- The western pipistrelle is the smallest bat in Arizona, with a forearm length of 27-33 mm, a wingspan of only 190-215 mm, and weighing 5-6 g. Dorsal fur is dark gray with a brownish cast on top of the head and around the base of the ears, and the underparts are pale, smoke gray. The short rounded ears, the muzzle, and the membranes are dark brown to black.

Only the California myotis (*Myotis californicus*) and the western small-footed myotis (*Myotis ciliolabrum*) are similar enough in appearance to be confused with the pipistrelle. All 3 are small with a keeled calcar, but the western pipistrelle has a club-shaped tragus with the tip bent forward, while *Myotis* species have a pointed tragus. As well, the western pipistrelle has only 1 tiny premolar (*Myotis* have 2 premolars) behind each upper canine.

*Distribution and habitat.* -- Western pipistrelles are scattered statewide in Arizona (Fig. 18). In winter, they are known from the southernmost part of the state and northwestern Mohave County. The species ranges throughout the western United States from southeast Washington to Michoacan and Hidalgo in western Mexico.

The western pipistrelle is found in desert and lowland habitats, as well as rocky canyons and greasewood flats. Plant associations include mesquite, creosote bush deserts, cottonwoods, sycamores, paloverde, saguaro, pinyon, juniper, fir, and spruce. Western pipistrelle elevational range is up to 6800 ft (2074 m).

*Biology.* -- Western pipistrelles have been known to live to 7 years of age. Males are 2-6% smaller than females. They hunt along canyons, streambeds and water holes, but never far from rocky cliffs where they roost. Day roost sites include rock crevices, mines, and caves with crevices. They may use manmade structures as both day and night roosts. Barbour and Davis (1969) theorize that these bats may occupy the burrows of kangaroo rats. Western pipistrelles will roost in very small areas (1 in (2.5 cm) crevices) near the surface, but will retreat if disturbed.

According to Findley and Traut (1970), migrations are not known to occur. These bats are usually abundant with males more likely to be taken during early spring and in autumn than females.

Morphological sexual changes in male and female pipistrelles occur in late summer and autumn and continue through early spring. Sperm is first available in September, and insemination begins in the autumn and continues through March. Arousal from torpor and return to a normal metabolic rate initiates ovulation. The western pipistrelle is known to form small maternity colonies but solitary mothers with young have been observed. Two young usually born in June.

Western pipistrelles emerge much earlier in the evening, and stay out later in the morning than any other bat. They are opportunistic feeders, foraging on many different types of small, usually swarming, insects, but focusing on only one kind during a feeding. Seasonal dietary differences have been recorded, including leafhoppers in the spring, small moths during the winter, and

flying ants in the summer after the rainy season. According to Hoffmeister (1986), Hayward and Cross (1979) believe the "principle regulatory factor for emergence is temperature."

*Population trends.* -- Western pipistrelle populations appear stable.

*Management factors.* -- Because of their solitary nature, pipistrelles may be difficult to detect, and thus to manage for. These are one of the more common species of bats found in urban areas and may be more likely to come into contact with people. Since they are often the first species of bat to fly in the evening and are often seen when it is still somewhat light outside, they may be more subject to predation than some other species.

## Western Pipistrelle *Pipistrellus hesperus*

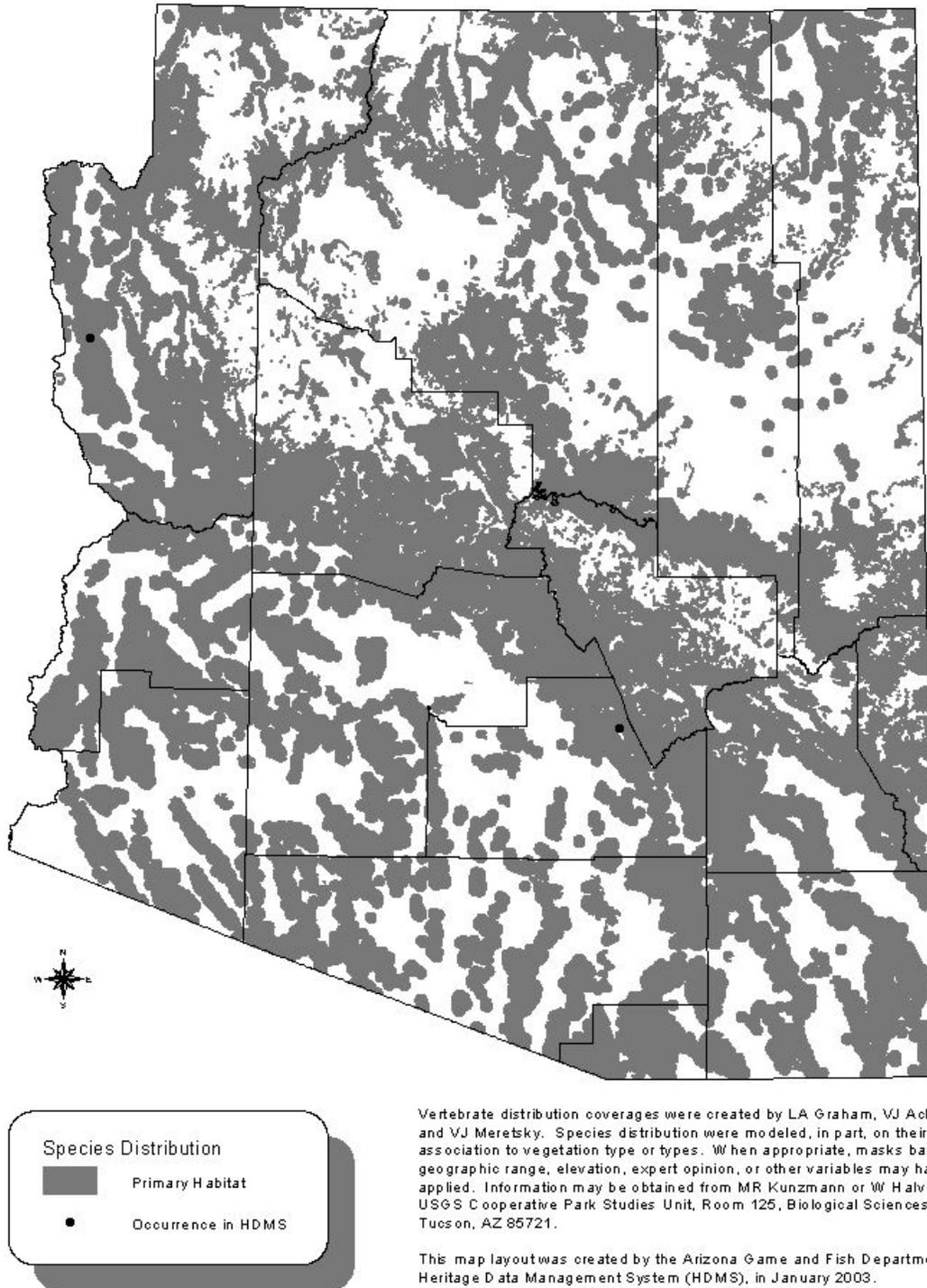


Figure 18: Habitat range and occurrence of the western pipistrelle in Arizona. Points represent roosts and colonies only.

BIG BROWN BAT – *EPTESICUS FUSCUS*

*Description.* -- The big brown bat has a forearm length of 42-51 mm, a wingspan of 325-350 mm, and a weight of 13-23 g. Females are significantly larger than males; both have the same morphological characteristics of keeled calcars, broad noses, broad rounded tragi, and broad wings. Ears are short, rounded and furred on the medial side at the base. Ear and wing membranes are chocolate brown to black in color. The glossy, long lax fur of the dorsum is usually snuff brown; and the fur of the venter is buffy.

It is difficult to confuse the big brown bat with other bats because of the large size, the 32 teeth, of which 2 are upper incisors. The unornamented nose is also indicative of the species.

*Distribution and habitat.* -- The big brown bat is found throughout Arizona in the summer (Fig. 19), but mainly in southern Arizona and along the southern slopes of the Mogollon Plateau in the winter. The species occurs widely over southern Canada, the United States, and western and central Mexico. It is abundant in the Midwest and rare in the southeastern states, central Texas and the northernmost part of its range. Summer and winter ranges are very similar.

This species can be found in Ponderosa pine forests, pinyon-juniper woodlands, the lower edge of the spruce-fir forests, and in the Lower Sonoran habitats. The elevational range seems to be highly variable. Based on records in the Heritage Data Management System, elevation ranges from 550 to 8670 ft (168 - 2644 m) (AGFD, unpublished data accessed 2001).

*Biology.* -- Big brown bats have the ability to enter torpor for extended periods of time provided that the temperature does not fall below freezing for a long length of time. They have been recorded as roosting in a variety of sites including attics, barns, bridge joints, hollow trees, mines, rock crevices, caves, and other similar locations.

Breeding occurs in the autumn, and probably throughout winter. Sperm is stored over the winter with ovulation occurring in April when small nursery colonies begin to form, mostly in man-made structures such as attics of houses, barns, and churches. The single young are born in June after a gestation period of about 2 months. According to Humphrey (1982), the litter size varies regionally. Big brown bats west of the Great Plains typically give birth to 1 young per litter. For those in the east, 2 young per litter are average. During the day, the young cling to the female's teat and are covered by her wing membrane. Females care only for their own young and have been observed retrieving fallen young from the floor of the nursery colony. Young bats begin to fly at 3 weeks of age and are able to negotiate turns at 4 weeks. At 10 weeks of age, the young have attained adult size. Big brown bats have been known to live for at least 10 years, 1 month.

This bat is an early flying species, emerging from its roost about 40-60 minutes after sunset. After an initial flurry of activity, the male forages irregularly throughout the night, while the females, which lag behind the males in the initial foraging bout, show great activity about 2 hours after the first period. Coleoptera is the most important food item while Lepidoptera is of little importance in the big brown bat's diet.

*Population trends.* -- Big brown bat populations appear to be stable.

*Management factors.* -- Clarification of species taxonomy is needed. Future research should also include observations of behavior, maternity colonies, winter roosts, and seasonal movements. Because this species is frequently found in urban areas, it may be at risk from bridge replacement, building demolition, and unsafe pest control management.

## Big Brown Bat *Eptesicus fuscus*

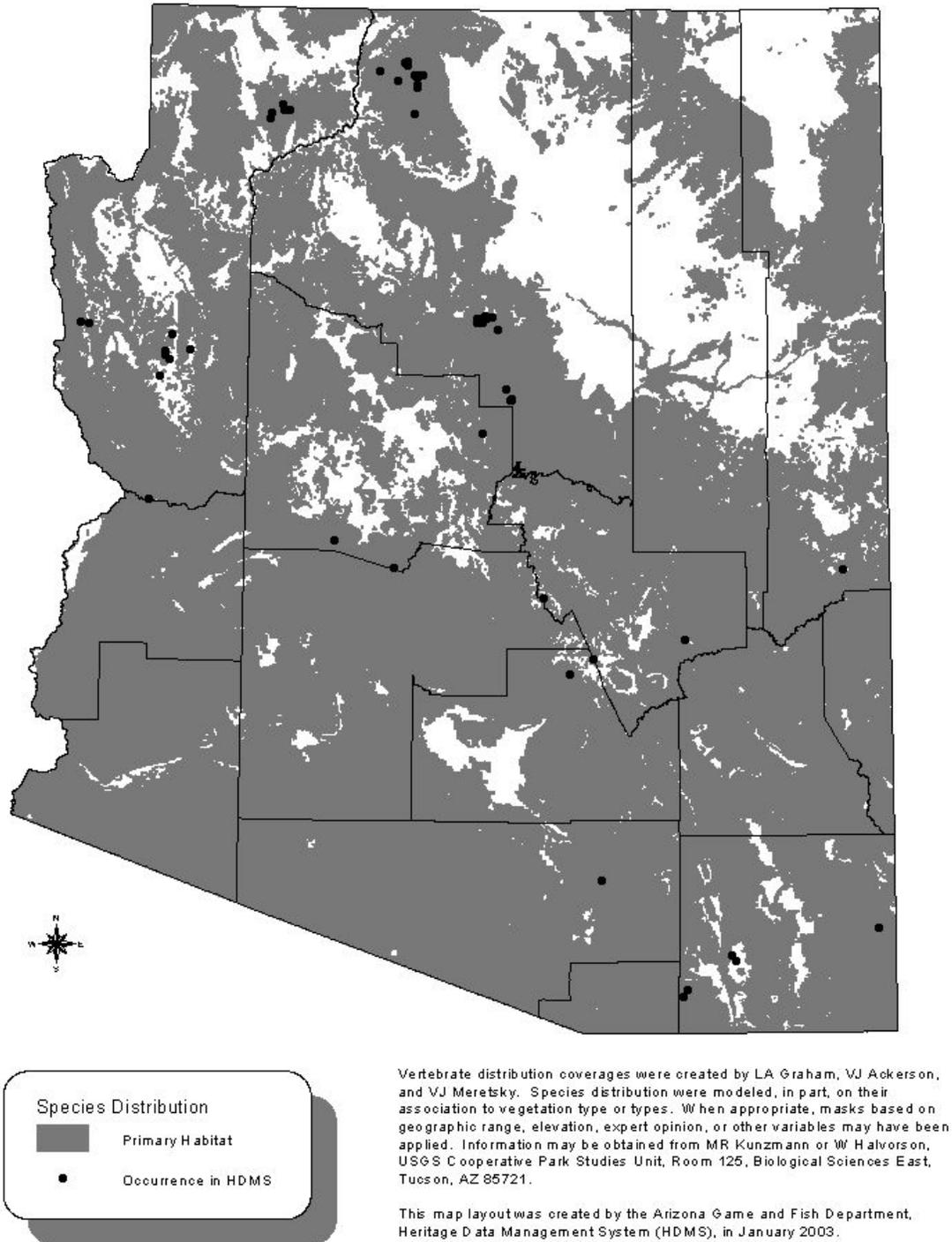


Figure 19: Habitat range and occurrence of the big brown bat in Arizona. Points represent maternity colonies, roosts, and sites where 3 or more pregnant or lactating females have been netted.

SOUTHWESTERN MYOTIS – *MYOTIS AURICULUS*

*Description.* -- The southwestern myotis is a robust member of the genus *Myotis*, with a forearm length of 27-41 mm, and wingspan of 270 mm. This bat has a distinct sagittal crest and a relatively inflated skull. Their long ears (19 to 22 mm) distinguish them from all other *Myotis* species except members of the long-eared *Myotis* group (in Arizona: the long-eared myotis (*Myotis evotis*) and the fringed myotis (*Myotis thysanodes*)). The southwestern myotis can be distinguished from these species by its overall more brownish coloration; its dorsal coloration is dull brown with the hairs possessing a darker basal band and the ventral pelage is buffy. The flight membranes and ears are brown, while those of the long-eared myotis are black. Ear length in the southwestern myotis averages less than 21 mm, whereas ear length in the long-eared myotis averages greater than 21 mm. The southwestern myotis has no distinct fringe of hairs on the posterior margin of the interfemoral membrane, as does the fringed myotis. Sufficient variation in color and ear length of these species exists that identification can be difficult. Researchers should take extra care in identifying these animals and make note of questionable identifications.

*Distribution and habitat.* -- In Arizona, the southwestern myotis occurs from the vicinity of Flagstaff southeast to Santa Cruz and Cochise Counties (Fig. 20). In winter, it is known only from Chiricahua Mountains and Huachuca Mountains. The species range includes the southwestern United States (southeastern and south-central Arizona and western New Mexico) and Mexico north of the Mexican state of Jalisco. However, the actual distribution of this species throughout its range is poorly known and there is some evidence that northward range extensions are occurring in Arizona and New Mexico.

The southwestern myotis is primarily found in ponderosa pine habitat and other semi-arid woodland habitats. These bats are also sometimes captured in desert scrub and desert grasslands and are found in tropical deciduous forests in eastern Mexico. This species seems to be restricted to montane forests throughout much of its range, although individuals may be encountered in lower elevation habitats during seasonal migrations. In Arizona, the elevational range of the southwestern myotis is from 1200 - 7300 ft. (366 - 2227 m).

*Biology.* -- Little is known of the roosting, migratory, or wintering habits of the southwestern myotis, as they have been poorly studied. Pregnant females have been observed roosting in caves. They are active from April through September in the southwestern United States.

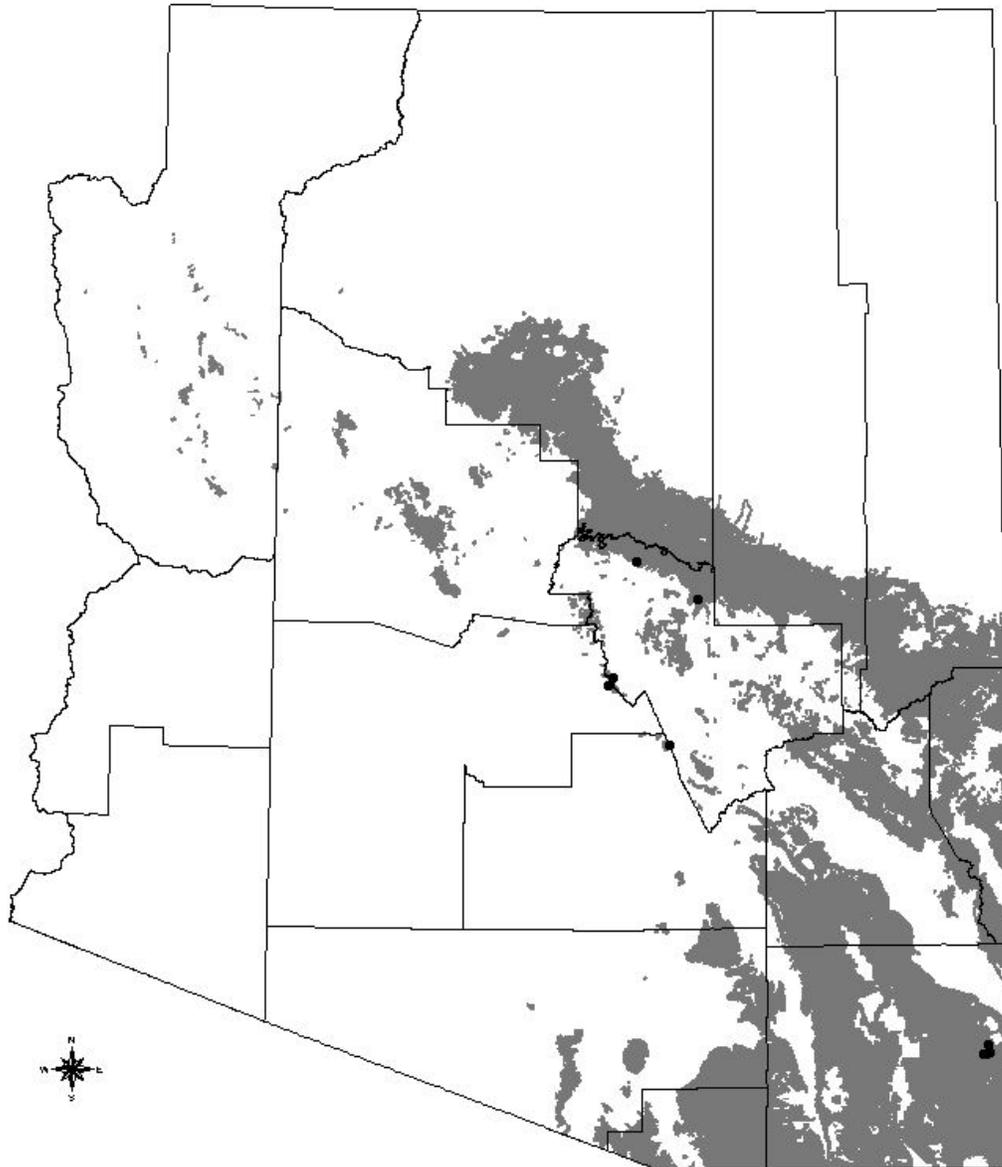
The southwestern myotis is most active 1 or 2 hours after sunset at temperatures between 52° and 66°F (11° and 19°C). It is classified by Findley (1987) as a hovering gleaner, which captures prey from the surfaces of vegetation, rocks, or the ground. The echolocation calls are characterized by low intensities, short durations, and low frequencies, which is consistent with a gleaning foraging strategy and specialization on moth prey. They fly at an average speed of 8 mph (12.9 km/hr). Their relatively short, broad wings also suggest that they are capable of maneuverable flight and use a hovering and gleaning foraging strategy. “One of the reasons so little is known about this bat is that it was not recognized as a species until 1960. Before then, it was thought to be a subspecies of the long-eared bat (*Myotis evotis*), and one will not find it discussed in publications written before 1960” (Monson 1973).

Like its close relatives in the long-eared *Myotis* group, the southwestern myotis probably mates in hibernacula in the autumn, with ovulation and fertilization occurring the following spring. They give birth to 1 young yearly in June or early July. The timing of parturition may be affected by climatic conditions.

*Population trends.* -- Populations of the southwestern myotis seem to be stable, though little data exists throughout the range of this species. They may be expanding their range northwards in the United States.

*Management factors.* -- Very little is known about roosting and wintering habits of this species, and its distribution is poorly understood. It is important to understand more about the habitat requirements of this species throughout the year and throughout its range. Movement patterns and roost switching behaviors should also be studied. Since the 2 subspecies of southwestern myotis occupy somewhat disjunct ranges, the possibility of significant genetic divergence among populations exists and should be investigated.

### Southwestern Myotis *Myotis auriculus*



**Species Distribution**

- Primary Habitat
- Occurrence in HDMS

Vertebrate distribution coverages were created by LA Graham, VJ Ackerson, and VJ Meretsky. Species distribution were modeled, in part, on their association to vegetation type or types. When appropriate, masks based on geographic range, elevation, expert opinion, or other variables may have been applied. Information may be obtained from MR Kunzmann or W Halvorsen, USGS Cooperative Park Studies Unit, Room 125, Biological Sciences East, Tucson, AZ 85721.

This map layout was created by the Arizona Game and Fish Department, Heritage Data Management System (HDMS), in January 2003.

Figure 20: Habitat range and occurrence of the southwestern myotis in Arizona. Points represent maternity colonies, all large roosts, and sites where pregnant or lactating females have been netted.

CALIFORNIA MYOTIS – *MYOTIS CALIFORNICUS*

*Description.* -- The California myotis is the smallest species of *Myotis* in America. It has small feet, small dark ears, a short forearm (29-36 mm), and a wingspan of 230 mm. This species has a well-developed keel on its calcar. The California myotis has a small skull, and the elevation from the rostrum to the braincase is abrupt. It has a small thumb (3.5-4.2 mm). Fur color is variable from pale orangish buff to dark brownish black, with variations occurring geographically and locally. The color of the ears is variable, but usually dark rather than light, contrasting with tawny, dorsal fur. Ears extend beyond nostrils 1-4 mm. Weight of males is about 3.0 g and females about 3.25 g. Females have a single pair of mammae arranged subaxillary.

The California myotis is easily confused with the western small-footed myotis (*Myotis ciliolabrum*). However, the California myotis has a smaller thumb (<4.2 mm) than the western small-footed myotis (thumb >4.2 mm). The western small-footed myotis also has glossier fur and a more sloping skull shape. As well, the tail of the California myotis is completely enclosed in the interfemoral membrane, while the western small-footed myotis's tail extends a few millimeters beyond the edge of the membrane (Constantine 1998).

*Distribution and habitat.* -- The California myotis is found throughout Arizona, but it is less common in the higher mountains (Fig. 21). Its elevational range is from sea level to 6000 ft (1830 m). In the winter, it is found in the southernmost part of the state south of the Gila River. The species range includes western North America from Alaska to Chiapas, Mexico.

In western Arizona, the California myotis occupies desert ranges or flatlands. In eastern and northern Arizona, it is found in desert shrub-oak woodlands to ponderosa pine zones.

*Biology.* -- The California myotis roosts in crevices and cracks in canyon walls, and sometimes in caves and mine shafts. "Perhaps more than any other species, this bat uses manmade structures as night roosts" (Barbour and Davis 1969). It is active in the first 2 hours after sunset and is often found near water. This species may roost during the day in any convenient shelter, and they do not regularly return to the same place. They occur singly or in small colonies. Preferred hibernation temperature is near that of surroundings.

Females give birth to 1 young, probably in June. The sexes are separate for most of year.

The California myotis has a slow, very erratic flight pattern with abrupt changes of direction, both laterally and vertically, usually feeding within about 5-10 ft (1.5-3 m) off the ground. They feed in early evening over desert scrub to oaks and along lower edge of conifers. They rarely forage more than 15 ft (4.5 m) above ground.

*Population trends.* -- California myotis populations appear to be stable.

*Management factors.* -- A revisionary study for this species should be undertaken.

### California Myotis *Myotis californicus*

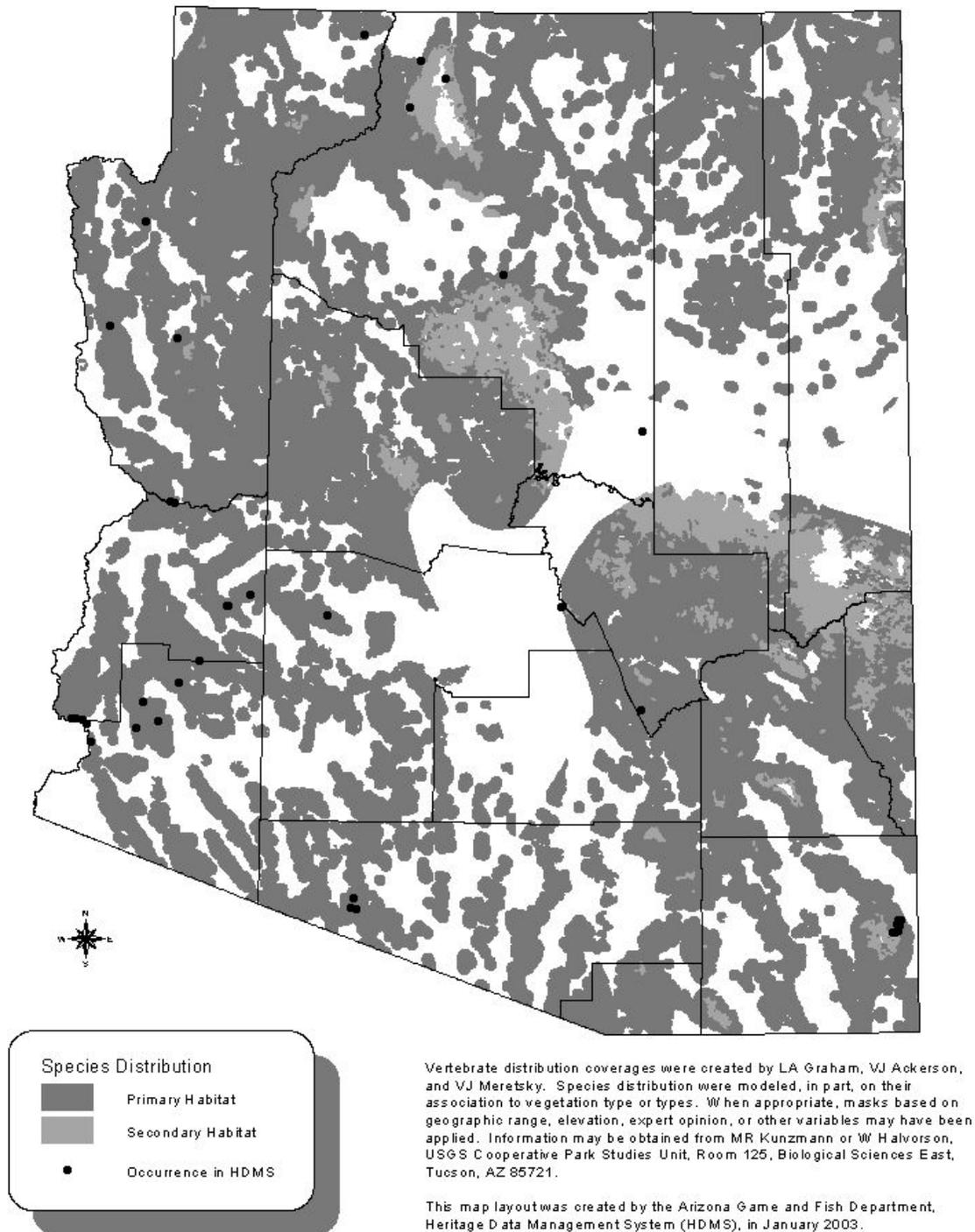


Figure 21: Habitat range and occurrence of the California myotis in Arizona. Points represent maternity colonies, roosts of 10 or more individuals, and sites where pregnant or lactating females have been netted.

WESTERN SMALL-FOOTED MYOTIS – *MYOTIS CILIOLABRUM*

*Description.* -- The western small-footed bat is a small bat with a tiny foot (6.0 mm), a short forearm (30-36 mm), a keeled calcar, black ears and a black facial mask. It is usually brown but ranges from pale yellow or tan to dark brown. The fur is relatively long and silky and frequently glossy.

The keeled calcar distinguishes the western small-footed myotis from all myotis but the California myotis (*Myotis californicus*) and the long-legged myotis (*M. volans*). It is distinguished from the California myotis by the slope of the forehead, which is flattened in the western small-footed myotis and rises more abruptly in the California myotis. The fur of the western small-footed myotis is glossy in contrast to the dull fur of the California myotis, and its thumb is longer (>4.2 mm vs. <4.2 mm in the California myotis). The tail of the western small-footed myotis extends beyond the interfemoral membrane, while that of the California myotis is completely enclosed within the membrane (Constantine 1998).

The western small-footed myotis can be distinguished from the long-legged myotis being smaller overall, but especially by forearm length (31-36 mm in the western small-footed myotis and 37-42 mm in the long-legged myotis). The western small-footed myotis also does not have fur to the elbow on the underside of the wing, as does the long-legged myotis. The western small-footed myotis is distinguished from the similar sized Yuma myotis (*Myotis yumanensis*) by having a keeled calcar, darker ears and a smaller foot (6-9 mm in contrast to 8-10 mm).

*Distribution and habitat.* -- The western small-footed myotis can be found in most of Arizona among oaks, chaparral and riparian areas but not in the desertscrub of the southwestern part of the state (Fig. 22). In the winter, it is found in central Mohave County and south of the Gila River in southeastern Arizona. This species occurs in 2 separate populations in the United States. In the eastern United States it is found from Maine and Ontario south through the mountains to northern Georgia, and southwest to eastern Oklahoma. In western North America, it occurs from southwestern Canada south to northern Baja California and western Oklahoma and then to Coahuila and Zacatecas in central Mexico. The elevational range is 4360 to 8670 ft (1330 to 2644 m), based on of unpublished data in the Heritage Data Management System (AGFD, accessed 2001).

*Biology.* -- The western small-footed myotis hibernates in caves and old mines. Summer roosts are in crevices, cracks, and holes, under rocks and in buildings. Habitat requirements are poorly known, especially in Arizona. It generally tolerates colder and dryer hibernacula than other small bats.

The reproductive behavior of the western small-footed myotis is relatively unknown. It probably breeds in the autumn. Small maternity colonies (up to 20 individual females with young) occur in buildings and tree cavities. Gestation is approximately 2 months with parturition of young in the summer. Like all *Myotis* species, this species has only 1 litter per year. Survival rates are significantly lower for females (42%) than for males (76%).

The western small-footed myotis probably feeds on flying insects. Flies and other insects, including fragments of ants, have been found in stomachs. A study of 8 individuals from near Flagstaff showed them to have been feeding primarily on lepidopterans, coleopterans and dipterans. Neuropterans, hymenopterans and hemipterans were also present, though to a lesser extent.

*Population trends.* -- Population trends for the western small-footed myotis are unknown,

*Management factors.* -- Additional information is needed about habitat requirements to guide management actions. Inventory and monitoring to determine population trends is also needed.

*Additional information.* -- This species has been considered synonymous with *Myotis subulatus* and *Myotis leibii*.

## Western Small-footed Myotis *Myotis ciliolabrum*

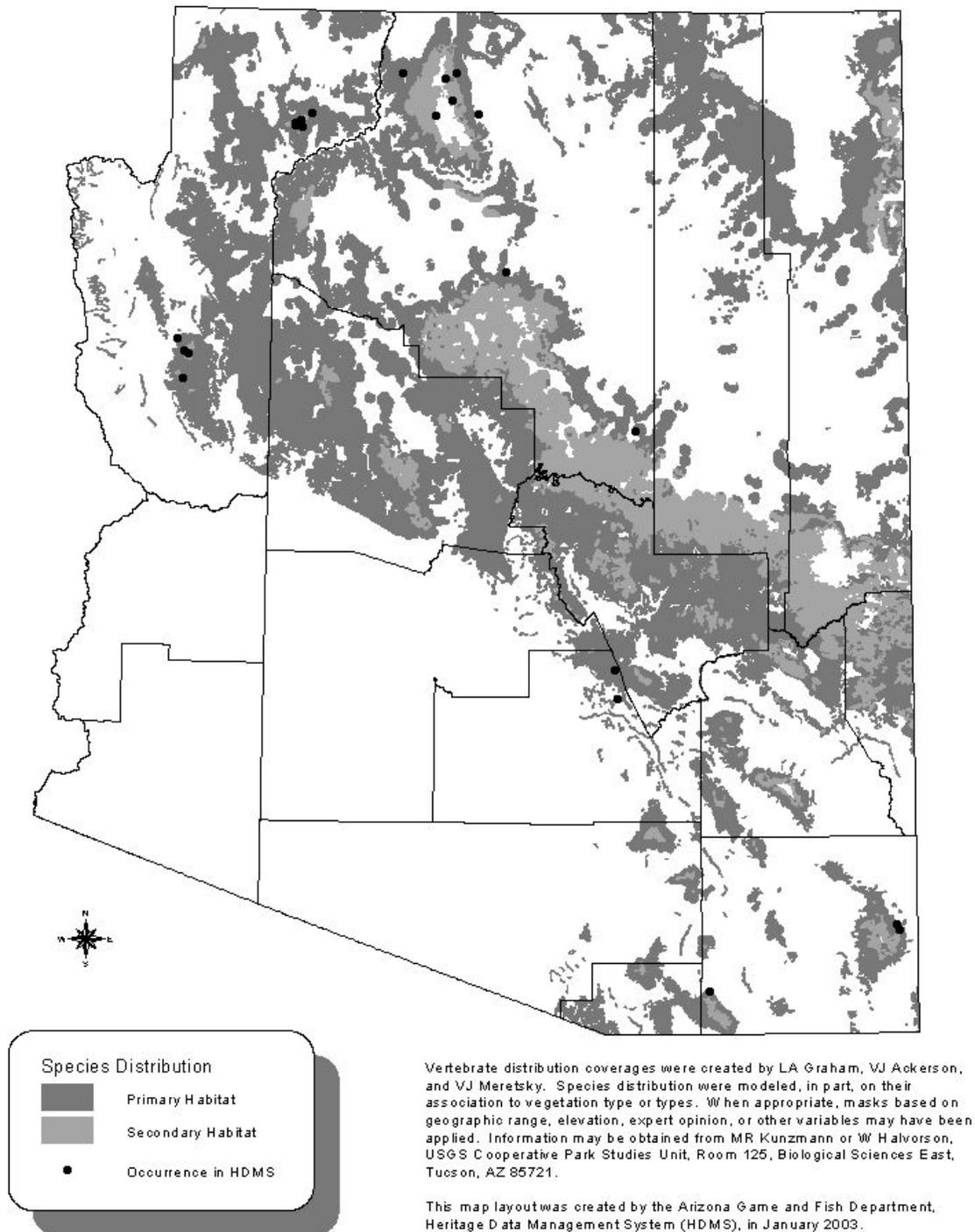


Figure 22: Habitat range and occurrence of the western small-footed myotis in Arizona. Points represent maternity colonies, roosts, and sites where pregnant or lactating females have been netted.

LONG-EARED MYOTIS – *MYOTIS EVOTIS*

*Description.* -- The long-eared myotis is a large *Myotis* with long, typically glossy black ears (18-23 mm long) extending 5-10 mm beyond the tip of nose when laid flat forward. The tragus is long and slender. Forearm length is 35.5-41 mm. Dorsal fur is light to medium brown. Fur is pale brownish to straw-colored overall, full, soft, and glossy. The wing and tail membranes are typically glossy black. The posterior border of the uropatagium has an inconspicuous fringe of minute hairs. The calcar extends about halfway from the foot to the tip of the tail, and is not keeled or only slightly so. Adult weight is 5-8 g. The cranium rises gradually from the rostrum to the braincase, and the skull is fairly narrow.

The long-eared myotis has long tooth rows with robust molars, and relatively large auditory bullae when compared to the other long-eared *Myotis* species (the southwestern myotis (*Myotis auriculus*) and the fringed myotis (*Myotis thysanodes*)). This species may be easily confused with the southwestern myotis, which is similar in size, ear length, and color, but tends to have brownish ears and membranes with a more dull, brownish pelage overall.

*Distribution and habitat.* -- The long-eared myotis is found on the Kaibab Plateau and the Mogollon Plateau in Arizona (Fig. 23). This species occurs in temperate western North America from central British Columbia and southern Saskatchewan and Alberta southward along the Pacific Coast to Baja California, eastwardly through Montana and Idaho to the western Dakotas, and from Nevada, Utah, Wyoming, and Colorado to New Mexico and Arizona.

Long-eared myotis are most often captured in mixed coniferous forests but also occur in higher elevation forests, pinyon-juniper woodlands, sagebrush steppe, and in riparian desert scrub habitats. The availability of appropriate roost sites may more strongly influence local distribution and abundance than plant community composition. In Oregon, areas where these bats forage and roost seem to be strongly influenced by the availability of water sources as well. Foraging areas and day roosts were more likely to be found close to a water source and were less influenced by forest composition (Waldien and Hayes 2001). The long-eared myotis is found at elevations from sea level to 10,000 ft (3058 m).

*Biology.* -- During the summer months these bats roost in small groups of 12 to 30 individuals in rock outcroppings, tree cavities, under peeling bark, in stumps, caves, mines, sink holes, lava tubes, or in abandoned buildings. Large diameter trees and snags seem to be the preferred tree roost sites (Rabe 1998; Waldien and others 2000). During winter it is likely that they use caves and abandoned mines as hibernacula.

Jameson and Peeters (1988) state that the long-eared myotis is “a late flying species, emerging after dark. Forages low from 4-6 ft [1.2-1.8 m] above ground.” However, other evidence (Hoffmeister 1986) reports 2 specimens taken in early evening. Foraging times probably vary with prey availability, ambient temperature, and reproductive status. These bats are often captured when air temperatures are low, but may be more active when insect activity is highest. This species feeds on Lepidoptera, Coleoptera, Diptera, Neuroptera, Hymenoptera, Hemiptera, and Homoptera. The majority of prey taken by the long-eared myotis, though, are Lepidopterans. Differences in food taken have been observed, with males eating primarily moths and females

taking more beetles. Where the long-eared myotis occurs sympatrically with the southwestern myotis there is evidence that long-eared myotis of both sexes prey mainly on beetles, while southwestern myotis individuals prey mainly on moths.

Long-eared myotis are categorized as "hovering gleaners" which feed by taking prey from the surface of foliage, tree trunks, rocks, or ground. They are fast and maneuverable in flight, have been observed hovering and are often observed foraging in dense vegetation. This species varies the echolocation frequencies and patterns used in response to different foraging situations. They typically use lower frequency calls and passive listening in order to detect prey, making them particularly adept at capturing tympanate moths which are sensitive to the typical echolocation frequencies used by insectivorous bats. Long-eared myotis seem particularly efficient at foraging in high elevation habitats and when ambient temperatures are low.

Unlike most other insectivorous bats, where females are typically restricted to lower elevations and warmer conditions during the breeding season, reproductively active female long-eared myotis occur throughout the elevational range of this species throughout the breeding season. These bats probably migrate short distances between summer and winter roosts, although very little is known about these migration patterns, and nothing is known about hibernacula. It has been suggested that they roost in the winter primarily in caves and abandoned mines. The only known hibernation site is an abandoned mine in Montana.

Mating occurs in the autumn, probably around the time these bats enter their winter hibernacula. Ovulation and fertilization occur in the following spring. The earliest reported date of pregnancy for this species is May 19 in California; the latest reported pregnancy was July 7 in British Columbia. Females give birth to 1 young per year in late June or July. Females form small maternity colonies in the summer, and males and barren females live singly or in small groups occasionally occupying the same roost as the maternity colony but roosting apart from it. Record longevity for this species is 22 years, but most individuals probably live for much less than this.

*Population trends.* -- Populations of the long-eared myotis are stable, though unique populations inhabiting relatively isolated mountain ranges may be threatened by loss of habitats. This species is moderately common in areas of suitable habitat but may be threatened by loss of suitable roost sites throughout its range.

*Management factors.* -- The lack of understanding of intra-specific variation within this species compromises the effectiveness of current management policy. An analysis of genetic variation within the long-eared myotis and among the 6 species of long-eared *Myotis* (the long-eared myotis, the southwestern myotis, the fringed myotis, Keen's myotis (*Myotis keenii*), Miller's myotis (*Myotis milleri*), and the Northern myotis (*Myotis septentrionalis*) is currently underway. This research will provide managers with the information they need to understand the identity of unique populations within the long-eared myotis and the boundaries among the long-eared *Myotis* species.

The hibernation and migratory habits of this species, as well as most *Myotis* species, are unknown. It is important to understand more about the habitat requirements of this species throughout the year.

## Long-eared Myotis *Myotis evotis*

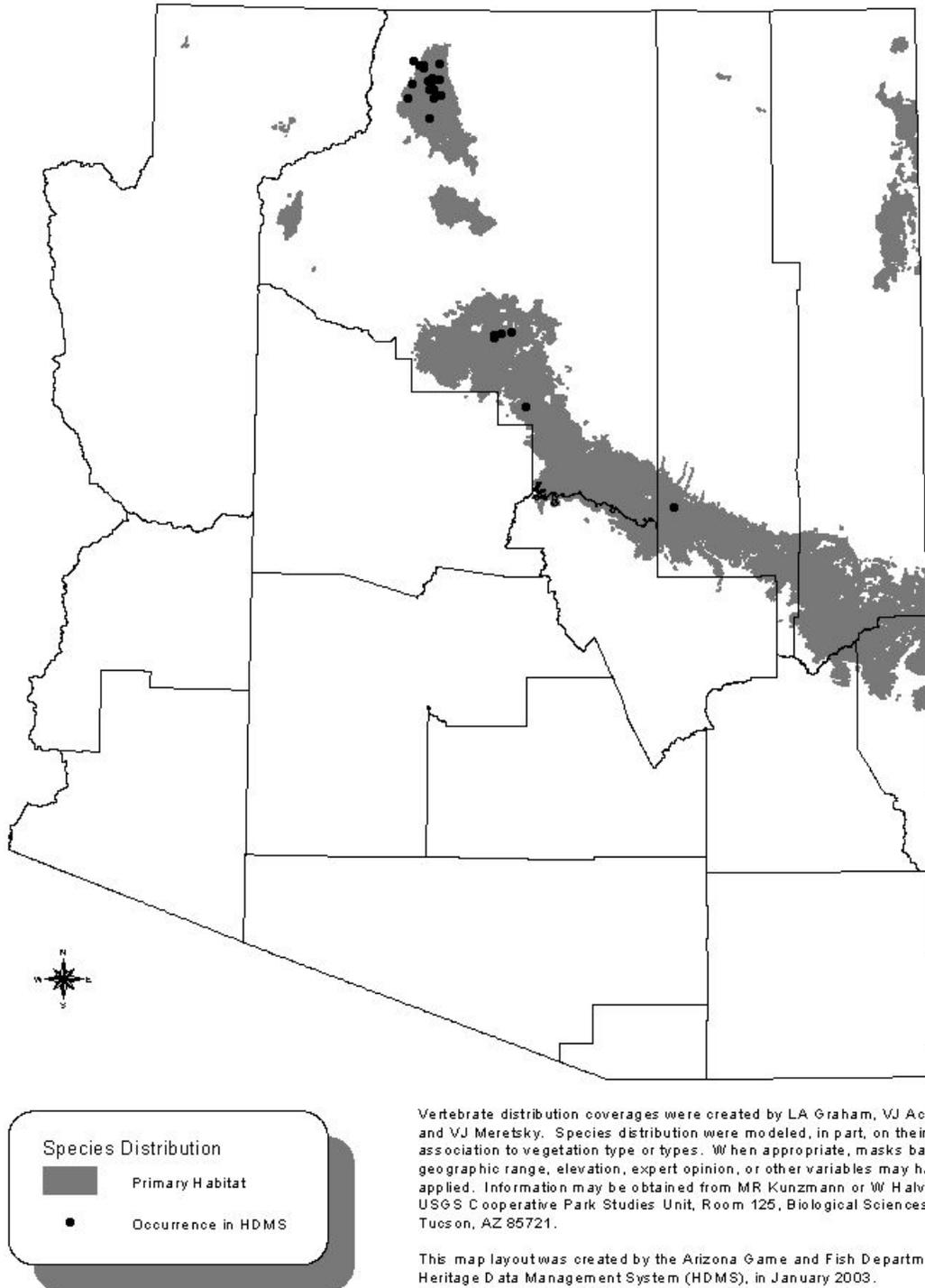


Figure 23: Habitat range and occurrence of the long-eared myotis in Arizona. Points represent maternity colonies, roosts, and sites where pregnant or lactating females have been netted.

ARIZONA MYOTIS – *MYOTIS OCCULTUS*

*Description.* -- The Arizona myotis is a medium sized *Myotis* (forearm length 36-41 mm) with sleek glossy fur. Its small ears (11-16 mm) and large feet (8-11 mm) are characteristic. Long hairs occur on the toes and extend beyond the tips of the claws. Fur color is often bright, generally tawny, ochraceous, pale tan, or reddish-brown to dark brown. It is the only long-footed (i.e. hindfoot length >8.0 mm) *Myotis* in Arizona with a gradually sloping forehead and the only *Myotis* in Arizona with only 1 small upper premolar behind the canine. In the rare individual with 2, it is on one side only or one is crowded out of alignment.

When compared to other *Myotis*, the lack of a keeled calcar distinguishes the Arizona myotis from the California myotis (*Myotis californicus*), the western small-footed myotis (*Myotis ciliolabrum*), and the long-legged myotis (*M. volans*). Shorter ears (11-16 mm) distinguish the Arizona myotis from the long-eared myotis (*Myotis evotis*, ear length 20-24 mm), the southwestern myotis (*Myotis auriculus*, ear length 19-21 mm) and usually from the fringed myotis (*Myotis thysanodes*, 12-19 mm). The Arizona myotis may also be distinguished from the fringed myotis by the lack of a macroscopic fringe of hairs on trailing edge of the tail membrane. Lack of bare spot between scapulae and lack of grayish back distinguish the Arizona myotis from the cave myotis (*Myotis velifer*). Darker ears, a longer forearm, and a glossier coat distinguish the Arizona myotis from the Yuma myotis (*Myotis yumanensis*), which usually has light-colored ears, a shorter forearm (31-36 mm), and a dull coat.

*Distribution and habitat.* -- In Arizona, most records for the Arizona myotis are from the Mogollon Rim from Alpine northwest to near Flagstaff, including Mingus Mountain, Verde Valley, Sierra Ancha Mountains, and the Pinal Mountains (Fig. 24). It likely occurs along the lower Colorado River Valley since it is known from at least 4 localities in California near that area, from the southernmost tip of Nevada south to near Yuma, and from 1 unmapped locality in the "Mojave Desert" of Arizona. There is also a record of 12 specimens collected in 1894 by W. Price from the then-abandoned Fort Lowell near Tucson (Howell 1989) and a 1992 record from Tucson (R. Sidner, University of Arizona, personal communication). The species ranges from extreme southeastern California through central and eastern Arizona into New Mexico, and extreme south central Colorado southward through extreme west Texas into Chihuahua. There is an isolated record from the Distrito Federal of central Mexico. Winter range is unknown; there are only 2 winter records: a few hibernating individuals in December from a mine northwest of Parker in California (G. Bell, personal communication, in Howell 1989) and some in late December from a mine in northern Sonora (B. Dickerman, field notes, in Howell 1989).

In summer in Arizona this species is usually found in ponderosa pine and oak-pine woodland near water. However, it is also found along permanent water or in riparian forest in some desert areas such as along the lower Colorado and Verde rivers. In New Mexico it is considered to be resident around large permanent bodies of water and transient elsewhere. Vegetation zone is not thought to be an important influence there. This bat is most common at higher elevations, mostly between about 6000 and 9200 ft (1830 and 2806 m). There are also some records from much lower elevations: between 150 and 1000 ft (46 and 305 m) along the lower Colorado, about 2400 ft (732 m) at Tucson, and around 3500 ft (1068 m) in the vicinity of the middle Verde River.

*Biology.* -- The little brown bat (*Myotis lucifugus*), of which the Arizona myotis was once considered a subspecies, is one of the better-studied species of bats. It is unlikely the Arizona myotis has provided as much opportunity for investigation as the other subspecies. Differences in anatomy, physiology, and distribution, as well as the elevation of the Arizona myotis to specific status (Piaggio and others 2002) make it unclear how much we can rely on data collected from little brown bats for insight into the biology and ecological relationships of Arizona myotis.

Reproduction of the Arizona myotis is poorly known. Apparently the sexes roost separately in summer as no males have been found at the maternity colonies that have been reported (1 colony each in California, New Mexico, and Arizona (for which there is possibly a second)). The Arizona and New Mexico maternity colonies are all in buildings near permanent water. The California maternity colony occupied crevices between timbers of a highway bridge near Blythe during the early 1940s. The bridge has since been torn down. This site was occupied at least from about mid April through about mid August. Few winter roosts are known. No hibernacula are known for Arizona or New Mexico; however, Findley and others (1975) suggests that in New Mexico they hibernate within the area of their summer range. Mines seem to be rarely used in the summer although both winter records are from mines. This species has been found roosting with Yuma myotis, cave myotis, and Mexican free-tailed bats (*Tadarida brasiliensis*).

Apparently this bat has 1 young per year in late June. Maternity colonies in the Southwest range from about 60 to 800 females. In Arizona 20 banded female Arizona myotis were recaptured at a minimum age of 2 years (Cockrum 1973). Recaptures of banded little brown bats elsewhere indicate a maximum life span of over 20 years. However, mean life expectancy for little brown bats in the eastern United States has been estimated at 1.5 years for males after weaning and 1.2-2.2 years after weaning for females (Fenton and Barclay 1980).

The Arizona myotis generally hunts low over water for flying insects, probably including mosquitoes and midges. In the southwest it has been observed foraging under large cottonwoods and in an orchard at low elevations.

*Population trends.* -- Population status and dynamics of the Arizona myotis are not well understood. One colony (near Blythe, California) and possibly a second (near Castle Hot Springs, Arizona) of the 3 or 4 known maternity roosts have been eliminated. A third colony (near Bosque Del Apache, New Mexico) is reported to be at least partially excluded from previously used buildings and the status of the fourth (on the Verde River) is unknown. It was in an old building that is now (as of 1990) also occupied by people. It is not known if the bats still use the building and if they do there is no guarantee they will be protected.

*Management factors.* -- The Arizona myotis seems to prefer human structures for maternity roosts. It may use mines or possibly caves for hibernation. Available water seems to be a consistent feature near all occurrences.

Status surveys are needed, and should include searches for maternity and hibernation roosts and studies of roost-switching and movement patterns.

### Arizona Myotis *Myotis occultus*

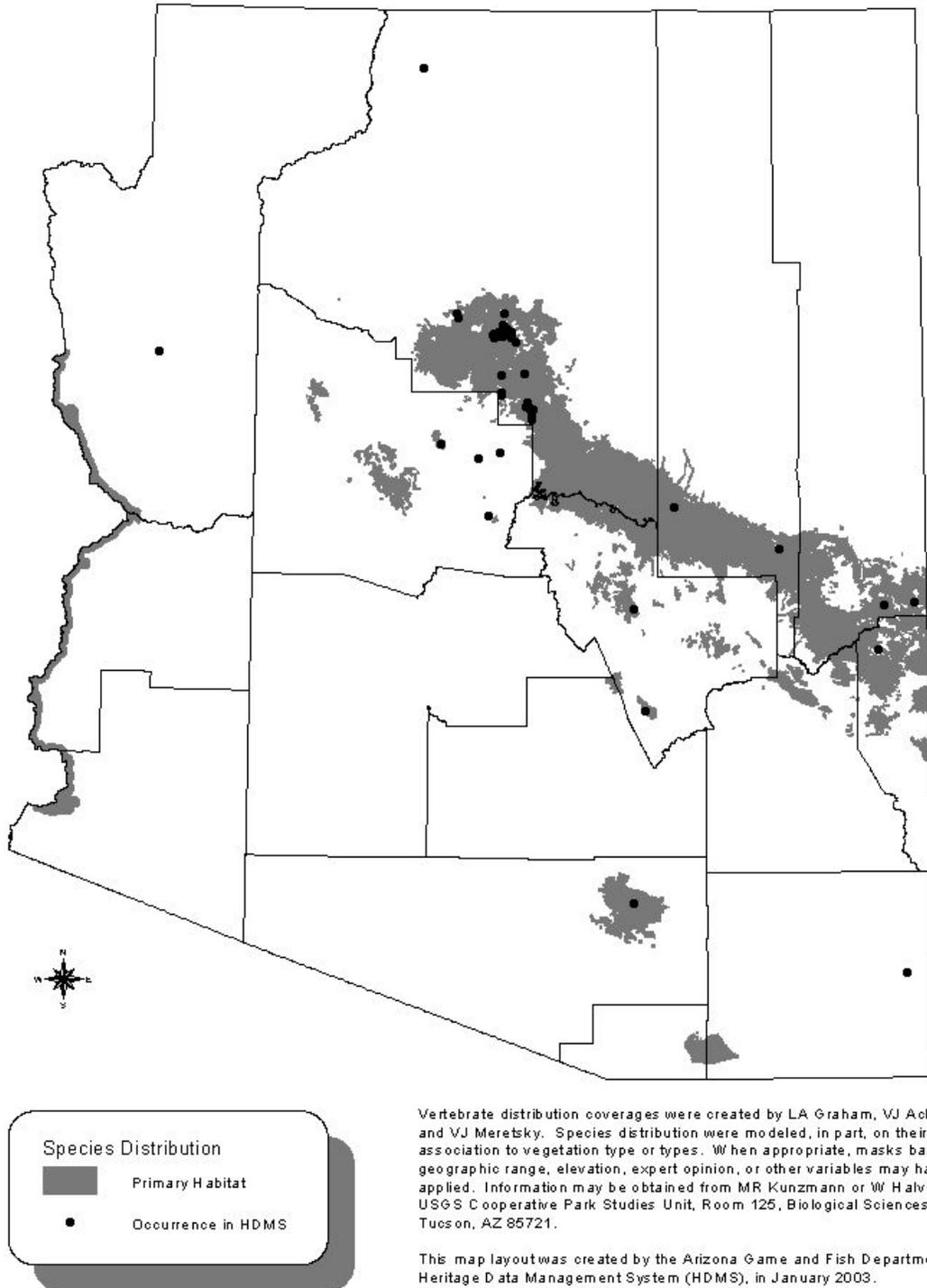


Figure 24: Habitat range and occurrence of the Arizona myotis in Arizona. Points represent maternity colonies, roosts, and sites where pregnant or lactating females have been netted.

FRINGED MYOTIS – *MYOTIS THYSANODES*

*Description.* -- The fringed myotis is a robust bat, with a forearm length of 40-47 mm, wingspan of 265-300 mm, and weight of 5-7 g. It is part of the long-eared *Myotis* group, with 16-20 mm long ears that project 3-5 mm beyond the muzzle when laid forward. The fur ranges in color from yellowish brown to darker olivaceous tones, with little difference between ventral and dorsal surfaces. Color varies geographically with a tendency toward darker colors in northwestern populations. The ears and membranes are glossy black. Sexual dimorphism exists with females exhibiting significantly larger head and body as well as forearm length. The robust calcar is not distinctly keeled. The wing membranes are moderately thick and elastic, making them resistant to puncture. This is a characteristic of bats that forage by gleaning from the ground or in areas of thick or thorny vegetation and is consistent with their short and broad wings and highly maneuverable flight (O'Farrell and Studier 1980).

Although similar to the long-eared myotis (*Myotis evotis*) in overall appearance, this bat is larger, except in ear size. Forearm length is generally larger than 40 mm, while forearm length of the long-eared myotis is typically shorter than 40 mm. The fringed myotis has a well-developed fringe of hair on the posterior edge of the uropatagium. This feature distinguishes it from all other North American *Myotis* species, though some long-eared myotis individuals also have a relatively inconspicuous fringe.

*Distribution and habitat.* -- The fringed myotis is found throughout much of Arizona, although it is not known from the northeastern or southwestern corners of the state (Fig. 25). Winter range in Arizona shifts to the southernmost counties and Mohave County. The species ranges through western North America from British Columbia, Canada, to Veracruz and Chiapas in southern Mexico. A disjunct population occurs in the Black Hills of Wyoming and South Dakota.

The fringed myotis occurs primarily in middle elevation (4000-8437 ft (1220-2571 m)) habitats ranging from deserts, grasslands, and woodlands. It occupies the lowest elevational range of all the long-eared *Myotis* species. It is most frequently captured in oak-pinyon woodlands and other open, coniferous, middle-elevation forests but has also been captured in high-elevation habitats, at sea level in coastal areas, and in low desert scrub associations.

*Biology.* -- Fringed *Myotis* tend to roost in the open in tightly packed groups, rather than in crevices. They have been recorded roosting in rock crevices, caves, mines, large snags, under exfoliating bark, and in buildings. These sites may be day or night roosts. It has been suggested that fringed myotis use lower elevation caves and mines as hibernation sites. In buildings, the sides of ceiling joints are preferred, although cracks between beams may also be used. Clusters of individuals tend to shift sites within the roost periodically in response to temperature changes or disturbance. Human disturbance can cause abandonment of the roost site. The fringed myotis may also roost in snags. Roost trees are large diameter snags in early to medium stages of decay and are more likely to be near water sources than random trees. Thermoregulation of *M. thysanodes* in roosts is highly variable, with individuals shifting between regulating body temperatures and conforming to ambient temperatures. Lactating females tend to maintain lower body temperatures in day roosts than do post-lactating and pregnant females.

Fringed myotis are known to migrate, although little is known about migration patterns or destinations. It has been suggested that autumn migrations are short distances to lower elevation sites or more southern areas where bats could be periodically active in winter. Physiological studies indicate that the fringed myotis has a great deal of control over body temperature regulation and can fly at low ambient and body temperatures. Spring migration to maternity roosts is rapid, occurring from mid to late April. This migration takes place in less than a month. These bats are most active 1-2 hours after sunset. They fly at about 8.6 mph (13.8 km/hr), and nearly vertical flight has been observed. According to Cockrum (1973), the greatest longevity recorded is 11 years, though most fringed myotis probably live for less than this.

The only detailed description of reproduction is from O'Farrell and Studier (1973) for the region of northeastern New Mexico. According to this report, females do not copulate until after leaving the maternity roost in the autumn. Copulation may occur at hibernacula, as in most other temperate vespertilionids. Ovulation, fertilization, and implantation occurred between April 28 and May 15. Parturition was between June 25 and July 7. Evidence from other areas suggests similar reproductive timing throughout this species' range. Young have open eyes and erect pinnae shortly after birth and are placed in a cluster separate from adult roost sites. At night they are left in the care of from 2 to 10 adult bats. Young are capable of limited flight after 16.5 days and are indistinguishable from adults in flight and form after 21 days. Sex ratio at birth is equal.

Fringed myotis eat mostly small beetles (73% frequency), but moths are also taken. Observations have indicated slow, highly maneuverable flight with foraging occurring in and around vegetation. These observations are consistent with their wing morphology. Fringed Myotis probably forage primarily by gleaning insects from surfaces.

*Population trends.* -- Populations appear to be stable in Arizona, though fringed myotis are rare in other areas.

*Management factors.* -- This species's greatest threat is being disturbed by humans, mostly through recreational caving, mine exploration and vandals. Prior to parturition, females become very secretive and virtually impossible to approach. Other threats include: closure of abandoned mines, renewed mining at historic sites, toxic material impoundments, pesticide spraying, vegetation conversion, livestock grazing, timber harvest, destruction of buildings and bridges used as roosts and destruction or disturbance of water sources and riparian habitat.

The lack of understanding of intra-specific variation within this species compromises the effectiveness of current management policy. An analysis of genetic variation within this species and among the 6 species of long-eared *Myotis* is currently underway. This research will provide managers with the information they need to understand the identity of unique populations of fringed myotis and the boundaries among the long-eared *Myotis* species.

The hibernation and migratory habits of the fringed myotis, as well as most *Myotis* species, are unknown. It is important to understand more about the habitat requirements of this species throughout the year. The presence of appropriate roost sites may be the most critical factor determining fringed myotis presence in an area. It is important for research on roosting and foraging habits to be conducted throughout the range of this species.

## Fringed Myotis *Myotis thysanodes*

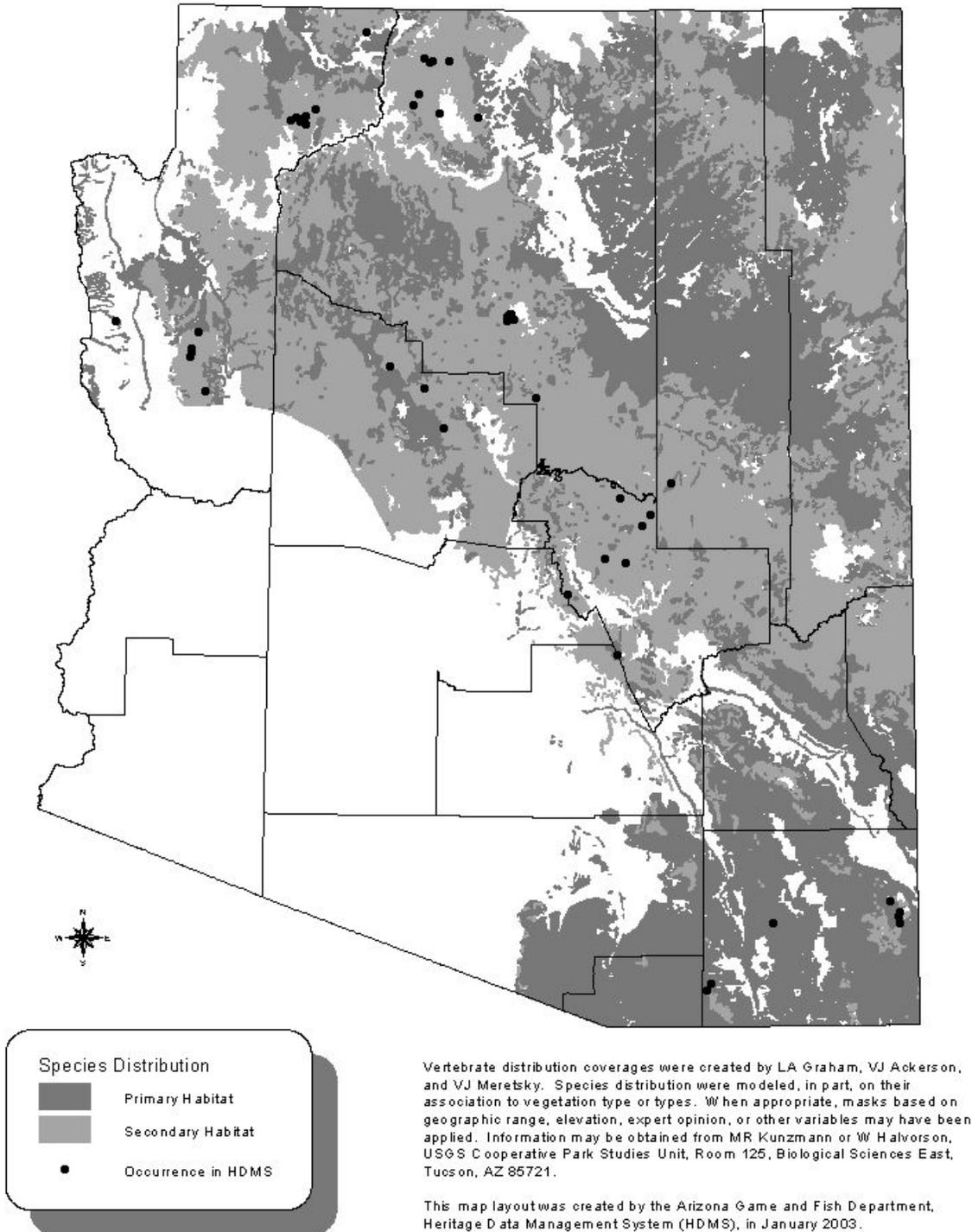


Figure 25: Habitat range and occurrence of the fringed myotis in Arizona. Points represent maternity colonies, roosts, and sites where pregnant or lactating females have been netted.

CAVE MYOTIS – *MYOTIS VELIFER*

*Description.* – The cave myotis is a large *Myotis* with a large hind foot (9-12 mm), long forearm (40-43 mm), robust teeth, and a well-developed sagittal crest on the skull. It is dull gray to almost black in color and is the only *Myotis* with bare patch on back between shoulder blades (may have to blow or brush bat's hair to see it). The natural pelage color of the cave myotis may be bleached if the bat is roosting in a site with high humidity and ammonia, such as found in guano caves (Fitch and others 1981). Average wingspan is 28-33 cm. The calcar is well developed, terminating in a minute lobule, but is not keeled.

The cave myotis is distinguished by its shorter ear (<18.0 mm), longer forearm (usually >40.0 mm), dull grayish color, and bare spot from the long-eared myotis (*Myotis evotis*) and southwestern myotis (*Myotis auriculus*), which have ears greater than 19.0 mm and a forearm length less than 40 mm. The cave myotis lacks a fringe on the edge of the tail membrane that characterizes the fringed myotis (*Myotis thysanodes*), and is also distinguished from this species by the dull grayish color and the bare spot on its back. The cave myotis can be distinguished by the lack of a keeled calcar, its dull grayish color, shorter ears, bare spot, and usually longer forearm from the long-legged myotis (*Myotis volans*), the California myotis (*M. californicus*), and the western small-footed myotis (*M. ciliolabrum*). It is distinguished by a longer forearm, its dull grayish color, and bare spot from the Yuma myotis (*M. yumanensis*) and the Arizona myotis (*M. occultus*).

*Distribution and habitat.* -- In Arizona, the cave myotis can be found south of the Mogollon Plateau from Lake Mohave, Burro Creek, Montezuma Well, San Carlos Apache Reservation and the Chiricahua Mountains south to Mexico. Although known from as far southwest as the Harquahala Mountains, Gila Bend, Organ Pipe Cactus National Monument and about 20 mi (32 km) north of Yuma near the Colorado, it has not been recorded from the extreme southwestern part of the state (Fig. 26). It is found in small numbers in southeastern Arizona in the winter. Hoffmeister (1986) suggests that most migrate farther south for the winter. The species ranges across the southwestern half of Arizona and immediately adjacent parts of California, Nevada, New Mexico and northern third of Sonora, Mexico.

It is predominantly found in desertscrub of creosote, brittlebush, paloverde and cacti, but sometimes up to pine-oak communities. Most records are from 300-5000 ft (92-1525 m) although there is at least one record from 5800 ft (1769 m) on the Nantan Plateau and at least 6 records between 6000 and 8800 ft (1830 and 2684 m) in the Santa Rita, Patagonia, Pinaleno, and Huachuca mountains.

*Biology.* -- Cave myotis roost in caves, tunnels, mine shafts, and under bridges and sometimes in buildings within a few miles of water. There are a number of records of 1 or a few individuals roosting in cliff and barn swallow nests. In summer, they are apparently tolerant of high temperatures and low humidities. One group was found in an attic in Gila County where July temperatures were 99°F (37°C) and relative humidity was 23%.

This species may be found in association and even clustering with the Mexican free-tailed bat (*Tadarida brasiliensis*) and the Yuma myotis. They enter hibernacula in late September or early

October. Winter roosts in Arizona are wet mine tunnels above 6000 ft (1830 m). Preferred temperatures have been reported as 46°-52°F (8°-11°C). In other areas cave myotis have been found to prefer hibernation roosts with high relative humidities, usually above 55% in February and frequently in roosts over water with humidities near 100%. In Kansas and Texas they appear to be year round residents, hibernating in caves. However movements have been recorded between Oklahoma and Kansas, and the distribution of the species apparently changes seasonally within Texas.

Studies in other areas indicate that even though they store fat prior to entering hibernation they may lose 25% during hibernation. Females go into hibernation heavier than males in Kansas. Females may then lose 25% and males 16% of their weight. In other areas individual bats have been shown to move around among different roosts during winter. Hibernating bats in northwest Texas occur in clusters of about 158 per ft<sup>2</sup> (1700 per m<sup>2</sup>). They are usually in the open on the walls or ceiling of a cave when temperatures are optimal and stable, but are likely to retreat to the more stable conditions of crevices when ambient temperatures fluctuate beyond their optimal range.

The cave myotis apparently leaves its roost after testing to see if it is dark enough outside. Although the average time of roost exit in Arizona is early in the evening, about 37 minutes after sunset, exit time depends on a variety of environmental and physiological variables. Shortly after exiting the roost, they generally fly to water and drink. Near Carlsbad, New Mexico, they have been observed to fly in a straight line for several miles to water.

Some evidence indicates that populations in Arizona have home ranges of hundreds of square kilometers during non-migratory times of the year. Two estimates of home ranges in southeastern Arizona by Hayward (1970) were 360 and 625 mi<sup>2</sup> (932 and 1619 km<sup>2</sup>).

Individuals probably return to the same locality every year. These bats are colonial and roost in clusters, usually near the entrance of a cave or mine. Population regulation is not well understood. Both predation and disease have been suggested as population controls. In other areas sex ratio has been reported as close to 1:1 with proportions varying with circumstances.

Copulation occurs in autumn, and probably again in winter during arousal periods. Sperm is stored in the uterus, and ovulation occurs in April. Gestation is 45-55 days in Arizona. Females congregate in maternity colonies of 50-15,000 individuals during May. Males, which arrive from southern hibernation roosts as early as March, form small groups of up to 100. Some adult males may be found in maternity colonies especially during June and July.

The single young are born in May to early July. Although the young are left when their mothers go to feed, if the colony is disturbed the mothers may carry the young in flight and move them to another part of the cave. During mass movements a few young may be left behind and die. Young are reported to fledge at about 5 weeks according to some and 6-8 weeks according to others.

Colonies are often located in caves, but may also be found under bridges and in buildings. Nursery colonies may form either in hibernating or summer caves. Nursing females are found in

the warmest and least accessible parts of caves in northwest Texas. Female and young have moved to the same roosts as the males by August and in September the females leave for the winter. Banding records indicate longevity is at least 6 years and a maximum life span of a single individual was just over 11 years.

Cave myotis are opportunistic feeders. Small moths are the most common prey item. They have also been observed to feed selectively on flying ants, taking 12 per minute for 5 minutes. These bats forage just above the tops of vegetation, staying close to the vegetation 6 to 15 ft above the ground, flying strongly and steadily except when in pursuit of prey. Some individuals may forage back and forth over the same 165-230 ft (50-70 m) route or under streetlights. They feed twice nightly during the summer in some places.

*Population trends.* -- The cave myotis is found in colonies of 2000 to 5000 throughout much of its range. The size of maternity colonies in Arizona varies from 50 to 15,000 females.

*Management factors.* -- Cave myotis are vulnerable at roosts, especially maternity roosts, because they congregate in large numbers. They are threatened in areas due to habitat loss caused by excessive development. Some of the potential threats to this species are: recreational caving, mine closures, roost destruction and loss of foraging habitat in riparian zones.

Status surveys are needed to gain baseline data on roost locations and populations and also to determine the degree of interspecific competition with associated species. Information is also needed regarding the status of historically identified colonies, trends in population numbers, on roosting and foraging requirements and basic life history.

### Cave Myotis *Myotis velifer*

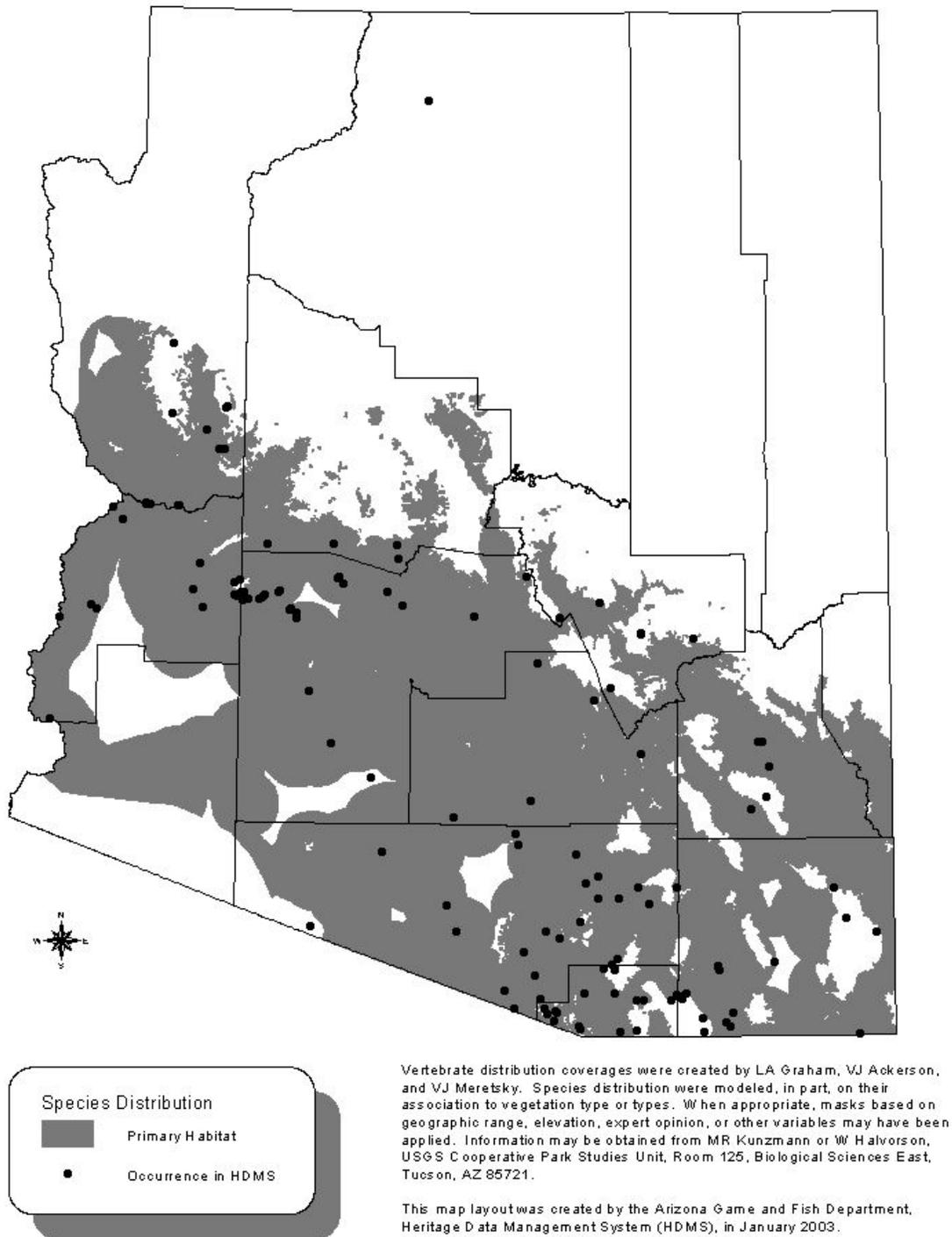


Figure 26: Habitat range and occurrence of the cave myotis in Arizona. Points represent maternity colonies, roosts of 10 or more individuals, and sites where 3 or more pregnant or lactating females have been netted.

LONG-LEGGED MYOTIS – *MYOTIS VOLANS*

*Description.* -- The long-legged myotis is one of the larger species of *Myotis*, with a forearm length of 38-41 mm, a hind foot length of 8-11 mm, a calcar about 14 mm long with a distinct keel projecting about 1 mm, and a ear length of 11-15 mm. Its fur is long and soft, color variable, dorsally ranging from ochraceous to dark reddish or blackish brown, ventrally ranging from pale buff to cinnamon or smoky brown. Its short ears have a strong basal margination. The tragus is long and pointed (6-8 mm). The wing membranes attach to the hind foot at the middle of the metatarsus. The ears and the flight membranes are blackish.

The short, rounded ears that barely reach the nostril when laid forward, small hind feet, distinctly keeled calcar, and comparatively long, dense fur on the underside of the wing membrane extending from the body to a line joining the elbow and the knee, distinguish the long-legged myotis from other *Myotis* species.

*Distribution and habitat.* -- In Arizona, the long-legged myotis is found in forested mountains, but is absent from the desert and desert mountains in the southwestern part of the state (Fig. 27). The species inhabits western North America from extreme southeastern Alaska and western Canada to central Mexico. The elevational range is from 4360-10,000 ft (1330-3050 m).

*Biology.* -- This species utilizes a variety of roosts including abandoned buildings, cracks in the ground, crevices in cliff faces and spaces behind exfoliating tree bark. Caves and mine tunnels are used as hibernacula.

Copulation begins in late August, and sperm is stored over the winter in female's reproductive tract. Ovulation occurs between March and May, and parturition is from May through August. Females have 1 young per year. This species forms large nursery colonies, often numbering in the hundreds. In the southwest, females give birth earlier in the season than most other bats. The long-legged myotis is known to live at least 21 years. Sexual dimorphism occurs, with the female having slightly larger forearm and condylocanine lengths (Warner and Czaplewski 1984).

The long-legged myotis is a strong, direct flier that is capable of speeds of 9.3-10.6 mph (15-17 km/hr). Echolocation calls of this bat consist of FM sweeps from 80-40 kHz with most of the energy at 46 kHz, these calls are from 1-10 ms in length. Calls are shortened during pursuit. The long-legged myotis is active throughout most of night, but activity peaks 3 or 4 hours after sunset.

Considered by Findley to be an "aerial pursuer," the long-legged myotis commonly forages 10-15 ft (3-4.5 m) high over water and in openings in woods. It flies more slowly and less erratically than the Arizona myotis (*Myotis occultus*) and the Yuma myotis (*Myotis yumanensis*), and can be recognized in flight when feeding. The long-legged myotis consumes primarily moths but has also been observed taking flies, termites, lacewings, wasps, small beetles and other insects. It pursues prey over fairly long distances around, under, and over the forest canopy. It is believed that they will use the same "feeding route" every evening. This is apparently an opportunistic forager, taking appropriate prey in approximate proportion to their availability in the environment.

*Population trends.* -- Long-legged myotis populations appear to be stable.

*Management factors.* -- Because of the bat's non-selective feeding habits, DDT and other pesticides may be a major threat.

Research needs include surveys for wintering roosts, and studies of movement patterns and roost-switching behavior.

## Long-legged Myotis *Myotis volans*

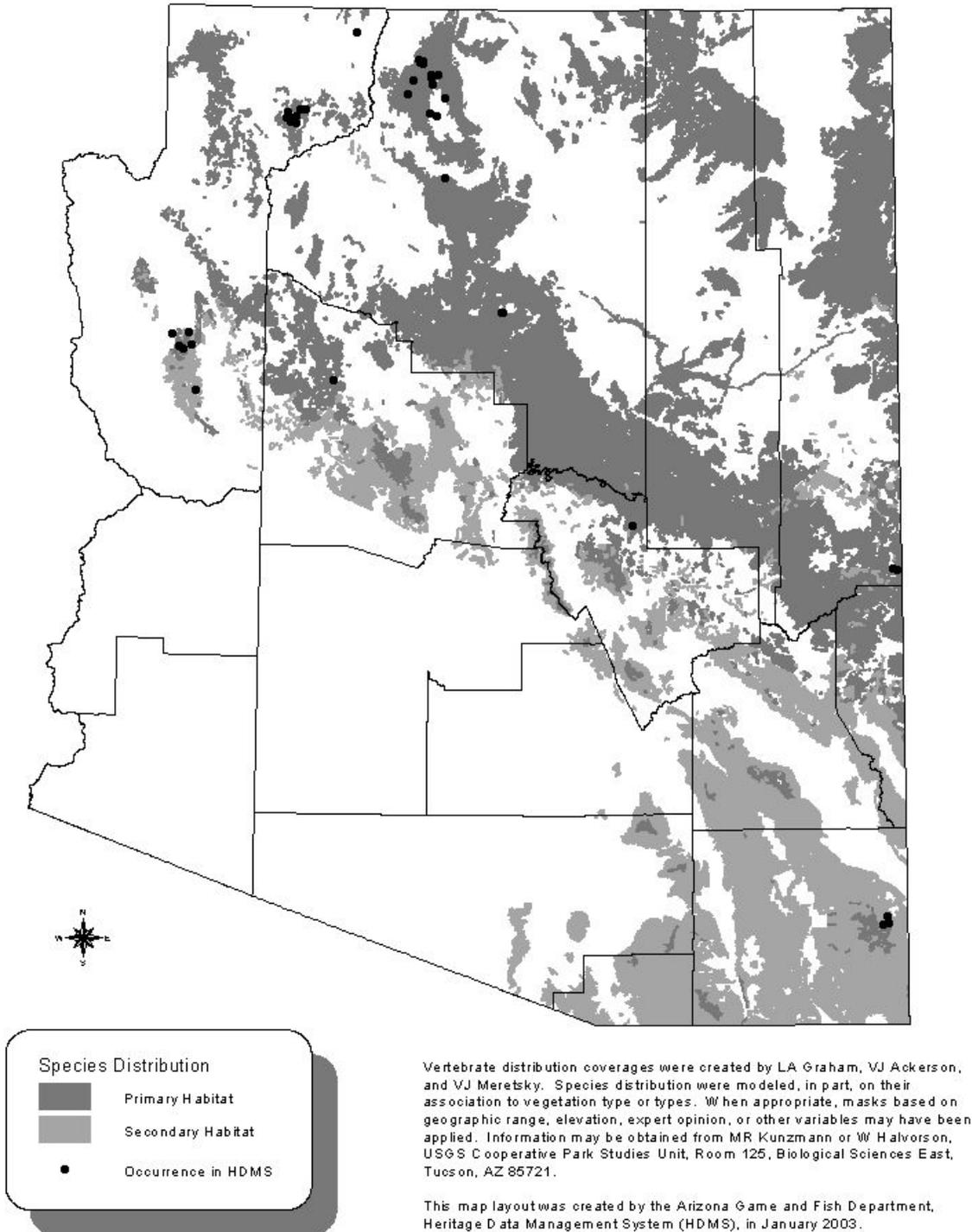


Figure 27: Habitat range and occurrence of the long-legged myotis in Arizona. Points represent maternity colonies, roosts, and sites where pregnant or lactating females have been netted.

YUMA MYOTIS – *MYOTIS YUMANENSIS*

*Description.* -- The Yuma myotis is one of the smallest *Myotis*, with a forearm length of 34-38 mm, an ear length of 14-15 mm, and weighing 5-9 g in weight. Dorsal fur is tawny, buffy or even brown, while the underparts are paler, buffy to yellowish white. Hairs on the dorsum are not tipped with a brighter brown. It has large feet (hind foot length 8-10 mm) and no keel on the lobed calcar. Its short ears are usually light or pale (same color as back). Its braincase is broad and high, lacking sagittal crest. The tail barely extends beyond the interfemoral membrane.

The Yuma myotis has larger feet and lighter ear and fur color than the western small-footed myotis (*Myotis ciliolabrum*) and the California myotis (*Myotis californicus*). It is also distinguished from these species by its short ears, braincase rising abruptly from level of rostrum, and lack of keeled calcar. The Yuma myotis's interfemoral membrane is furred nearly to the knee.

*Distribution and habitat.* -- The Yuma myotis is found throughout most of Arizona, but not in the northeastern corner nor the southeastern part of state (Fig. 28). This bat has recently been observed on the Navajo Reservation (AGFD 1996). It is found in juniper-pinyon associations, but is probably absent in higher, boreal areas. Its winter range is along the Lower Colorado River. The species range includes western North America from British Columbia, Canada, south to Hidalgo and Michoacan, southern Mexico. The elevational range is from below sea level to 11,000 ft (3355 m).

*Biology.* -- In the summer, the Yuma myotis is found in Arizona near water over which it forages for food. It is a late flier and usually flies low to the water, feeding extensively on small moths (78.6% by frequency) and other small insects including dipterans and even some ground beetles. This species tends to be lunar phobic due to a preference for lunar phobic insects or to avoid predators such as owls. It rarely roosts in caves or mine shafts, preferring to inhabit cliffs and rocky walls, buildings, and abandoned cliff swallow mud nests. It is colonial, hanging in closely grouped clumps. It apparently migrates to the south for the winter.

Copulation probably occurs in the autumn and fertilization in the spring. About 35 females occupy a roost. Nursery colonies are usually in buildings, caves, and mines or under bridges. One young is born between May 25 and June 5. As of July 5, most young are able to fly, but a few may still be nursing.

*Population trends.* -- Yuma myotis populations appear to be stable

*Management factors.* -- Yuma myotis tend to be found near permanent watercourses such as the Colorado and Little Colorado Rivers.

Surveys for roosts and determination of migration routes are needed. Some mine roosts may be at particular risk for environmental contamination.

### Yuma Myotis *Myotis yumanensis*

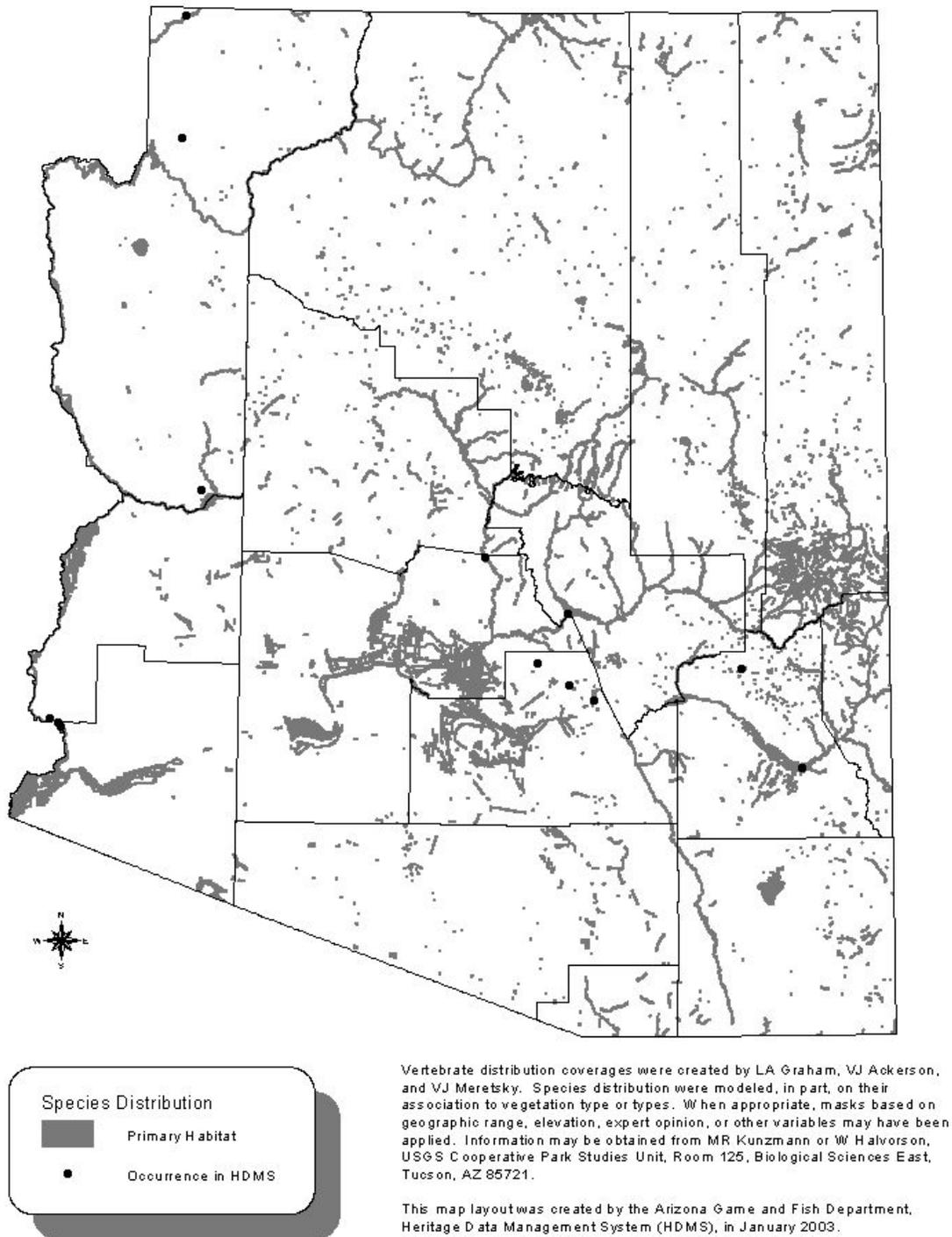


Figure 28: Habitat range and occurrence of the Yuma myotis in Arizona. Points represent maternity colonies, roosts of 10 or more individuals, and sites where 3 or more pregnant or lactating females have been netted.

## RESOURCES

### ROOSTS

Research on time budgets of bats indicates that they spend more than half of their lives roosting (Kunz and Pierson 1994). Roosts are probably a limiting resource for bat populations, and are often considered the factor most affecting bat abundance and diversity (Humphrey 1975). Most bats roost during the day and forage at night, although some species (especially some Megachiroptera) are active crepuscularly or diurnally. Roosting environments may vary considerably and include such structures as caves, mines, rock crevices, exposed tree branches, loose bark, buttress roots, cavities in trees, foliage, “tents” made from modified leaves, bridges, buildings, and other human structures. Most research on roosting behavior has focused on colonial species that form large aggregations, as these are easier to locate and study. Research has also been biased toward maternity roosts and hibernacula for the same reasons, as well as for their importance to the bats’ life history.

Roosts must provide shelter from the elements, a microclimate suited to the needs of bats, and protection from predators. In addition, roosts must be close enough to foraging habitat and water. Bats have used some roost sites for generations, which implies that roosts are valuable components of their behavioral and ecological needs. However, roost specificity and loyalty can vary widely among species, and even within species, depending on the season and type of roost. Tree-roosting bats often switch roosts repeatedly throughout the year, while mine and cave-roosting bats may spend long periods in 1 roost during the year and return to the same roost faithfully year after year. Roost requirements in some species are very specific in terms of temperature regime, humidity, protection from predators, substrate, and light. Distances from roosts to foraging areas may also play an important role in roost selection. Generally Microchiroptera feed within 6-9 mi (10-15 km) of their roost, but some may range up to 50 mi (80 km) or more in a night (Davis and others 1962).

Bats need roosts for day shelter, raising young, and for many species, hibernation. Bats may also need night roosts, places to rest and digest food while foraging. Some species utilize transitory roosts during migration, and others perform courtship and mating inside roosts. The characteristics of these roost types may differ greatly.

For most species of Microchiroptera, males and females are spatially segregated during the maternity season, with females of many species forming maternity colonies where they give birth to and care for their young. Colonies may range in size from a few individuals to several million. These large colonies may provide protection from predators as well as specialized micro-environments as the body heat from the bats can raise the ambient temperature of the roost several degrees.

During the maternity season, males often form smaller bachelor colonies. These colonies may be in different habitats than maternity colonies. However, research is lacking on the characteristics of most bachelor roosts and the requirements of male bats.

In environments that are highly seasonal, bats may hibernate during cold periods when food supplies are inadequate or they may migrate to warmer climates. Not only does this involve a change of roost, but it also usually entails accumulation of fat reserves before migration or hibernation. Hibernacula generally must offer a stable environment for roosting bats, where they may maintain a lowered body temperature and metabolic rate without danger of freezing. During hibernation, bats are highly susceptible to disturbance, making hibernacula an important focus for management and protection efforts. For California leaf-nosed bats that do not enter torpor, warm geothermally-heated winter roosts in caves and mines are critical for their survival.

Not all bat species are heterothermic. For those species that are not, migration may be necessary in seasonal environments. As well, some heterothermic species must migrate from suitable warm-weather roosts to reach their hibernation sites. During migration, bats may use transitory roosts, which they occupy for only a few days or weeks at a time. Location of and requirements for transitory roosts are generally poorly known, as are the pathways that migrating bats take between their summer and winter roosts. Courtship and mating may also take place in these transitory roosts.

Many bats use separate night roosts to rest and groom between foraging bouts. In general, requirements for acceptable night roosts are less stringent than those for day roosts, and night roosts are often found in close proximity to foraging habitat. Night roosting bats may frequently be found in and around buildings and bridges in urban areas, in shallow caves and mines with no dark zone for day roosting bats, and in trees. Night roosts may also be used for social behavior, including allo-grooming and possibly mating in some species. Mating and courtship may also occur in roosts that are just used by bats for these purposes.

### Caves

Almost half of the bat species in the United States regularly roost in caves. The largest colonies of bats in the world are found in caves, most notably the 20 million Mexican free-tailed bats roosting in Bracken Cave in Texas. Formerly, Eagle Creek Cave in Arizona was home to 25 million Mexican free-tailed bats, but numbers declined precipitously in the late 1960's. Declines in the numbers of cave bats have been attributed to pesticide use, unintentional disturbance by cave visitors, vandalism, and activities by researchers. It is likely that combinations of these factors have contributed to the substantial declines seen at many important roosts (Mohr 1972).

Caves can provide stable temperature and humidity conditions for both maternity roosts and hibernacula. Large and complex caves may offer a range of temperatures with cold air or warm air traps. The variety of microclimatic conditions within a single cave provides opportunities for bats to change roosting locations as their metabolic requirements change over a season (Twente 1955). Air flow within caves may differ depending on the number and arrangement of entrances and the interior structure of the cave. Even small caves with no dark zone may be used for night roosting.

Education and partnership initiatives with local caving groups and grottoes have sometimes resulted in the development of positive management and usage guidelines for caves that are important to bats.

*Species.* -- Most species in Arizona use caves, cliffs, and rock crevices as roosts. There are no hard and fast rules separating cave dwellers from crevice-roosting bats. However, certain species are more commonly found in one type of roost than in the other. Species commonly found in caves are ghost-faced bats, Mexican long-tongued bats, lesser long-nosed bats, California leaf-nosed bats, Townsend's big-eared bats, big brown bats, Allen's lappet-browed bats, southwestern myotis, western small-footed myotis, long-eared myotis, Arizona myotis, fringed myotis, cave myotis, and Mexican free-tailed bats.

*Threats.* -- Human disturbance is probably the biggest threat to cave-dwelling bats. While vandalism and direct aggression toward roosting bats definitely occur and can cause large amounts of damage, even "responsible" cave visitors may unknowingly cause harm to roosting bats. Repeated disturbance at a roost site may cause bats to abandon the roost and move into a less favorable (but less disturbed) alternative roost. Disturbance at hibernacula may wake hibernating bats, causing them to burn stored fat and perhaps preventing them from being able to survive the winter (Thomas 1995). Population declines may be accelerated if numbers at maternity colonies are not sufficient to raise roost temperatures to the levels needed for healthy growth of babies (Mohr 1972).

Development of larger caves for tourism may also disturb bats, not only through direct disturbance, but also through changes in the micro-climate of the cave due to lights, doors, and other developments (Mann and others 2002). In the past, use of caves for guano mining has also been implicated in declines of bat numbers. Natural disturbances, such as flooding, may also endanger cave roosting bats.

In some situations, metal gates can be installed to allow passage by bats while restricting access to humans. Such gates, when properly designed and installed, have allowed populations to recover at many sites. However, not all species of bats accept gates. Poorly designed gates may restrict airflow, provide roosts for predators, disrupt cave micro-climate, prevent safe passage for the bats, or be easily breached (Tuttle and Taylor 1998; Currie 2000). Alternative closure methods, such as signs, perimeter fencing, and motion or light detectors may be used at sites where gating is impractical or undesirable. However, in some cases, signs, fencing, and other such efforts may attract more attention to roost sites. Variation in accessibility, vulnerability, and topology between sites thus requires individual evaluation for protection methods.

#### Rock crevices and cliffs

Even in areas without large caves, bats can often be found roosting in other rock features, such as in crevices between rocks, in cracks on rock and cliff faces, and even on cliff faces out in the open. As well, some crevice roosting species may utilize crevices within caves and mines. These roosts offer good protection from predators and suitable roosting habitat for smaller colonies and single individuals. Crevice roosts may not be suitable for hibernation, however, due to greater exposure to temperature fluctuations.

*Species.* -- Western pipistrelles, California myotis, long-legged myotis, spotted bats, pallid bats, big brown bats, Mexican free-tailed bats, pocketed free-tailed bats, big free-tailed bats, Underwood's mastiff bats, and greater western mastiff bats are commonly found in crevices and cliffs.

*Threats.* -- Bats roosting in crevices inside caves and mines are subject to the same threats as cavity-roosting bats in these habitats. As well, more exposed crevice roosts may be disturbed by rock climbers, as well as by such factors as road and dam construction and reservoir flooding in canyons.

### Mines

Twenty-seven of the 45 species of bats in the United States are known to roost in mines, and for several of these species, mines may represent critical habitat (Tuttle and Taylor 1998). The lesser long-nosed bat, Arizona's one endangered bat, appears to be heavily dependent on abandoned mines for roosting sites. Other Arizona species that rely heavily on mines are cave myotis, Yuma myotis, big brown bats, pallid bats, Townsend's big-eared bats, Allen's lappet-browed bats, Mexican long-tongued bats, Mexican free-tailed bats, and California leaf-nosed bats. With the loss of traditional roosts due to disturbance, habitat modification, and other factors, mines may become more important habitat features for roosting bats.

Mines share several characteristics with caves that make them good bat habitat, including areas of stable temperature and humidity, low light levels, and protection from predators. As with caves, certain mine structures may create cold or warm air traps providing appropriate microclimate for roosting bats. Multiple mine entrances may create air flow, which may also affect the variety of microclimates available. Like caves, mines may be used as day roosts (maternity, bachelor, or transitory), night roosts, courtship sites, and hibernacula. However, mines may also be susceptible to greater disturbance than caves.

There are an estimated 80,000-100,000 mines in Arizona, but not all mines are equally suitable for bat habitat. Of Arizona mines surveyed by the AGFD Bat Project, about one-third showed evidence of bat use, and approximately 10% appeared to be significant roosts (T. Snow, AGFD, personal communication). However, most surveys for this project involved one-time visits to the roosts and may not reflect actual mine usage. P. Brown (Brown-Berry Biological Consulting, personal communication) has found 75-80% bat use (bats or guano) in Arizona mines with 10% showing "significant" usage. Knowledge of which factors characterize appropriate roosting habitat is sorely lacking. It is quite possible that many mines that are not currently used by bats could become appropriate roosts if protected from disturbance.

*Species.* -- In addition to the species listed above, California myotis, western small-footed myotis, long-eared myotis, Arizona myotis, fringed myotis, cave myotis, long-legged myotis, western pipistrelles, and ghost-faced bats may also roost in mines.

*Threats.* -- The threat of human disturbance to bats living in mines is similar to the threat of disturbance to cave-roosting bats. Human visitors can intentionally or unintentionally disturb and even cause mortality to roosting bats. Mineral and artifact collectors are entering mines in increasing numbers. As well, bats roosting in mines face additional threats because mines are inherently unstable. Collapsing mine workings may injure bats, block entrances, or change the internal micro-climate of the mine. The instability of mines also makes them a human safety hazard, and thus subject to closure or destruction. Renewed mining often destroys historic mine workings and in many cases replaces them with open-pits which are unsuitable for bat habitat.

Pollution of surface water from renewed mining can also pose a major threat to mine-roosting bats (Brown and Berry 1997).

As for caves, gates may be used to prevent people from entering dangerous mines, while leaving them open to bat use. "Soft closure" methods such as warning or interpretive signs, which do not physically restrict entrance to the roost, may also be useful in some instances. Because of the inherent dangers of abandoned mines, in some cases mines should be permanently closed. Such activity should not take place until biological surveys have been completed to assess the workings for bat use. Unused and unsuitable mines may then be permanently closed through backfilling or dynamiting, while gating efforts may be focused on those mines that provide suitable bat habitat. Surveys should be thorough and include assessment in all four seasons, since bat use may vary considerably throughout the year. A bat assessment should be performed immediately prior to permanent closure since bats can move to a previously unoccupied if a survey was conducted in another year or season.

### Trees

A few species of bats are obligate tree-roosting species; these include silver-haired bats, western yellow bats, hoary bats, and western red bats. Fringed myotis, big brown bats, Arizona myotis, and Yuma myotis are also commonly found in tree roosts. Bats may roost in a number of different tree features: on branches and within foliage, among dead fronds on palm trees, under exfoliating bark, and in cavities in either live or dead trees. Tree-roosting bats generally do not show the high roost fidelity that seems to be characteristic of cave, mine, and building roosting bats, but instead move frequently between trees. Often, however, these multiple roosts are confined to a relatively small geographic area (Lewis 1995). This may be a predator avoidance behavior. A study of lactating female long-legged myotis on the Kaibab Plateau showed that they used multiple roosts, moving sometimes nightly, sometimes staying for several days (Siders, unpublished data). This behavioral pattern means that it may be difficult to specify single trees that are of paramount importance to bats. Rather bats may rely on a stand with several suitable trees in it.

Some tree-roosting bats may prefer to roost in trees that are located within forest stands rather than in open environments (Vonhof 1995). This may be due to a lack of alternative roosts in the area or to higher predation risk in a more open environment.

Most likely, bats select snag roosts based on the specific microhabitat provided by the roosts. Nevertheless, the typical snag roost used by bats in Arizona forests is located under loose bark in a large diameter conifer (Herder and Jackson 2000; Rabe and others 1998). Research in ponderosa pine forests has shown that these roost snags are also more likely to be found among clusters of other large snags. However, whether this spacing is selected for by bats or is an artifact of ponderosa pine regeneration and management history is unclear. Beyond these basic characteristics however, research results are inconclusive. Herder and Jackson (2000) found roost snags were in relatively open forest areas while Rabe and others (1998) found snags were surrounded by relatively dense growth of small trees. The effects of slope, aspect, cattle grazing, surrounding forest basal area, shrub density and other landscape and stand scale characteristics are not consistent among studies. Additional research is necessary to determine the effects of these and other habitat characteristics on roost selection by bats at multiple spatial scales.

Hardwoods are also used by bats as day roosts. Bernardos (2001) located 34 Southwestern myotis roosts in Gambel oak trees, both alive and dead. Gambel oak comprise only 25% of the canopy cover in pine-oak stands, yet lactating Southwestern myotis appear to select cavities in Gambel oak within pine-oak stands.

Bats are long-lived mammals, and most snag roosts are available to bats for only a few years (Thomas and others 1979; Cline and others 1980). Roost-switching (changing roost location during the reproductive cycle) is common in snag-roosting bats (Rabe and others 1998; Brigham and others 1997; Vonhof and Barclay 1996; Brigham and Fenton 1986). Roost switching may be a mechanism for predator avoidance or reducing parasite load (Fenton and others 1994; Lewis 1995). The transitory nature of snag roosts may force forest bats to switch maternity roosts in response to changing conditions of the roost itself (Rabe and others 1998; Vonhof and Barclay 1996). Because a maternity colony might require multiple roosts to raise young each summer, managers should be aware that traditional estimates of snags required to maintain cavity nesting birds (Balda 1975; Cunningham and others 1980) are unlikely transferable to bats.

Managers should use caution in applying the results of forest bat studies in the Pacific Northwest to Arizona Forests. There is a growing body of literature on snag selection by bats in Oregon, Washington and Canada (Brigham and others 1997; Vonhof 1995) and these studies may help to understand the roosting habits of Arizona bats. However, there is some evidence that snag roost selection in Arizona forests may differ from selection in forest habitats in northern forests. One commonality among northern forests bat studies is that bats appear to select tall snags that extend above the surrounding canopy for the increased solar exposure they provide (Vonhof and Barclay 1996). Bats from these studies are also commonly found in cavities excavated by birds (Kalcounis and Brigham 1998). Southwest forests are warmer and drier than those in the Pacific Northwest. To date, few bats have been found to use cavities within snags in Arizona and there appears to be no clear trend in regards to the solar exposure of roosts.

Major Maternity roost characteristics:

1. Large diameter snags with loose bark or large diameter oak trees with cavities
2. Snags are located in clumps of other large diameter snags or groups of large oaks
3. Located close to water and foraging habitat
4. Several maternity roosts may be necessary for a single group of females each summer

*Species.* -- In addition to the species listed above, California myotis, western small-footed myotis, Arizona myotis, pallid bats, and Allen's lappet-browed bats have been found roosting under loose tree bark. The long-eared myotis may roost in hollow trees and has been found roosting in large fire scars.

*Threats.* -- Forestry practices that favor selectively removing older and larger trees, or removing old dead trees (snags) constitute the greatest threat to tree-roosting bats, as these are most likely to have, and to develop through time, the cavities and loose bark that bats need for roosting. Both prescribed fire and wildfires may also threaten forest bats and their roosts, although they may also create new snags for roosting. As urbanization and recreational use of existing forests

increase, disturbance and fragmentation of tree stands may reduce their suitability for bat roosting.

### Buildings

With increased urbanization and destruction of traditional roost sites, several species of bats have begun to utilize buildings and other man-made structures as roosts. Although these may provide some of the same advantages as traditional roosts (e.g. protection from predators, favorable temperature ranges, protection from the elements), they may also have disadvantages (e.g. increased susceptibility to disturbance, less favorable location with respect to foraging areas). As well, some species seem to be much more adept at utilizing building roosting sites than others. Building roosts may involve bats utilizing crevices in stone or brick walls or under siding and signs or it may involve the colonization of an attic or other large open area.

Older buildings may be more susceptible to bat usage because they are not as well sealed as newer buildings.

*Species.* -- In Arizona, the most common species found in buildings are big brown bats, Mexican free-tailed bats, western pipistrelles, and pallid bats. Yuma myotis, California myotis, western small-footed myotis, long-eared myotis, Arizona myotis, fringed myotis, cave myotis, long-legged myotis, pocketed free-tailed bats, Underwood's mastiff bats, greater Western mastiff bats, silver-haired bats, lesser long-nosed bats, and ghost-faced bats may also be found in buildings. Townsend's big-eared bats and California leaf-nosed bats are occasionally found night roosting in buildings.

*Threats.* -- Fears and misconceptions about bats may lead people to exclude bats from buildings. Public health concerns, especially having to do with rabies and, to a lesser extent, histoplasmosis, may prompt governmental agencies to recommend exclusion of any bats found in human structures. In some cases, such concerns may be warranted, especially if bats are entering living and working quarters, if young children or pets may gain access to individuals, or if the bats' presence threatens the structural integrity of the building (as may happen with large colonies roosting in attics where guano build-up may threaten ceiling stability). As well, noise and odors from large colonies may also prompt removal. However, in many cases where bats are roosting on or near the outside of the building, they can be safely allowed to remain.

Unsafe pest control practices, including application of toxic chemicals and pesticides, may harm bats and even the people living or working in the building.

### Bridges

Bridges and culverts can be important roost sites for bats. Although only a small percentage of highway structures provide ideal conditions for day-roosts, there is a high occupancy rate for the bridges that are suitable (Keeley and Tuttle 1999; S. Wolf, unpublished data). In the Tucson metropolitan area, 92% of concrete parallel beam bridges with crevices large enough to hold bats were occupied by day-roosting bats; however, these bridges accounted for only about 15% of bridges in the area. Many more bridge structures are suitable for night-roosts than for day-roosts; a survey of bridges and culverts in 25 states found 29% of all structures had evidence of night-roost activity (Keeley and Tuttle 1999). In rural Cochise County, Arizona, bridges provide some

of the best-documented examples of bat homing and extreme site fidelity by both colonies and individual bats. Particular bridges have been used by marked colonies and marked individual bats for decades (Davis and Cockrum 1962; Sidner 1997).

What makes a bridge suitable for bats varies with different species. Factors may include the dimensions of the roost site such as width, depth, and height of a crevice in a bridge and the crevice temperature regime compared to ambient temperatures. The amount of disturbance from human activity under the bridge, surrounding land use, and distance to foraging areas may also be important to certain species. In Tucson, large colonies of Mexican free-tailed bats use the deepest crevices in the highest available bridges, and roost in bridges throughout the urban area. In contrast, cave myotis roost in bridges only in the outlying areas of the city, but use crevices of varying depths in bridges of varying heights. Species diversity varies among bridges. Most bridges are occupied by only 1 or 2 species, whereas others offer conditions appropriate for multiple species. One bridge in Tucson houses 5 species, and 2 other bridges are occupied by 4 species each.

In addition to the day roost sites described above, bats also use bridges as night roosts. Slab and I-beam type bridges, which do not have crevices, may provide suitable night roost sites. Species such as the lesser long-nosed bat and California leaf-nosed bat roost in caves and mines during the day but may use bridges (and other man-made structures) as night roosts.

Bridges in Arizona are used by maternity colonies, bachelor colonies, night roosting, and migrating bats. In Tucson, some bridges are also used throughout the winter by Mexican free-tailed bats and western pipistrelles, and small numbers of California and cave myotis. These bats do not hibernate for the entire season, but enter torpor for at least several days at a time.

Some bridges may not be suitable for overwintering bats or maternity sites, but may provide a temporary roost site for migrating bats. Although any one particular bridge in an area may not be crucial to a population, collectively, these bridges are an important resource.

*Species.* -- The following species are known to use bridges in Arizona: Mexican free-tailed bats, western pipistrelles, big brown bats, pallid bats, California myotis, cave myotis, Yuma myotis, silver-haired bats, California leaf-nosed bats, fringed myotis, western small-footed myotis (Davis and Cockrum 1963), lesser long-nosed bats, Mexican long-tongued bats (Sidner 2001), Townsend's big-eared bats (Sidner 2001), and big free-tailed bats (R. Davis found a specimen of this species under a bridge in Cochise County near Douglas in 1985 [R. Sidner, personal communication]). The following species have been documented using bridges or culverts in other states: long-eared myotis, Arizona myotis, and long-legged myotis.

*Threats.* -- Bridges provide bats with numerous roost sites; however, the bats are vulnerable to intentional disturbance and extirpation by vandals. Large colonies of bats roosting in bridges are most vulnerable to vandalism because they are most easily detected by passers-by. Bats roosting in bridges that span dry washes rather than water are most vulnerable because they are easily accessible to people. Bats are killed, injured, or harassed in a variety of ways; they have been shot, hit with paintballs, had rocks thrown at the crevice (reportedly to make them come out faster), and have been knocked to the ground by someone running a stick along the crevice. Bats

have been destroyed by Department of Transportation workers when tarring road surfaces because the hot tar can penetrate through expansion joints where bats are roosting. At bridge maternity roosts this is especially problematic because non-volant juveniles cannot escape. Dead bats in tar in crevices of several bridges in Cochise County have been observed over several years from multiple tarring events, and an entire maternity colony of *Antrozous pallidus* was destroyed in this manner in 1989 (Sidner 1997).

We do not know how important one particular roost site is to a population or species. Obviously, those bridges occupied by the largest number of bats should receive close monitoring and protection. Using abundance as the only criterion, however, would be a mistake. For example, a bridge used by 50 pipistrelles or 100 cave myotis may be much more important to the species than a bridge used by 1000 Mexican free-tailed bats. Determining the significance of a bridge to a population requires more knowledge than we presently have - knowledge of the entire population in an area throughout the year. Therefore, any bridge that serves as a roost site should be protected if possible. Communication with the Arizona Department of Transportation is a necessity to prevent additional destruction of bat roosts.

Many modern bridge designs do not provide the roosting potential present in older designs. As these older bridges are replaced, roosting habitat will be lost.

Roost sites for bats in bridges have been, until recently, an unintentional artifact of bridge design. Because of growing concern for the conservation of bats, conservationists and bridge design engineers have begun to work together to include features specifically designed as roost habitat in designs for new bridges and to retrofit existing bridges with roost site structures. The Federal Highway Administration and several state departments of transportation have become involved in surveys of bridges for bat use and developing strategies and techniques for preserving or enhancing roost habitat (Keeley and Tuttle 1999). The Arizona Department of Transportation has incorporated bat habitat into a new bridge on the Tonto National Forest (Keeley and Tuttle 1999).

Existing structures for retrofitting, such as the Texas Bat Abode and the Oregon Wedge (Keeley and Tuttle 1999), work well in certain circumstances. Research is necessary, especially in hot climates, such as Arizona's, to determine the best location in a particular bridge for the structure, and if insulation is necessary to provide the appropriate temperature profiles. Because many variables influence roost selection, research conducted in bridges already occupied may provide more information initially than installing structures in unoccupied bridges.

For bridges that must be replaced, leaving the old bridge standing, rather than demolishing it, would preserve existing roost sites and save the cost of the removal of the old bridge. A second strategy is to add concrete slabs with crevices in between them to the bottom of the new bridge. The slabs could be from the old bridge or newly constructed. Relocating the portion of the bridge used as the roost site from an old bridge to the new one has been successfully implemented in Australia (Keeley and Tuttle 1999).

Bats may also be disturbed or excluded from bridges during maintenance and repair work. Communication between wildlife agencies and departments of transportation can help alleviate

some of these problems by allowing scheduling of such activities for a time when they will have the least impact on the bats.

#### Manmade Roosts

Manmade roosts, such as bat houses and artificial bark are becoming more popular. However, success with such roosts has been mixed throughout Arizona. For instance, bat houses have been successful in the northern parts of the state, especially in the Flagstaff area, but are generally not successful in central and southern Arizona, particularly in the Phoenix area. Studies such as BCI's North American Bat House Research Project have generally not addressed the specific problems inherent in creating manmade roosts for bats in such an extreme environment. Further experimentation and innovative designs will likely be needed before we see much success with bat houses in central Arizona.

Artificial bark has been used successfully in northern Arizona forests. This type of roost is made by constructing a panel of fiberglass molded to look like tree bark (Chambers and other in prep). This artificial bark can then be mounted on a tree to create a crevice that mimics those found under the peeling bark of snags. These can be constructed to have a single roosting chamber or multiple chambers. In areas where forest management has created a paucity of natural snags, such artificial roosts can be important for increasing roost availability to bats.

Bat houses are used by most crevice-roosting bats, and artificial bark has been successfully used by many species of tree-roosting bats.

#### Other roosts

In addition to the "traditional" roost sites listed above, bats may also take advantage of other roost sites, including the abandoned mud nests of cliff swallows, which big brown bats, Yuma myotis, and cave myotis have been found to roost in. Another habitat unique to the Southwest is abandoned saguaro boots, holes in saguaro cacti (typically made by woodpeckers) around which the saguaro has secreted a resinous sap to form a woody hollow. These saguaro boots may house big brown bats, western red bats, and Underwood's mastiff bats (T. Tibbitts, personal communication). Similar to bridge roosts, tunnels and dams may also provide roosting places for bats.

## FORAGING HABITAT

Foraging habitat requirements may vary greatly among species and even, seasonally and spatially, within species. For insectivorous bats, prey availability may change considerably between seasons or habitat types. The amount of selectivity of foraging bats for prey type may differ among species, although this is poorly understood. To fully understand the importance of different types of foraging habitats for insectivorous bats, we must understand the relationship between the bat and the species that it preys on, as well as the relationship between the prey and its habitat.

Although bats may travel long distances between roosting and foraging sites, proximity to appropriate roosts may influence the suitability of a particular area for bat foraging. The availability of night roosts near a foraging area may increase bat usage.

The appeal of a particular area may also depend on the predictability of the resource base. This can vary widely depending on the nature of the resource base. Some areas, especially riparian areas and agricultural fields, may have predictably large populations of certain insects, whereas other areas may have more ephemeral populations. Nectar-feeding bats may have an advantage in this respect, as their resource base is immobile. Large patches of flowering plants constitute reliable foraging areas that may be utilized night after night throughout and, to some extent, between seasons.

Availability of water for drinking may be of importance to bats when selecting foraging habitat. Although some species of bats (i.e. Yuma myotis) usually occur near open water, many species are found in arid areas without any surface water.

Bats may also be susceptible to predation and disturbance when foraging, so choice of foraging area may depend on some amount of protection from these threats. Frequently, insectivorous bats forage near forest edges, which, aside from supplying insect prey, may provide shelter from predators or weather. Some areas that may be rich in insects, especially in urban settings, may not be suitable foraging habitat due to noise, lights, or disturbance from humans. However, some bats regularly forage for insects around lights.

*Threats.* -- Both insectivorous and nectarivorous bats may be quite loyal to foraging areas, returning to the same site year after year (Brigham 1991; K. Hinman, personal communication; P. Brown, personal communication). Alterations of these sites may have large impacts on the bats that rely on them. Such alterations could include, but are certainly not limited to, logging, grazing, fire, and urbanization. Pesticide use and pollution of foraging sites may also negatively affect bats foraging in particular areas. Grazing in areas visited by nectarivorous bats may deplete populations of forage plants.

Unfortunately, lack of knowledge about the requirements of bats in terms of foraging areas severely hampers efforts to manage for these areas. More research is needed to determine what constitutes good foraging habitat for different species of bats. Researchers and managers should take a landscape level approach that incorporates roosts, foraging habitat, and other resources into management planning and conservation initiatives.

#### WATER AVAILABILITY / IMPORTANCE

In addition to roosts and foraging habitat, water is another integral component of bat habitat. Not only is free water important for drinking, the presence of water generally increases associated vegetational and structural diversity, and many species of wildlife, including bats, may use these habitats disproportionately more than others. Water may also provide important foraging habitat, and waterways may constitute good flyways.

While many species of bats are reliant on open water for drinking, some desert species roost 25 or more miles ( $\geq 40$  km) from any open water. In telemetry studies of California leaf-nosed bats, Brown (personal communication) found that these bats would bypass open water and spend all their flight time gleaning desert wash vegetation. While at times they have been captured over water, California leaf-nosed bats, Townsend's big-eared bats, western pipistrelles, pallid bats, and California myotis regularly occur in areas with no surface water (although sometimes springs choked with vegetation are in the vicinity). When water is available, these species will drink, but it appears that surface water may not be essential to the survival of some desert bats (P. Brown, personal communication). For nectar-feeding species such as lesser long-nosed bats and Mexican long-tongued bats, whose diet is mostly liquid, free water for drinking also does not appear to be important.

The presence and juxtaposition of each of the 3 major habitat components, roosting habitat, foraging habitat and water, may influence, or be influenced by, the others. For instance, bat roosts may often be found near water sources, and water sources may also influence the quality of bat foraging habitat or roost selection.

Bats use a variety of water sources. These include ponds, lakes, and reservoirs, streams and rivers, livestock tanks, wildlife drinkers, springs, and probably any other source of open water to which bats can gain access.

The usefulness of a water source to bats often depends on the type of source, its accessibility, reliability, location on the landscape, and the vegetation or other features that may be growing in or around it. Because bats drink while on the wing, scooping water up with their lower jaws or tongue, accessibility is determined both by the water sources' freedom from obstructions, such as fencing or vegetation, and the flight characteristics of the particular species of bat. Still or slow-flowing water is likely to be more usable to bats than faster-flowing water (Von Frenckell and Barclay 1987). Bats that exhibit the greatest degree of maneuverable flight can probably be expected to exhibit the greatest variety in access to and use of water resources, whereas bats with less maneuverable flight can be expected to be more limited in the water resources that are available to them (Altringham 1996). For instance, the fringed myotis, which is particularly agile in flight, could be expected to use water resources of a wide range of sizes and accessibility, while the big free-tailed bat, a larger and less agile bat, may be limited to more open water with less surrounding vegetation or other features that affect its flight path. Even if the water is generally open or otherwise accessible to bats, factors such as emergent or surrounding vegetation could influence the ultimate value of the water source; too much surrounding vegetation will restrict access to only the most maneuverable bat species. However, the presence of some vegetation around water may provide some protection from predators and can improve

foraging conditions by blocking wind, while emergent vegetation may also provide substrate for insect prey.

The exact distribution and density of water resources on the landscape necessary to sustain bat populations is largely unknown. In addition, as noted above, water needs of bats are likely to vary according to the species, the season of the year, and the condition of individuals. For instance, reproductive females exhibit higher water needs than non-reproductive bats of the same species, and it is generally thought that maternity roosts of most species need to be in close proximity to a reliable water source.

Water also can be used as foraging habitat, and several bat species appear to forage preferentially over both still and moving water. Big brown bats, silver-haired bats, Arizona myotis, and Yuma myotis all forage over slow moving water. Yuma myotis can be very abundant foraging over lakes and ponds in some areas during summer. During insect hatches, other species will forage over water as well.

*Threats.* -- The recreational and economic values of water and its associated habitats can put bats at substantial risk of human disturbance.

When designing, implementing, or modifying water improvements for livestock and wildlife, land managers can improve their usefulness to bats by insuring that the free water is available to as many species as possible. This can be done inexpensively by eliminating, modifying, or reducing obstructions such as fencing, plumbing, and covers. Although there is ample evidence that overgrazing by cattle and wildlife can affect the long-term availability of water to bats, in some cases, the elimination of all grazing at a particular site can allow recovering riparian vegetation to completely block bat access. These trade-offs should be considered in the context of the availability to bats of alternate water sources and other habitat features when managing livestock and wildlife.

Bats that concentrate their activities around polluted water are at risk of being affected, either directly or indirectly, by contaminants (Clark and others 1983). Species that rely heavily on aquatic insect prey may be adversely affected by disturbances, such as pollution or siltation, that alter prey abundance (Tuttle 1979).

## MIGRATORY CORRIDORS

Little is known about the migratory pathways used by bats traveling between winter and summer habitats. As in more long-term habitats, migratory corridors must provide roosts, foraging habitat, and water. However, because of the transitory nature of bats' use of these habitats, they may be able to exploit resources that would be considered marginal or insufficient for more permanent habitats.

Some bats may lessen their dependence on foraging habitat while migrating by building up fat reserves before migration. Other bats may need continuous access to resources along their entire migration route. Nectar-feeding bats follow a "nectar corridor" of flowering plants between their winter and summer habitats (Fleming and others 1993), allowing them to continue to forage during migration.

Transitional roosts used by bats during migration may be used for only a few days or weeks, thus increasing the difficulty of identifying such roosts and determining their importance to the population.

*Threats.* -- Lack of knowledge about migratory corridors and pathways and lack of effective techniques for long-distance tracking of bats considerably hamper efforts to manage these habitats.

Many of the same threats that influence roosts, foraging habitat, and water resources in more permanent habitats will affect these resources along migratory corridors.

Several species of bats, including lesser long-nosed bats, Mexican long-tongued bats, western red bats, and Mexican free-tailed bats migrate between Arizona and Mexico, thus requiring international cooperation to identify and preserve essential habitat elements along their migratory corridors.

## GOALS AND OBJECTIVES

### OVERVIEW

In order to direct action for bat conservation in Arizona, we have delineated goals and actions that focus on 4 broad categories: 1) Research; 2) Inventory and Monitoring; 3) Management; and 4) Education. Within each category, there is an introductory problem statement discussing the need for focusing efforts in that category. Following this, there is a list of goals to address this problem, with a brief statement of issues associated with each goal. Within each goal section, priority actions are identified to direct efforts. In many cases, tasks specific to Arizona are given as examples of projects that will help accomplish the stated goals. These tasks do not constitute a complete list of projects that should be undertaken, merely examples of suggested actions. Local managers should identify the goals that apply to their areas of authority, set priorities for actions to address these goals, and identify specific projects within these actions to carry out.

Whereas education goals and objectives apply statewide across habitat types, some research, inventory and monitoring, and management goals are more relevant for certain areas. Within the habitat type sections, these area-specific goals are designated for cross-referencing. As well, some specific suggestions for actions are given for managers of these habitats.

The order of categories, goals, and actions should not be construed as a rank of priorities. All levels of goals are considered equal in importance to Arizona bat conservation.

RESEARCH

**Problem**

Insufficient knowledge of factors causing decline of North American bats, combined with insufficient data on population status and trends, greatly impede specific and comprehensive recommendations for management.

**Goal 1 – Establish baseline populations and trends.**

Population structure, dynamics, and trends have seldom been monitored over time for bats, making status determination difficult. Estimating historical and current populations and establishing trends is essential for tracking and prioritizing conservation needs and evaluating progress. Reliable survey and monitoring techniques, standards, and equipment are much needed to facilitate such efforts.

*Priority Actions*

1. Evaluate technologies such as ultrasonic detection to identify bat species; and photography and infrared imagery to monitor bat numbers entering and exiting roosts.
  - ◆ Evaluate effectiveness of echolocation call identification methods using ultrasonic detectors.
  - ◆ Evaluate effectiveness of photomonitoring techniques at roosts such as Eagle Creek and Grand Canyon National Park Bat caves.
  - ◆ Determine effectiveness of Doppler radar imaging in locating Arizona bat roosts and monitoring bat movements.
  - ◆ Evaluate different methods to mark animals and determine which is the most effective for which species. Population units, movements, courtship, etc. all rely on marked animals, and the tolerance for different techniques will vary with the species (banding, wing tattoos, telemetry, PIT-tagging).
2. Conduct research to better understand how, when, and why bats use, vacate and move between roosts.
  - ◆ Study movement patterns and roost switching for southwestern myotis, Arizona myotis, fringed myotis, and long-legged myotis in Arizona forests.
  - ◆ Study movement patterns and roost switching for California leaf-nosed bats, Allen's lappet-browed bats, and Townsend's big-eared bats in Arizona mines and caves.
  - ◆ Initiate studies of year-to-year roost site fidelity, especially in forest-dwelling bats.
3. Conduct research to better identify and define population units, relevant for conservation planning and research, including what constitutes a species's bachelor or maternity colony, a hibernating population, or other potentially important aggregations, such as migratory or courting groups.
  - ◆ Conduct research to determine if bachelors and maternity colonies of California leaf-nosed bats utilize entire mountain ranges or specific geographical areas. Begin looking at important courtship sites that may define population group.

- ◆ Conduct research to determine if bachelor or maternity colonies of Townsend's big-eared bats utilize entire mountain ranges.
- ◆ Conduct research to determine if western red bat population units can be determined in Arizona riparian areas.
- ◆ Keep population records and estimates for all bat species, even for "common" bats such as Yuma myotis and Mexican free-tailed bats.

**Goal 2 - Identify key resource requirements and limiting factors.**

Bats rank among North America's least studied wildlife. Therefore, information commonly available for other species, such as abundance, distribution, migratory patterns, and roosting and foraging habitat requirements, is lacking for many bat species.

*Priority Actions*

1. Identify requirements for nursery and hibernation roosts, reproduction, foraging, and drinking, beginning with the most vulnerable and threatened species. Focus data collection on key resources, especially on roosting and feeding locations of greatest current or past use.
  - ◆ Identify lesser long-nosed bat habitat needs, especially near the current northern range boundary.
  - ◆ Identify Mexican long-tongued bat habitat needs, especially regarding roost and foraging requirements.
  - ◆ Identify Townsend's big-eared bat habitat needs, especially regarding nursery and hibernation roosts and foraging requirements.
  - ◆ Identify spotted bat habitat needs, especially regarding nursery and seasonal roosts and foraging requirements.
  - ◆ Identify Allen's lappet-browed bat habitat needs, especially regarding nursery and seasonal roosts and foraging requirements.
  - ◆ Characterize habitat utilization by bats, such as western red, hoary, and western yellow bats, roosting and foraging in Arizona riparian areas.
  - ◆ Identify and monitor habitat use of Arizona forest bats.
  - ◆ Characterize habitat utilization by bats roosting in Arizona urban areas.
  - ◆ Use the USGS's National Vegetation Classification System (NVCS) to define habitat and vegetative communities, and to map distributions of species within these habitats.
2. Compare requirements in diverse habitat types to better understand the geographically varying needs of species with wide distributions.
  - ◆ Identify and compare Allen's lappet-browed bat habitat use within Mohave Desertscrub and Montane Conifer Forests of Arizona.
  - ◆ Identify and compare pallid bat habitat use within Lower Sonoran Desertscrub, Mesquite grasslands, and Oak woodland habitat types within Arizona.
  - ◆ Identify and compare spotted bat habitat use within Montane Conifer Forests, Desertscrub Riparian, and Grassland habitat types within Arizona.

3. Increase understanding of special migratory and seasonal needs; identifying migratory or travel routes, associated hazards, and requirements for roosts and foraging habitat.
  - ◆ Identify foraging areas associated with lesser long-nosed bat transitory roosts.
  - ◆ Identify migratory corridors for lesser long-nosed bats and Mexican long-tongued bats.
  - ◆ Identify and monitor key reproductive-display sites used by California leaf-nosed bats.
  - ◆ Identify foraging areas and winter roost requirements for spotted bats in northern Arizona.
  - ◆ Identify foraging areas and winter roost requirements for Allen's lappet-browed bats in Arizona.
4. Estimate ideal and feasible species carrying capacities, based on current and restorable habitat conditions in Arizona.
  - ◆ Develop and design methods for estimating species carrying capacities throughout different habitat types in Arizona.

**Goal 3 – Develop a centralized data repository for research and inventory data.**

One of the major difficulties in identifying and protecting key resources and tracking population trends in bat populations is the lack of a centralized data repository in which records from around the state can be entered and retrieved.

1. Develop and maintain a statewide database for roosts, species occurrences, and survey data which will allow tracking of species ranges, populations trends, and usage of resources. Include fields for negative data (non-occurrence) and for information on habitat improvements and protection efforts.
2. Maintain a central library of publications from bat research in Arizona, including technical reports and gray literature as well as papers appearing in peer-reviewed journals.

**Goal 4 - Describe and quantify the effects of historic habitat changes and current land management practices.**

Major habitat changes in Arizona and the Southwest have almost certainly had important effects on bats species' distributions and populations. Land management practices, on both public and private lands, have been implemented for more than a century with little understanding or regard for bats. The impacts of various environmental contaminants on bats, including herbicides and carbamate or organophosphate pesticides, as well as biological control methods, have not been adequately studied and may be directly responsible for substantial local reductions, either directly or indirectly, of non-target insects. Such information is essential for designing management plans to include bats.

*Priority Actions*

1. Describe and quantify the impacts of timber and fuelwood harvesting, fire suppression and prescribed burning, mining, grazing, agriculture, and other habitat

- altering and ground disturbing activities on bats, including implementation methods, standards and guidelines.
- ◆ Study impacts of historic habitat conversion, including conversion of grassland to shrub grassland and changes in forest composition and structure, on bat communities and their resources.
  - ◆ Continue to include bat studies in habitat improvement projects such as the Mt. Trumbull and Fort Valley Forest Restoration projects.
  - ◆ Include bat studies in forest chaining and prescribed burning projects throughout Arizona.
  - ◆ Study impacts of timber harvesting and fuel-wood gathering on bats in Arizona forests.
  - ◆ Study the effects on snag roost longevity, loss and creation with management actions such as prescribed fire and fuel-wood gathering.
  - ◆ Study impacts of renewed mining, regarding loss of roosting and foraging habitat, throughout Arizona.
  - ◆ Study the impacts of mine closure for hazard abatement and reclamation.
  - ◆ Study impacts of fire suppression, prescribed burning, and grazing on bats: specifically impacts affecting *Agave* spp. distribution and lesser long-nosed bats.
  - ◆ Analyze amount and distribution of cotton crops and crop dusting practices; determine implications for Arizona bats.
  - ◆ Analyze the changes in insect prey base in relation to agricultural or other habitat conversion.
2. Determine the effects of environmental contaminants, including heavy-metals run-off, cyanide and sulfuric acid leaching ponds, mercury contamination, and other water quality issues; unregulated dumping; pesticides; and herbicides. Identify the kinds of chemicals used and timing of application, and where feasible compare bat success where the potential pollutants are present versus absent. Encourage monitoring of toxicant levels in bat guano deposits, both to determine impacts on exposed versus unexposed populations, and also as an indicator of overall environmental health.
- ◆ Conduct studies to determine effects of sulfuric acid leaching associated with Arizona copper mines.
  - ◆ Monitor toxicant levels in guano deposits at important bat roosts in high contaminant areas such as the Gila River between Buckeye and Gila Bend, and along the lower Colorado River.
  - ◆ Monitor selenium levels found in guano deposits at the Eureka Mine, Yuma myotis roost.
  - ◆ Monitor effects of lepidopteran control practices used in Arizona forests.
  - ◆ Determine effects of heavy metal loads, specifically mercury and selenium, on bats in the Atascosia Mountains (Pena Blanca and Arivaca lakes).
  - ◆ Evaluate the use of pheromones or other natural pest control techniques to reduce the use of pesticides.

3. Evaluate the effectiveness of current mitigation techniques, such as artificial habitats and varied methods of protecting key roosts in caves and mines. Where feasible, develop and test improved mitigation techniques.
  - ◆ Monitor effect of cave commercialization and visitation on cave myotis in Kartchner Caverns.
  - ◆ Evaluate the effectiveness of bat-friendly gates at the following mines and caves:
    - State of Texas Mine (lesser long-nosed bats)
    - Beau Mine (California leaf-nosed bats and cave myotis)
    - Tonopah Belmont Mine (Mexican free-tailed bats, California leaf-nosed bats, and cave myotis)
    - Eureka Mine (California leaf-nosed bats and Yuma myotis)
    - Stanton Cave (Townsend's big-eared bats)
    - St. Johns Mine (Townsend's big-eared bats)
    - Union Pass mines (Allen's lappet-browed bats)
    - Wild Horse Mine (cave myotis)
    - Roosevelt Lake Siphon Tunnels (cave myotis)
    - Redmon Cave (fringed myotis)
    - Flag Mine, Hualapai Mtns (Townsend's big-eared bats)
  - ◆ Evaluate the effectiveness of bat-friendly gates in mining reclamation.
  - ◆ Evaluate the effectiveness for mitigation of 1) retrofitting bridges with bat roosts and 2) constructing new bridges and culverts with bat-friendly designs.
  - ◆ Evaluate the effectiveness of artificial bark bat roosts.
  - ◆ Develop a bat house research program, which will evaluate, design, and measure the effectiveness of bat houses used in Arizona.
4. Although vampire bats do not occur in Arizona, control efforts in Mexico and Central America may affect bats that migrate to our State. Therefore, research is needed to determine the impact of vampire bat control on Arizona bat populations. Evaluate current vampire bat control techniques used by rural people in Mexico.

**Goal 5 – Increase genetic studies related to management and conservation.**

One difficulty in establishing the affects of population changes in bat communities is our lack of knowledge of the genetic structure of bat populations and the genetic basis of species designations. Genetic studies have increasingly been used in conservation efforts to direct management actions and to better quantify goals for conservation of particular populations.

1. Develop and support genetic studies of species limits and relatedness, for instance: the separation of eastern and western red bats, species relationships of *Corynorhinus* big-eared bats, and desert and mountain populations of *Idionycteris*.
2. Conduct studies of genetic exchange and levels of heterozygosity in isolated subpopulations to determine genetic isolation and inbreeding.

**Goal 6 – Establish and quantify the economic and social impacts of North American bats.**

One of the most effective methods for raising public appreciation of bats is to document their economic and ecological values, from ecosystem maintenance to forestry, agriculture, and backyard gardens. Risk analysis is also needed to put the highly publicized, though minor, disease threats associated with bats in perspective.

*Priority Actions*

1. Conduct research to quantify the economic values of bats, with special emphasis on consumption of crop, garden, and forest pests, and pollination and seed dispersal, as well as on ecotourism associated with bat-watching sites.
2. Document verified bat rabies risks and prevention costs relative to other diseases.

**Goal 7 – Develop standards and protocols to enhance research quality and minimize harm to bats.**

There is a need for standardization of research methodologies for studying bats, including not only for accessing roosts during hibernation or maternity use, but also for radio tracking, light tagging, banding, mist netting and trapping. In addition, it is important to establish the suitability of technical equipment for various research purposes to ensure against inappropriate use that invalidates research results.

*Priority Actions*

1. Test and compare the reliability of bat survey, census and identification techniques. Refine echolocation detection technology and develop new technology for detecting, identifying, and counting bats.
2. Standardize research methods and protocols to establish minimal standards for conducting bat research.
  - ◆ Establish protocols for monitoring bat numbers entering and exiting roosts, including recommendations for appropriate use of live counts and infrared imagery.
3. Establish a bat-banding clearinghouse to ensure appropriate band use and that recovery information is maximized to advance scientific discovery.
4. Establish bat researcher training programs to increase field competency and minimize harm to bats.
  - ◆ Continue to support BCI's Bat Conservation and Management workshops.
  - ◆ Sponsor ANABAT and other bat sound analysis workshops for agency biologists and other partners.
  - ◆ Conduct annual workshops on field identification and survey techniques for researchers who cannot attend BCI classes.

## INVENTORY AND MONITORING

### **Problem**

Few bat populations have been inventoried or monitored over time. Status trends, ecosystem roles, and habitat requirements remain largely uninvestigated. This greatly impedes conservation planning and management. Land management practices are being implemented continent-wide, with little or no documentation of their effectiveness in mitigating damage or enhancing habitats for bats. In an effort to fill these knowledge gaps biologists are now widely using new technology to investigate species distributions, population trends, and habitat requirements, and there is an urgent need to verify and standardize technologies and techniques.

### **Goal 1 – Inventory and monitor caves, mines, and other natural and artificial roosts and habitats that support, or once supported, the most important bat colonies and populations.**

It is impossible to effectively prioritize key roosts and habitats for conservation and management without at least discovering them and estimating bat numbers, species composition, status trends, and threats. Several of North America's most important cave and mine roosts have only recently been discovered, highlighting the urgency of cave and mine surveys and inventories. In some cases where populations were extirpated in the past due to human disturbance, their potential significance is no longer recognized. As a consequence, they are ignored in conservation and management planning while remnant populations that are barely surviving in refuges of last resort are protected. Success requires that key resources be discovered and protected. Identifying and focusing on these sites first can dramatically improve our conservation successes.

### *Priority Actions*

1. Prepare and share guidelines for recognizing currently unoccupied, but potentially key bat roost resources.
2. Survey snags, caves, mines, buildings, bridges, and other potential locations of key roosts to determine past and present significance to bats, examining each for both evidence (such as guano or staining) and suitability of use. Inventory such locations and make wildlife managers aware of needs for protection and long-term status trend monitoring. In some cases, recently abandoned mines can be recognized as having ideal potential even though they have not previously supported bats.
3. Define and monitor critical resource corridors for bats, including flyways used nightly to reach feeding and drinking sites and those used seasonally in migration.
4. Monitor important habitats to better understand patterns of use, requirements, and distribution.
5. Support long-term monitoring of bat population trends for all species, particularly for listed species and species of concern.

- ◆ Lesser long-nosed bats: all known nursery colonies and transitory roosts should be monitored annually during the maternity season (May-June) and autumn migration (late July-mid September) using standard methods.
- ◆ Develop long-term monitoring schedules for mist netting sites throughout the state.
- ◆ Develop, coordinate, and increase participation in acoustical monitoring routes throughout the state.

**Goal 2 – Monitor the effects of land management practices, human disturbances, and artificial assistance on bats, ensuring that state, tribal, and federal land and resource management plans incorporate and implement appropriate standards and guidelines.**

Incorporation of bat needs into land management and other wildlife plans is only a beginning. If plans are not implemented as written and/or the prescriptions and mitigation measures do not have the desired effects or outcomes for bats, conservation objectives will not be met. Artificial watering sites and roosting structures for bats are proving successful in mitigating habitat destruction, however, monitoring the success of varied designs and locations are important to progress.

*Priority Actions*

1. Conduct implementation and effectiveness monitoring of all soil and watershed, range, timber, mining, military training and testing activities, and other ground disturbing actions with potential impacts on bats, and provide feedback to land managers.
2. Monitor the effects of artificial roosts and watering structures for bats, and share results widely.

**Goal 3 – Refine spatial and temporal distribution maps and prepare one set of shared maps for all Arizona bat species. Include these maps in the North American Bat Conservation Plans.**

It is vitally important for biologists and land managers to know which species occur in their areas. Environmental impact assessment and planning are impossible without this information. Geographic species boundaries alone are not enough. Managers need to also understand how species distribution changes with seasons, habitats, and elevation. Finally, they must be informed of acceptable techniques for conducting field inventories and making accurate species identifications.

*Priority Actions*

1. Monitor and verify field techniques used for detection and species identification.
2. Refine and standardize methods and protocols for determining and plotting species distributions continent-wide.
3. Collect data on seasonal distribution changes according to elevation, habitat, and geography during field inventories.

4. Provide GIS data for these seasonal, habitat, and elevational ranges for all bat species to land management agencies.
  - ◆ Utilize the NVCS to map species distributions onto vegetative community maps.
5. Standardize data collection and reporting methods.

**Goal 4 – Encourage interstate and international cooperation on inventory, monitoring, and habitat assessments to incorporate bats that cross borders into broader wildlife programs.**

Significant human resources can be saved by developing and implementing shared inventory and monitoring programs across international and state boundaries. Further, numerous existing wildlife inventories, particularly for birds and other mammals, can easily be modified and expanded to include bats. Opening lines of communication with biologists conducting other inventory and monitoring programs is an important first step toward accomplishing this goal.

*Priority Actions*

1. Establish an international inventory and monitoring team to standardize methods and procedures, and identify shared programs.
2. Identify and encourage collaboration with other state, national, and international organizations having responsibility for natural resource inventory and monitoring. Establish roles and responsibilities for data collection and sharing where there are overlapping priorities and information needs.

## MANAGEMENT

### **Problem**

More than half of North America's bat species rely on caves or mines as essential roosts. Tens of millions of bats have been extirpated from such roosts by human actions. At least 20 caves that housed such numbers in the past are currently unused due to human disturbance or adverse alteration. Many North American species are also heavily dependent upon old growth forests, however bats traditionally have not been considered in forest management planning, and this constitutes a major threat to their survival. At least 3 species of bats use nectar corridors to migrate from central Mexico to southwestern United States. Conserving a continuous nectar corridor not only will support the migration of nectar-feeding bats, but also a large number of other nectar-feeding animals. Also, numerous cliff-face crevices, ideally located adjacent to riparian habitat used by bats, have been lost during road construction or reservoir construction. As growing numbers of bats have been forced to abandon traditional roosts in caves and have lost tree cavities, snags, and cliff-face crevices, they have when possible moved into manmade structures, ranging from mines and dams to buildings and bridges. Many of these structures are now being razed or replaced with modern structures that do not meet bat needs. In the case of mines, they are actively being closed in hazard abatement programs.

### **Goal 1 – Develop management standards and guidelines for bats, including them in existing plans that direct habitat and species management activities for other wildlife.**

Bats rank among the least studied animals. Accordingly, management plans and projects have been developed and implemented for more than a century with little or no thought to their needs. With dozens of bat species now either federally listed as endangered or considered sensitive by federal, provincial, tribal, or state governments, it is imperative that bats be considered in environmental impact assessments and in wildlife management plans at all levels.

#### *Priority Actions*

1. Develop management standards and guidelines and habitat goals for bats and ensure they are incorporated into federal, provincial, tribal, and state land management and wildlife conservation plans.
  - ◆ Develop bat management guidelines for bats roosting in cave and mines, dams and bridges, and buildings.
  - ◆ Develop colony management guidelines for snag roosting bats in Arizona forests.
2. Standardize database information schemes to ensure compatibility and facilitate sharing between organizations and researchers.
  - ◆ Develop an Arizona Bat Occurrence and Roost Site Database, which includes information for all 28 Arizona bat species, plus mine hazard abatement and water quality issues.
3. Implement standardized permits, qualifications, and protocols for conducting bat research, inventory and monitoring, and conservation activities.

**Goal 2 - Identify, protect, and enhance key roosting, feeding, and drinking resources for bats. Reestablish bat populations to the extent feasible and necessary to maintain ecosystem health in all ecoregions.**

Roosts and associated foraging and drinking habitat are critical resources for all bats. Roosts sheltering thousands or millions of bats in caves or mines are the most often noticed and can be extremely important to a large proportion of a species' population. Nevertheless, other natural or manmade roosts, such as tree cavities, snags, cliff-face crevices, bridges, and buildings are also of vital importance to species that use them. Roosts that include a large proportion of a region's bats, exceptional species diversity, or the largest remaining groups of species that are endangered or in rapid decline are a high priority for protection. Habitats adjacent to key roosts also warrant priority consideration. Where traditional roosts or key habitat elements (such as drinking sites) have been lost; provision of alternate manmade roosts and other habitat enhancements may be necessary.

*Priority Actions*

1. Identify all important natural and manmade roosts. Prioritize these for protection, especially those containing the largest populations for a single species or the most diverse collections of species, containing threatened or endangered species, or receiving a high degree of disturbance or threats. Cave and mine roosts can be categorized according to: a) total numbers of bats accommodated (either past or present); b) number of species sheltered; c) apparent value of the site in meeting bat needs; d) long-term safety of the site, if protected; e) known threats if not protected; and f) status of the species involved.
  - ◆ Protect 90% of the sites sheltering hibernation populations or maternity colonies that rank within the largest 10% known for each of the state's most vulnerable species. Keep in mind that the number and percentage of roosts may require adjustment as more sites are identified.
2. Evaluate and characterize the ephemeral nature of snag roosts. Determine how long they are suitable as roosts and at what stage they become suitable. Create recommendations for land managers on how to manage to create and maintain these features through time and across the landscape.
3. Establish and evaluate effectiveness of manmade roosts in areas where the loss of natural roosts now limits population recovery. Incorporate manmade roosts, where feasible, in new construction projects, and evaluate the usefulness of artificial bark as roosting habitat in forested areas where snag habitat is lacking.
  - ◆ Incorporate bat-friendly bridge and culvert designs into 25% of new highway structures that are potential roosts because of macrohabitat features, and retrofit 25% of existing structures with roost potential with manmade habitats according to the latest available research.
4. Identify foraging areas for bats near the key roost sites through radio-telemetry and/or acoustic monitoring. If a roost is protected, but the critical foraging habitat is not effectively managed, the bats may still decline in numbers.

5. Where restoration and protection are feasible, prioritize key habitat sites over those where remnant populations may simply have taken refuge as a last resort, even when the originally used sites are currently abandoned due to human disturbance.
6. Protect, restore, maintain, and monitor key open water drinking sites for bats.
7. Protect, restore, maintain, and monitor key flight and migratory corridors.
8. Focus protection efforts on areas where the best forage, roost, and water diversity conditions exist.
9. Monitor the effectiveness of management actions implemented for bat conservation, including bat gates, manmade roosts, and other restoration and protection projects.

**Goal 3 – Incorporate bat conservation language into existing statutes for wildlife protection.**

Program support and funding for bird conservation dramatically exceeds resources allocated, per species, to bat conservation. This fact is due, at least in part, to almost 100 years of legislative support and tri-governmental collaboration. Although important MOU's exist between some agencies, only the Endangered Species Act, and to a limited degree the National Environmental Policy Act and National Forest Management Act, mandate that bat conservation considerations be included in environmental impact assessment and land management planning. Because bats provide the same ecosystem services, are affected by the same environmental practices, and use the same habitats as birds, they deserve equal consideration.

*Priority Actions*

1. Work with legislators and governments to establish policies and international treaties and agreements for bats, with special emphasis on migratory species.

**Goal 4 – Integrate this strategic plan into other existing plans and initiatives.**

Existing initiatives, such as Partners in Flight, and plans, such as the North American Waterfowl Plan, can become excellent vehicles to advance bat conservation. Bat conservation issues and needs overlap significantly with issues and needs being addressed for other wildlife, especially birds. The same habitats, authorities, and organizations are involved, and significant savings can be realized by integrating conservation plans.

*Priority Actions*

1. Identify and act on opportunities to collaborate with other wildlife interest groups in the North American Bat Conservation Partnership.
  - ◆ Conduct periodic coordination meetings regarding implementation of this plan with other conservation groups such as Partners in Flight and North American Waterfowl Management Plan Joint Ventures.

2. Identify other international wildlife planning efforts and investigate ways to collaborate on overlapping and complementary goals.

## EDUCATION

### **Problem**

Throughout North America, the misunderstandings created by inaccurate presentation of public health and other issues involving bats are a serious threat to bat survival and public support for bat conservation. Although general public awareness of the beneficial values of bats has increased over time, ignorance remains an important impediment to bat conservation. Medical professionals, government agencies, private industry, and educators lack the resources necessary to educate the public on how bats can safely and beneficially coexist with humans.

### **Goal 1 – Develop educational materials to reach important audiences.**

Educational materials that emphasize such issues as the ecological role of bats, the benefits of bats to human welfare and economies, the conservation and management needs of bats, and the resolution of public health or nuisance concerns are all high priorities for development. These actions offer opportunities for broad collaboration among partners and can be jointly developed at reduced costs.

#### *Priority Actions*

1. Encourage wildlife managers, miners, geologists, professional or organized caving groups, animal control and public health officials, wildlife service providers, and bat rehabilitators to help by developing specialized materials, such as technical field manuals and handbooks.
  - ◆ Develop and distribute a technical manual for bat exclusion techniques.
2. Develop audiovisual programs and educational materials to assist teachers and environmental educators in incorporating bats into existing curricula.
  - ◆ Continue Project Wild workshops (Bat Natural History Workshop) for teachers and encourage addition of bats in study curricula.
  - ◆ Encourage participation in Project Wild workshops (Bat Natural History Workshop) from other groups such as professional geologists, miners, caving groups, animal control and public health officials, and wildlife rehabilitators.
  - ◆ Create additional bat educational trunks for use in all 6 Arizona Game and Fish Department Regions.
  - ◆ Support production of a *Bats and Snags* brochure, developed by the USFS North Kaibab Ranger District.
  - ◆ Support bilingual programs promoting bats.

### **Goal 2 – Integrate bat education materials into other successful programs and materials.**

Existing educational materials that have been demonstrated to be effective and widely used can be simply and cost-effectively modified to include bats, saving significant human and financial resources.

#### *Priority Actions*

1. Encourage inclusion of bat educational curricula, such as Discover Bats!, into the most widely known environmental education programs, for example Project Wild, Project Learning Tree, Backyard Habitats, and others.

2. Identify and contract major textbook publishing companies to incorporate bats in science, math, English and Spanish lessons currently being developed. Provide teacher instructions about how and where bats can be incorporated into existing textbook lessons.
3. Educate the general public about bats.
  - ◆ Continue to include bat programs in County Wildlife Fairs.
  - ◆ Coordinate and increase annual National Bat Survey Week efforts in Arizona.
  - ◆ Produce and reprint English and Spanish editions of *Bats of Arizona, Wildlife Views Special Edition*.
  - ◆ Produce and reprint *Bats of Arizona* poster in Spanish and English editions.

**Goal 3 – Foster collaboration with specialized groups who can help.**

The bat conservation and research communities are small and will never have sufficient resources to address existing educational needs. Certain specialized groups with overlapping interests can be extremely helpful in extending bat conservation programs.

*Priority Actions*

1. Promote collaborative educational programs between bat researchers, the conservation community, professional educators, the general public, local utility companies, county extension agents, and departments of transportation and mineral resources.
2. Develop and implement public participation programs that encourage citizens to assist with outreach and education efforts, such as bat walks, lectures, school presentations, and other volunteer services.
3. Strengthen ties with public health officers, educators, bat rehabilitators, timber, agricultural, grazing, mining, caving, and climbing groups to encourage them to lead bat education initiatives for their constituencies.
4. Prepare and implement monitoring plans to evaluate educational program effectiveness.
5. Develop and lead education workshops for teachers, biologists, researchers, and other specialized groups. Specialized groups may include the Arizona Riparian Council, Arizona Native Plant Society, Arizona Audubon Council, The Nature Conservancy, caving grottos, gem and mineral societies, and climbing groups.

**Goal 4 – Focus educational efforts in the most important bat conservation locations, and on the most important issues.**

It has been clearly demonstrated, through initiatives like the Program for the Conservation of Migratory Bats (PCMM), that focusing efforts on communities near the most important bat roosts is an effective way to establish long-term protection. Students educated about the values of their neighborhood bats educate their families, which builds

community pride for their special resource and, ultimately, lasting stewardships. Rapid conservation progress can also be achieved by focusing educational efforts on social, environmental, and management issues that have the greatest potential for negative impacts on bats.

*Priority Actions*

1. Target bat education programs in communities near important bat roosts or other habitats.
  - ◆ Develop bat kiosks at the London Bridge, Pantano Wash and Broadway Bridge in Tucson, and Sycamore Creek Bridge. Promote educational programs for bats and bat exodus viewing at these key sites.
  - ◆ Identify other key bat-watching areas (Watchable Wildlife) with informational kiosks.
  - ◆ Promote bat conservation and education at the Tucson Gem and Mineral Show, with special emphasis on how to avoid disturbing bats when entering mines.
  - ◆ Target bat education programs in Arizona mining communities.
2. Develop educational programs for animal control and public health officials, where possible, producing them in collaboration with leading veterinarian and public health organizations.
  - ◆ Conduct workshops on bat-friendly exclusions and factual rabies information for animal control agents and wildlife service licensees.
3. Develop and implement conservation and education programs for urban residents about bats living in urban environments

**Goal 5 – Initiate broad, statewide education campaigns, and establish linkages to exchange information and foster international collaboration.**

Broad educational programs can change attitudes and behaviors of whole generations of Americans. The 5000 square-foot English- and Spanish-language exhibit, Masters of the Night, has toured major U.S., Canadian, and Mexican cities for 8 years, providing millions with their first-ever glimpse into the world of bats. Also, formal and informal networks should be established to exchange technology, information, and resources, saving time and money and accelerating progress.

*Priority Actions*

1. Increase international coordination between academic institutions to conduct research and transfer expertise and technology.
2. Develop and implement an international communication plan to raise human awareness of the importance and needs of bats.
3. Translate educational materials, such as field handbooks and school curricula, into English, Spanish, and various tribal languages.

4. Produce and share a state database of people and organizations with bat conservation expertise.
5. Where feasible, make special efforts to communicate scientific research to the public.
  - ◆ Develop and maintain bat working group web pages.

## PROGRESS EVALUATION

Because of the lack of information and the difficulty in assessing population trends for bats, it is very difficult to set quantifiable targets with which to measure our progress. The time frame for reaching our objectives will vary depending on several factors including: the condition of the habitat necessary to sustain and enhance bat populations, the level of knowledge about species requirements, and the capability of the land owner or land manager to manage for bats. Conservation recommendations listed will provide direction for land managers to reach the conservation goals listed. All research and inventory and monitoring goals listed in the plan address information gaps that will have direct application to land managers, thus a constant feedback of new information will keep the plan current.

To assist us in achieving our objectives and priority actions, our next step will be to develop an implementation schedule. This will identify possible partnerships for specific projects, provide timelines for when projects should be completed, and indicate budget estimates for each project. As the NABCP program moves forward, we will continue to bring on new partners and remain open to new ideas and approaches for better bat conservation. In the implementation phase, coordination with other wildlife conservation groups (i.e. waterfowl, birds, herps) will increase. The formation of area-specific bat partnerships similar to the North American Waterfowl Management Plan Joint Ventures and Partners in Flight will likely evolve from this increased coordination. Planning, implementation, and evaluation will remain the most integral parts of our conservation process. Evaluation is an essential step in the success of our efforts. Joined with planning and implementation, evaluation provides the link back to making planning more specific and implementation more effective than before.

In order to keep management, research, inventory, and education concerns current, this plan should be reviewed and, if necessary, updated every 5 years.

## HABITAT TYPES

The goal of this section is to provide background into the habitat types in which bats are found, to define critical factors of those habitats, to delineate threats to these habitats, and to identify species and goals that are particularly relevant to managers of these habitats.

Given the close proximity of different habitat types within Arizona and the ability of flying bats to move great distances, many bat species probably migrate seasonally among habitat types. Unfortunately, because of the cryptic nature of bats and the lack of technology to track movements, even small scale seasonal movements are poorly understood. However, capture records infer that such movements do occur. For example, some pallid bats probably overwinter in desert hibernacula, forage in the deserts in early spring, migrate into forested habitats in midsummer, give birth to young in forest tree roosts, and disperse southward to deserts in autumn. Similar life histories can be inferred for several other Arizona bats.

### INTRODUCTION TO TYPE CLASSIFICATION

The habitat classification scheme used in this report generally follows that laid out in the Arizona Partners in Flight Bird Conservation Plan (Latta and others 1999) and additional details regarding specific habitat types can be found in that document or in Brown and others (1980). However, their more specific habitat classifications were grouped for the purposes of this report into the following sections:

- Forests and Woodlands – Spruce-Fir, Mixed Conifer, Aspen, Pine, and Pinyon-Juniper

- Sky Islands – Madrean Pine-Oak

- Riparian/Wetlands – Low Elevation Riparian, High Elevation Riparian, Freshwater

  - Marshes, Open Water

- Grasslands – Desert Grassland, High Elevation Grassland

- Deserts/Shrublands – Mohave Desertscrub, Sonoran Desertscrub, Chihuahuan Desertscrub, Cold Desertscrub, Chaparral

We have also included sections on Agricultural habitat and Urban habitat.

## FORESTS AND WOODLANDS

### Introduction / General Description

Forests provide foraging habitat, maternity roosts, travel corridors, and hibernacula to bats. Of the 28 species of bats found in Arizona, all but 6 are known to occupy forested habitats, at least occasionally. Some species are commonly found only in forests, and their life histories are poorly understood outside the forest context (e.g., Arizona myotis, long-legged myotis, and long-eared myotis), while other species, such as pallid bats, use various habitats at different times of the year.

Forests and woodlands within Arizona can be subdivided into 6 vegetation associations or subclasses:

1. Spruce Fir – Dominant species: Engelmann spruce, subalpine fir, corkbark fir, Douglas fir, white fir, bristlecone pine, blue spruce, and aspen. Elevation: 2000-3800 m (6500-12,500 ft). Resource uses: lumber, fuelwood, livestock grazing, recreation.
2. Mixed conifer – Dominant species: white fir, Rocky Mountain Douglas fir, blue spruce, quaking aspen, Gambel oak, ponderosa pine, southwestern white pine, Engelmann spruce, blue spruce, and subalpine fir. Elevation: 2450-3050 m (8000-10,000 ft). Resource uses: lumber, fuelwood, livestock grazing, recreation.
3. Aspen – Dominant species: aspen (often interspersed with mixed conifer forest). Elevation: 2450-3050 m (8000-10,000 ft). Resource uses: fuelwood, fence posts, recreation.
4. Pine-Pine/Oak – Dominant Species: ponderosa pine, Gambel oak, and aspen. Elevation: 1980-2590 m (6500-8500 ft). Usage: lumber, fuelwood, livestock grazing, recreation.
5. Pinyon-Juniper – Dominant species: Rocky Mountain juniper, Utah juniper, one-seed juniper, alligator juniper, California juniper, and Rocky Mountain pinyon pine. Elevation: 1500-2300 m (4900-7550 ft). Usage: firewood, pinyon nuts, lumber, livestock grazing, conversion to grassland.
6. Madrean Pine-Oak – see Sky Islands section of this plan

Riparian areas within the above subclasses are addressed in the Riparian section of this plan

Few forest bats are restricted to any one of the subclasses above; most occupy several or all of the forest subclasses throughout the year. Some bat species are more common in 1 or 2 subclasses while others are present in all. The Aspen subclass, although distinct and unique, is usually found in small patches within Spruce Fir and Mixed Conifer forests. See Latta and others (1999) for a detailed description of these vegetation associations.

### Roosts

Bat roosts within forests can be found in live trees, snags, stumps, logs, caves, mines, rocks, rock outcrops, cliffs, bridges, and buildings. Long-eared myotis have been found to roost in stumps in Canada (Vonhof and Barclay 1997) and Arizona (Rabe and others 1998) and have also been found to roost in logs and small rocks. Herder and Jackson (2000) documented long-legged myotis, fringed myotis, and Townsend's big-eared bat roosts in rock outcrops within forests. Bats may also be found using forest buildings, both abandoned and occupied. When present, mines and caves may create ideal roost habitat for bats.

In Arizona forests, caves and mines are not as common as in other areas of the state; therefore trees, both live and dead, provide the most abundant roosts available to bats. Even 10 years ago, bat use of trees as roosts was largely speculative and based on a few accounts of woodcutters and serendipitous observations. Fortunately, the recent development of tiny radio transmitters has greatly expanded our knowledge of roost use by bats in Arizona forests.

### Foraging

Most forest bat species are insectivores, therefore foraging habitat means habitat where they may hunt insects. Bats use several strategies when pursuing insect prey; these strategies include hawking or capturing insects when they are flying, gleaning insects from vegetation, and capturing insects off the ground. Some bat species use one of these strategies exclusively, while others may use all 3 techniques. Some bats fly close to the ground and are affected by structure and clutter (vegetation density) within the canopy (Kalcounis and others 1996). Other species fly above the forest canopy and may be relatively unaffected by canopy structure (Krusic and Neefus 1996).

Very little quantitative data is available on the foraging needs of bats due to the difficulties involved in tracking the movements of a nocturnal, cryptic animal, and evaluating the abundance and distribution of insect prey. Much of the information presented below is based on observations and anecdotal evidence. Nevertheless, some generalizations may be useful.

Openings within forest stands appear to be used while foraging for insects by many forest bat species. Allen's lappet-browed bats' and spotted bats' echolocation calls (which are low enough in frequency to be detected by the human ear) are commonly heard circling about small meadows and on the edges of large meadows. Calls of the larger bat species (such as greater western mastiff bat, big free-tailed bat, and Mexican free-tailed bat) are also heard in large meadows in summer (Rabe and others 1998). Meadow habitats may be an important resource for spotted bats during reproduction. Lactating spotted bats in northern Arizona travel >30 mi (48 km) from their low elevation desert roosts to forage in high elevation meadows (Rabe and others 1998; Siders and Steffensen 1998). Silver-haired bats are often seen foraging in loops up and down forest roads. Diverse vegetation probably leads to a diversity of insect prey available to foraging bats. Bat mist net captures at water sources surrounded by diverse tree species are often high in total bat numbers and bat species diversity. This suggests that bats extensively use these areas for foraging and/or drinking, at least during some periods in summer. A telemetered lactating fringed myotis captured while foraging in pine oak woodland on Mt. Laguna in San Diego County commuted 6.8 mi (11 km) nightly from a cliff face roost in chaparral 2300 ft (700 m) below (Miner and others 1996).

Because they are such strong flyers, bats from the family Molossidae (especially the big free-tailed bat, Mexican free-tailed bat, and western mastiff bat) may be heard or caught foraging in forest habitats although their day-roosts may be >50 mi (>80 km) distant and in another habitat type. Most captures of these bats are therefore of foraging or migrating individuals coming to water to drink. Based on reports of echolocation calls, some of these bats habitually forage in forests throughout mid to late summer.

### Water

The fir, mixed conifer, aspen, and pine oak forest vegetation associations or subclasses in Arizona tend to occur at higher elevations than the pinyon-juniper, desert, or grassland habitats. Therefore, although water is still an important and perhaps even limiting factor for bats in these higher elevation forest types, it is still relatively more abundant than in the lower elevation and more arid habitats.

Prior to European settlement and livestock grazing, the most common water resources in these higher elevation forests were likely perennial and intermittent streams, and springs with naturally pooled water, whose distribution is determined by topography and geomorphology. After the advent of livestock grazing, cattle tanks, reservoirs, and other human made water impoundments (whose abundance and distribution are less dependent on topographical features and therefore more abundant and widely distributed than naturally occurring waters) have probably surpassed natural streams and springs as to their importance to forest bats. There is speculation that this has affected the long-term abundance and distribution of Arizona's forest bat populations; however it is impossible to confirm or refute this due to the absence of prior or current data on bat population trends or status. One management implication is that the effects on forest bats should be considered when land managers change the abundance or distribution of water during the cattle allotment management plan process.

### Migratory Pathways / Corridors

Currently, knowledge of the migratory pathways and corridors used by forest bats is based on speculation and chance captures. Little effort has been expended to trace intermediate and long-range movements of bats within Arizona. Western red bats, hoary bats, silver-haired bats, and western yellow bats pass through forests during northerly migrations. Male silver haired bats are most often caught in Arizona forests in early summer. Females are seldom caught in Arizona because female silver-haired bats probably migrate north through New Mexico. Male hoary bats are captured all summer long in some locations, indicating that they may both migrate through and reside in Arizona forests throughout the summer.

Some female pallid bats appear in forests near the Mogollon Rim in summer where they form maternity roosts and disappear (probably to the south) in autumn. Adult male pallid bats are seldom found in pure conifer forests, although males are common in grasslands to the north, northeast, and northwest of the state's central ponderosa pine forests.

Long-legged and fringed myotis are caught in lower elevations (Sonoran desert scrub and chaparral habitats) in very early summer. Based on captures, both these species appear to follow an altitudinal migration from desert scrub to pinyon/juniper to ponderosa pine to higher mixed conifer forests in some areas. Fringed myotis and long-legged myotis are relatively abundant in mixed conifer forests on the San Francisco Peaks by midsummer (Morrel and Rabe 1998; Warner 1988). Interestingly, a large maternity colony of fringed myotis has also been found in a mine in the California Mojave Desert at 2300 ft (700 m) elevation (P. Brown, personal communication)

The diversity of bats in the forests near the Grand Canyon is unique. Movements of bats in and out of the Grand Canyon in Northern Arizona do occur, and the juxtaposition of caves, crevasses,

and high cliffs with conifer forests present bats with an array of habitats. The Grand Canyon and the Colorado River doubtlessly serve as a migratory corridor for many species (e.g. Mexican free-tailed bats, big free-tailed bats, greater western mastiff bats, spotted bats, and probably others) although no hard evidence is available for this contention. Mexican long-tongued bats have been caught in the Grand Canyon in recent years, and probably could be considered accidental migrants up the Lower Colorado River corridor.

### Species

Most Arizona bat species utilize forest and woodland habitats to some extent. Primarily tree-roosting species such as silver-haired bats, western yellow bats, hoary bats, and western red bats are most likely to be affected by changes to forest structure. Fringed myotis, big brown bats, Arizona myotis, Yuma myotis, California myotis, western small-footed myotis, long-legged myotis, and long-eared myotis are also likely to be heavily dependent on forests and woodlands. Species which utilize these habitats to a lesser extent include: Mexican long-tongued bats, Townsend's big-eared bats, cave myotis, spotted bats, western pipistrelles, greater western mastiff bats, big free-tailed bats, pallid bats, Allen's lappet-browed bats, southwestern myotis, fringed myotis, and Mexican free-tailed bats.

### Threats

Threats to bats in forest habitats come primarily from human-induced habitat conversion. Forestry practices that favor clear-cutting and large tree removal reduce the availability of large older trees favored for roost sites. Logging and spraying for beetles and lepidopterans may also affect distribution of insects that are prey species for bats. Livestock grazing and fire suppression may have similar effects by altering the natural succession of plant growth and thus disrupting natural insect communities (Dennis and others 1998; Pierson and others 1999).

Forest fires may destroy roost trees and foraging habitat, although they may also be responsible for the creation of new snags, which can be used as roosts.

Recreational activities, such as hunting, camping, and hiking may increase disturbance of forest-dwelling bats at roost sites and may also contribute to habitat conversion. As well, increased human visitation may lead to an increased risk of fire. Overall loss of forest and woodland habitat is increasing with increased urbanization and development.

Research Objectives – (see also Goals and Objectives, Research - Goal 1: Actions 2-3, Goal 2: Actions 1-4, Goal 4: Actions 1-3, Goal 6: Action 1)

Critical habitat for forest and woodland dwelling bats still needs to be identified. Projects such as radiotracking studies, which investigate roost requirements, roost switching, and foraging habitat requirements are needed to guide management actions. As well, research into acceptance and use of manmade roosts should be carried out to increase success of mitigation efforts.

Efforts should be made to census populations and establish baseline data for comparative studies. These should include mist-netting surveys, roost surveys, and echolocation studies. Such studies, however, should be carefully planned and standards and protocols should be developed to insure the robustness of data collected and to decrease impacts on the bats themselves.

Research into the effects on bats of timber and fuelwood harvesting, fire suppression and prescribed burning, pesticide usage, and other habitat alteration and conversion is needed to direct management and conservation actions.

Inventory and Monitoring Objectives – (see also Goals and Objectives, Inventory and Monitoring - Goal 1: Actions 1-5, Goal 2: Actions 1-2, Goal 3: Action 3)

Potential roost sites should be identified and surveyed for bat usage or potential bat usage. This will include mine and cave surveys as well as location of appropriate snag roosts.

Foraging and roosting sites suitable for long-term monitoring should be identified to assess the effects of different land use and other factors on bat populations. Existing survey protocols should be modified to include regular inventories of bats.

Management Objectives – (see also Goals and Objectives, Management - Goal 1: Action 1, Goal 2: Actions 1-9)

Logging and forestry practices that leave mixed-aged stands and/or preserve older trees and snags should be encouraged. Snags that are, or could be, used as roosts should be preserved. Prescribed fires may help to restore natural habitat cycles and even create new roosting sites, while reducing fuel loads that could lead to catastrophic fires. However, such practices must be monitored closely to determine their effects on bats, including both the loss of and creation of snags. Loss of snags and roosting areas should be mitigated through construction of manmade roosts and use of artificial bark on existing trees.

The effects of grazing on the understory and herbaceous layer and thus on prey habitat should be studied, and, if necessary, grazing levels should be managed to maintain sufficient prey levels for bats.

Development and urbanization that leads to loss of roosting and foraging habitat should be contained where possible to maintain undisturbed areas of forest.

## SKY ISLANDS

### Introduction / General Description

The term sky islands refers to Madrean pine-oak habitat in the mountain regions of southeastern Arizona, including the Chiricahua, Santa Rita, Baboquivari, Tumacuacori, Huachuca, Hualapai, Santa Catalina, Pinaleno, and Pinal Mountains. Elevation of these sky island habitats is from 3940 to 7220 ft (1200 to 2200 m). The dominant tree species in the sky islands are Chihuahua pine, Apache pine, ponderosa pine, alligator bark juniper, Mexican pinyon pine, Emory oak, Arizona white oak, Mexican blue oak, Gambel oak, silver-leaf oak, and netleaf oak; these are often interspersed with grasses, shrubs, and succulents. These high-elevation, mountaintop islands are isolated by valleys of desert and grassland.

### Roosts

Roosts in the sky islands may consist of all types of tree roosts, rock crevices, cliffs, caves and mines. Tree roost use is similar to that in other forested areas of the state, but sky islands habitat is much more likely to also contain cave and mine roosts than other forested habitats. Because of the combination of roosting habitat and water availability, bat species may be concentrated in sky island habitat.

### Foraging

Many bats that roost in sky island habitat may forage within the forested regions and riparian areas within this habitat. However, the sky islands may also provide roosting habitat for species that then forage in the surrounding desert and grasslands areas, which in themselves may not afford sufficient roosting opportunities.

### Water

Water in the sky islands habitat is available through springs, streams, and creeks. With the spread of human activity in these areas, artificial water sources, such as cattle and wildlife drinkers and swimming pools may have increased water availability.

### Migratory Pathways / Corridors

For some species, such as the lesser long-nosed bat and Mexican free-tailed bat, there are known transitory roosts identified in sky island habitat, indicating that these areas are important stops on migratory routes. These habitats probably provide refuges for several other migratory species seeking roosting and foraging areas during migration over what might otherwise be unsuitable habitat.

### Species

Many Arizona bat species may be found in sky islands habitat, including Mexican long-tongued bats, lesser long-nosed bats, greater western mastiff bats, pocketed free-tailed bats, big free-tailed bats, Mexican free-tailed bats, pallid bats, Townsend's big-eared bats, Allen's lappet-browed bats, silver-haired bats, western red bats, hoary bats, western yellow bats, western pipistrelles, big brown bats, southwestern myotis, California myotis, western small-footed myotis, fringed myotis, cave myotis, and long-legged myotis.

### Threats

Threats to sky island habitat are similar to those in other forest and woodland habitats. However, the sky islands have historically been less subject to severe logging and forestry usage than other such habitat. As well, interest in the uniqueness of this habitat has increased efforts to manage the area responsibly. Recreational use and increased human settlement may cause more disturbance currently than resource extraction activities. Grazing may also affect understory and prey habitat (Dennis and others 1998).

Research Objectives – (see also Goals and Objectives, Research - Goal 1: Actions 2-3, Goal 2: Actions 1-4, Goal 4: Actions 1-3, Goal 6: Action 1)

The identification of habitat requirements and resource usage by bats in the sky islands is needed to direct management and conservation actions. In particular, research into the impacts of human activities on bat populations and habitats should be carried out.

Because many bat species use a variety of habitat types, the importance of sky island habitat within the context of other habitat types should also be studied.

Inventory and Monitoring Objectives – (see also Goals and Objectives, Inventory and Monitoring - Goal 1: Actions 1-5, Goal 2: Actions 1-2, Goal 3: Action 3)

Important bat roosts need to be identified and monitored. Suitable locations for long-term monitoring should be determined and should include roost sites, foraging areas, and flyways. Inventory efforts should be carried out across the landscape and in all seasons to determine differences in habitat use across elevational ranges and throughout the year.

Management Objectives – (see also Goals and Objectives, Management - Goal 1: Action 1, Goal 2: Actions 1-9)

The use of prescribed burning to reduce fuel loads and decrease the opportunity for catastrophic fires should be investigated. Snags that may be used as bat roosts should be maintained and developed. Mines and caves that may provide suitable roosting habitat for bats should also be identified and protected. Where necessary, manmade roosts can be used to mitigate for habitat loss.

The effects of grazing on the understory and herbaceous layer and thus on prey habitat should be studied, and, if necessary, grazing levels should be managed to maintain sufficient prey levels for bats.

## RIPARIAN / WETLAND

### Introduction / General Description

Riparian areas in or near permanent or intermittent flowing water and/or floodplains generally contain different vegetation and species than surrounding non-riparian areas. Riparian areas at different elevations, moreover, may also differ in their dominant species. Desert washes at low elevations may have surface water only very rarely, but may still support distinctive vegetation, including paloverde, mesquite, catclaw, ironwood, smoketree, desert willow, and netleaf hackberry. In areas with slightly more regular water flow, vegetation may take the form of deciduous woodlands including cottonwood, willow, sycamore, ash, and walnut, as well as seepwillow, mesquite, desert willow, arrowweed, saltbush, and salt cedar. At high elevations, maple, alder, box elder, aspen, Douglas fir, white fir, oak, and cypress may also be associated with riparian habitat. Marshes and swamps containing duckweed, cattail, rushes, and sedges may also be associated with riparian woodland habitats in some areas of the state.

### Roosts

Riparian woodlands may provide suitable roost sites for tree roosting bats, while landforms such as cliffs and rock crevices increase roosting opportunities. With increased urbanization and visitation to riparian areas, construction can result in increased bridge and building roost sites as well.

### Foraging

The combination of water with suitable riparian vegetation creates foraging habitat for insectivorous species that may be roosting in a variety of areas. In certain situations foraging habitat in riparian areas may actually be limiting for bats (P. Brown, personal communication). Where desert trees are confined to the dry washes, California leaf-nosed bats forage only in this habitat. Where present, water provides habitat for insects that bats may feed on as well as drinking water for the bats themselves. Surrounding vegetation supports insects, maintains water, and provides flight corridors for bats, perhaps through protection from predators or wind buffering. Even when streambeds are dry, bats still will often use these natural pathways to commute between roosts and foraging habitat.

### Water

A major benefit of riparian areas to bats is, of course, the availability of drinking water. Depending on accessibility, size, and surrounding vegetation, riparian and wetland areas provide a large proportion of the drinking water for bats in Arizona.

The water in riparian areas is also an important resource for the prey base of most insectivorous bats.

Pollution of these waters, or redirection of water flow, may have considerable impacts on the their availability to bats and insects alike.

### Migratory Pathways / Corridors

Riparian habitats and their surrounding vegetation are likely important migratory corridors as well as pathways for nightly commuting between foraging areas. The combination of water,

foraging, and protection from predators, as well as opportunities for roosting, creates habitat that can support bats as they move between their seasonal roosts. Such corridors, which are often distinct from surrounding vegetation, may even provide orientation points for bats on migration or commuting flights.

### Species

Most Arizona bat species are found in association with riparian habitat during at least part of the year. The western red bat is generally recognized to be especially reliant on cottonwood/sycamore ecosystems. Yuma myotis are found in close association with open water and riparian systems. Declines of cave myotis populations in California have been linked with loss of cottonwood riparian systems. Other bat species found in the habitat surrounding the riparian or wetland habitat (forest, desert, etc.) most likely are highly dependent on the riparian habitat for food, water, and travel corridors.

### Threats

Riparian habitats are severely threatened by development, recreational activities, and agricultural activities. Invasions by exotic species can also drastically modify riparian habitats. Pollution not only affects quality of drinking water, but also vegetation and other factors. The attractiveness of riparian areas in arid landscapes subjects them to increased human settlement and usage, which may significantly alter the landscape. Diversion for irrigation, channelization, and flood control of existing waterways may decrease riparian vegetation and cause narrowing of riparian corridors. Vegetative conversion may also affect the prey species available to the bats (Pierson 1998).

Construction of dams and water diversion may severely alter riparian habitat. Much riparian habitat is cleared for agriculture and development or opened to grazing. Along the lower Colorado River, cave myotis have declined in numbers over the past 60 years as the cottonwood/willow riparian has been removed (P. Brown, personal communication). In this same area, the Arizona myotis appears to have been extirpated.

Heavy recreational use of riparian areas, including camping, hiking, ORV use, etc. may also have a large impact on the suitability of this habitat for bats.

Research Objectives – (see also Goals and Objectives, Research - Goal 1: Action 2, Goal 2: Actions 1-4, Goal 4: Actions 1-2, Goal 6: Action 1)

Critical to establishing management objectives for riparian habitats is identification of resource requirements for bats in these areas. This includes research into usage and requirements for foraging areas, roosting sites, and flight corridors. These factors must also be looked at within the context of surrounding habitat types.

Inventory and Monitoring Objectives – (see also Goals and Objectives, Inventory and Monitoring - Goal 1: Actions 1-5, Goal 2: Actions 1-2, Goal 3: Action 3)

Seasonal use of riparian areas should be determined through mist-netting, acoustic monitoring and thermal imaging techniques. Mines, caves, buildings and bridges near the riparian corridor

should be censused regularly, and suitable sites for long-term monitoring should be identified. Acoustic monitoring stations should be established in riparian habitats with various degrees of degradation.

Bat populations and activity should be monitored before, during, and after restoration activities.

Management Objectives – (see also Goals and Objectives, Management - Goal 1: Action 1, Goal 2: Actions 1, 3-9)

In 2001 the Western Bat Working Group adopted a resolution to support “research, inventory, conservation, maintenance, restoration, and re-establishment of historical cottonwood and sycamore ecosystems across western North America.” Existing patches of riparian habitat must be maintained and restoration of riparian forests should be a high priority. Limitation of recreational usage of sensitive habitat should be implemented. Care should be taken to maintain linear landscape elements, such as riparian corridors, between bat foraging and roosting habitat. Snags and other potential roosting habitat should be retained and protected.

To avoid destruction of riparian habitat, urban development should be planned away from sensitive riparian and floodplain areas, and buffer zones should be established between these areas and surrounding development. Riparian and wetland restoration and creation activities should be incorporated into development plans.

Dam construction or channelization should consider long-term effects on bats through vegetative modification and prey-base disturbance.

## GRASSLANDS

### Introduction / General Description

Much of the grassland habitat in Arizona has undergone conversion due to grazing. The low elevation semidesert grasslands have been converted from perennial bunch grasses to sod grasses and annuals. Mesquite, yucca, and ocotillo densities have increased as well. Higher elevation grasslands often occur as clearings in forests. They are dominated by bunchgrasses and perennial forbs, but fire suppression has allowed invasion by conifers from adjacent woodlands, and grazing has caused vegetative reduction and conversion. Many areas that were dominated by bunchgrasses have become converted to shrublands, with cacti and woody species moving in (Humphrey 1968).

### Roosts

Grasslands themselves offer little in the way of roosting opportunities, but are often associated with landforms such as cliffs, that may provide roosting areas. As well, bats using grasslands for foraging areas may be roosting in nearby forests or in caves and mines in the area. In large grassland areas, bat activity may be low due to lack of suitable roosting sites nearby.

### Foraging

Overall, little is known about bats use of grasslands in Arizona. However, studies which have addressed grasslands have found evidence of the importance of grasslands as foraging areas for bats (Snow and others 1996; Rabe and others 1998; Green and others 1998; Koloszar and Snow 1999), although Green and others (1998) found that grasslands were used by males to a much greater extent than by reproductive females. Although mist-netting for bats in grasslands is difficult, echolocation calls may indicate foraging in these open areas. Green and others (1998) found that bat calls increased in areas of structural complexity, indicating that bats may forage more readily in areas at the edge of grasslands or where trees or present rather than in open areas. This may be due to increased insect availability or increased protection from predators and wind.

### Water

Water in grasslands may consist of natural streams or springs, cattle tanks, and wildlife drinkers. Riparian areas in grassland habitat may also be important sources of water.

### Migratory Pathways / Corridors

The role of grasslands as migratory corridors for bats is unknown. Small grasslands within larger areas of forest are likely used as foraging areas along migratory pathways, while larger areas of grasslands may be avoided due to increased susceptibility to predation.

### Threats

Primary threats to grasslands include landscape conversion due to overgrazing and fire suppression. Overgrazing can lead to increased erosion, decreased ground cover, and conversion of vegetation to shrubs. Fire suppression can lead to increases in invasion by woody species. The effects of such conversion on bat species are unknown, but probable effects include a changing prey base of available insect species due to vegetation conversion (Dennis and others 1998). Another major threat to grassland habitat is the development of rural subdivisions and division of land into 36-40 acre parcels.

### Species

According to Koloszar and Snow (1999), species suspected or known to use grassland habitats are Yuma myotis, Arizona myotis, long-eared myotis, southwestern myotis, fringed myotis, long-legged myotis, California myotis, western small-footed myotis, silver-haired bats, western pipistrelles, big brown bats, western red bats, hoary bats, spotted bats, Allen's lappet-browed bats, Townsend's big-eared bats, pallid bats, Mexican free-tailed bats, big free-tailed bats, and greater western mastiff bats.

Research Objectives – (see also Goals and Objectives, Research - Goal 1: Action 2, Goal 2: Actions 1-3; Goal 4: Action 1-2; Goal 6: Action 1)

Not much is known about bat usage of grasslands. Further research into the ways in which bats use grassland habitat is needed to direct management actions. In particular, research is needed on the effects of habitat conversion and other human-mediated activities in grasslands on the resources used by bats.

Inventory and Monitoring Objectives – (see also Goals and Objectives, Inventory and Monitoring - Goal 1: Actions 1-5, Goal 2: Actions 1-2, Goal 3: Action 3)

Identification of suitable roost sites, foraging areas, and flyways for long-term monitoring will help establish inventory activities. Differences in seasonal habitat use should be taken into account when determining long-term monitoring locations. Standardized acoustic monitoring techniques should be established for activities in areas where mist-netting is not appropriate.

Management Objectives – (see also Goals and Objectives, Management - Goal 1: Action 1, Goal 2: Actions 1, 3-9)

Effects of grazing and habitat conversion on the insect prey-base of bats should be investigated. Grazing should be maintained at sustainable levels. Prescribed burning should be studied as a way to maintain optimal habitat. Landscape features of particular importance to foraging and roosting bats should be protected and maintained.

## DESERTS AND SHRUBLANDS

### Introduction / General Description

Arizona contains portions of all 4 major North American deserts. The Sonoran Desert occupies roughly the southwest third of Arizona; and the Mohave, Chihuahuan, and Great Basin Deserts occupy areas in the northwest, southeast, and northern portions of the state. All of these areas receive relatively little precipitation; although specific amounts, seasonal distribution, and type (often snow in the Great Basin) varies among the deserts. All these habitats are relatively open, although the Sonoran Desert is vegetatively quite diverse and is known as a tree desert because of the number and diversity of its large shrub and tree-like species, especially in the Arizona Upland Subdivision.

Arizona Interior Chaparral occupies areas in central Arizona, generally between 4000-6000 ft (1200-1800 m), and generally in a band below the Mogollon Rim. These areas are dominated by turbinella oak and manzanita and are more mesic than deserts, but less so than woodlands and forests.

### Roosts

Abandoned mines provide important bat roosting habitat throughout much of the desert and chaparral areas in Arizona, and species such as California leaf-nosed bats, pallid bats, lesser long-nosed bats, Mexican long-tongued bats, Mexican free-tailed bats, Townsend's big-eared bats, cave myotis, and Yuma myotis are heavily tied to mines in these areas. Caves provide important roosting habitat for generally the same species found in mines, but the number and distribution of caves is limited in much of Arizona. Mastiff and free-tailed bats generally roost in large overhangs on cliff walls, or in buildings, bridges or other man-made structures that allow the bats to drop out of the roost to gain airspeed. Other species, such as Western pipistrelles, roost in cracks and crevices in cliffs and rocks. Tree roosts are scarce in desert and chaparral habitats, but some tree roosting opportunities are available in saguaro boots and in larger trees as found by some desert waters.

### Foraging

Numerous bats use and forage within desert habitats. Lesser long-nosed bats rely on saguaro cactus, organ pipe cactus, and agaves for their diet of nectar, pollen, and fruit. Mexican long-tongued bats also rely on agaves but more in oak woodlands. All other Arizona species are insectivorous, and forage wherever insects are found. In desert areas insects are often more abundant around water. Bats are often drawn to such areas to drink and probably also to capitalize on areas with higher prey densities. California leaf-nosed bats and pallid bats glean large arthropods (sphinx moths, katydids, scorpions, beetles, etc) off vegetation or from the ground.

### Water

Deserts by definition are dry areas, with limited water a factor that all plants and animals found in such habitats must deal with in some way. Chaparral habitats, though moister, generally also provide limited surface water. Bats, like birds, have the distinct advantage of being able to fly so areas used for roosting, foraging, and to drink need not be immediately adjacent to one another. Still for many species, surface water to drink must be available within a few miles of suitable

roosts. However, some bat species are able to get water from their insect prey and do not need surface water. Many bat roosts exist over 25 mi (40 km) from any surface water. The distribution of water in desert and chaparral habitats has changed considerably in historic times. Prior to European settlement and introduction of livestock, many of Arizona's rivers, streams, and springs flowed more extensively than they do today. Much of Arizona's flowing water and riparian habitats have been lost in the past 150 years or so. This loss of some sources of water has, however, been offset by an increase in man-made water sources. Catchments designed for bighorn sheep or other game species also provide water for bats and other nongame species. Livestock tanks and drinkers also provide important water sources for bat species, depending on the design of such drinkers. Such wildlife or livestock waters are typical bat netting locations in desert areas. Rivers have been dammed, removing surface water from some areas of historic flow, but lakes and canals provide alternate water sources. In urban areas, pools, constructed lakes and ponds, and water recharge facilities provide water for bats and other species. Although bat populations in some portions of Arizona may be partly limited by water availability, overall it is likely that surface water is more abundant now in many desert areas of the state than it has been in recent centuries.

#### Migratory Pathways / Corridors

Little is known about the importance of desert habitat as migratory corridors for insectivorous bats. However, work done on lesser long-nosed bats by Fleming and others (1993) suggests that desert habitat is heavily used by nectar-feeding bats migrating between seasonal roosts. These bats follow a "nectar corridor" of blooming cacti and *Agave* plants. The existence of sequentially blooming plants along such a corridor appears to facilitate the movement of these bats between their wintering habitat in central Mexico and their summer habitat in southern Arizona and northern Mexico.

#### Species

Given the extent and diversity of desert areas in Arizona it should not be surprising that over half of the species of bats in Arizona occupy desert and/or chaparral areas for all or a portion of the year. California leaf-nosed bats and lesser long-nosed bats are found nearly exclusively in desert areas while Mexican long-tongued bats use primarily woodland but sometimes desert areas. All 5 species of free-tailed bats in Arizona (Mexican free-tailed bats, pocketed free-tailed bats, big free-tailed bats, Underwood's mastiff bats, and greater western mastiff bats) use desert areas. Big brown bats, pallid bats, Townsend's big-eared bats, Allen's lappet-browed bats, western pipistrelles, and cave, California, and Yuma myotis are also found in deserts during at least a portion of the year. Spotted bat maternity roosts have been found in large cliffs in the desert regions of the Grand Canyon and Kanab Creek areas. Even among the tree bats, the red, yellow, and hoary bats are found in some desert regions, although usually in areas near water with larger trees.

#### Threats

Threats to desert habitat in Arizona include landscape and vegetation conversion related to grazing and rapidly increasing urbanization. These factors may affect insectivorous bats indirectly due to their effects on the insect fauna, but may directly affect nectarivorous species. In particular, grazing on agave bolts by both cattle and wildlife can destroy flowering stalks, thus reducing available forage for nectar-feeding bats. Trampling of young plants by cattle may also

affect agave survival. Fire, which has increased in desert areas due to the introduction and proliferation of exotic annual grasses and the increase in human-started fires, can cause loss of desert habitat in the short term and even type-conversion to more open habitats with repeated fires.

Urbanization also threatens desert habitats. Urban sprawl has been estimated to consume an acre an hour in Arizona. Phoenix has carved a major urban center out of the Sonoran Desert and the loss of desert habitat there and around Tucson can be seen daily. Smaller desert cities such as Yuma and Casa Grande also continue to grow. As farmers sell their land in the Phoenix area for development, they are clearing areas of native vegetation for agriculture in outlying areas, as well as leasing land on Indian reservations and converting it to agriculture.

The large increases in Arizona's population also results in increased direct human disturbance of bats. Caves and abandoned mines, some of which have become very important bat roosts, are seeing increased human visitation. The human entry itself can be very disruptive to bats, particularly in maternity roosts or hibernacula. Concerns about human injuries in abandoned mines lead many landowners to implement mine closures. Impacts on bats can be substantial if a mine is totally closed, or if it is closed in a manner that restricts bat entry and exit or results in changes in temperature, humidity and/or airflow. If closure is judged necessary, surveys should be conducted for bats; if there is evidence of bat use, an appropriate closure method should be used to minimize impacts (e.g. signing, fencing, or bat-friendly gating).

Research Objectives – (see also Goals and Objectives, Research - Goal 1: Actions 2-3, Goal 2: Actions 1-3, Goal 4: Actions 1-3)

Research should focus on habitat requirements and resource usage and should include identification of important roost sites, such as mines and caves, and determination of foraging areas through radio-telemetry. Certain species use multiple habitat types regularly; information on differential resource usage by bat species in desert areas as compared to the same species in other habitats (forests, grasslands) will help identify management and conservation concerns.

Inventory and Monitoring Objectives – (see also Goals and Objectives, Inventory and Monitoring - Goal 1: Actions 1-5, Goal 2: Actions 1-2, Goal 3: Action 3)

Annual censuses of known roost sites (caves, mines, bridges etc.) should be carried out. In particular, the largest known roost of Allen's lappet-browed bat at Chalk Peak should be monitored. Other sites suitable for long-term monitoring should be identified, including foraging areas and flyways. Where appropriate, acoustic monitoring techniques may be used when mist-netting is not feasible.

Management Objectives – (see also Goals and Objectives, Management - Goal 1: Action 1, Goal 2: Actions 1, 3-9)

Appropriate "bat-friendly" gates should be used to assure mines occupied by bats remain available to the bats while being safely closed to humans. In caves that receive high levels of recreational use, managers should regulate or restrict use during the period of the year they area

used by bats. Important roosts on private land (such as the Chalk Peak roost for Allen's lappet-browed bats) should be protected either through acquisition or conservation easement.

Bats should be kept in mind when designing and constructing wildlife or livestock waters. Generally bats will benefit most from sources with greater surface areas and where they can easily fly in and drink while skimming the water surface. Small drinkers, or water levels maintained down below the lip of a trough or drinker will be inaccessible to many species. Likewise, shade covers, which might be desirable to reduce evaporation, might also restrict bat use of a constructed water.

Research into the effects of fires, grazing, and habitat conversion on desert-dwelling bats should be carried out to direct management guidelines, so that such activities do not negatively impact bat populations.

## AGRICULTURE

### Introduction / General Description

The amount of land under agricultural use in Arizona has been declining over the past forty years. In 1960, 1,264,000 acres in Arizona were dedicated to major irrigated crops. By 1994, the acreage had declined to 936,000. Despite this decline, agriculture accounts for almost 2 billion dollars in annual cash receipts for the state. Major crops in Arizona are cotton, vegetables, citrus, durum wheat, and alfalfa. In the southern part of the state, the warm climate supports farming year-round (AASS 2000).

Cattle, both beef and dairy, are the major livestock raised in Arizona. As of January 1, 2001, there were 850,000 head of cattle in Arizona, with an estimated value of \$629 million (AASS 2000).

### Roosts

In general, agricultural areas offer little in the way of roosting sites for bats, although surrounding landforms and/or forests may provide some roosting habitat. The only roosts likely to be found within agricultural areas are building roosts. Barns may provide good habitat for several species of bats, and the animals are less likely to be disturbed or evicted from such structures than from residential structures. Some farmers may also provide artificial roosts, such as bat houses, to attract bats to the area.

### Foraging

The primary provision of agricultural habitat for bats is in providing foraging areas. Insects attracted to crop stands can represent a major food source for insectivorous bats. Many bats specialize on moths whose larvae are crop pests. The open areas of agricultural fields can provide especially good foraging habitat for those bat species that are less maneuverable in cluttered environments. However, the species of bats foraging over agricultural areas is usually different than the species found in the native habitat type prior to agriculture.

Bats consume an enormous amount of insects nightly. Bats typically eat more than 50% of their body weight in insects each night, and a nursing female may consume enough insects to equal her own body weight, as much as 4500 or more small insects (Harvey and others 1999).

### Water

Irrigation ditches, livestock tanks, and other man-made sources of water can be available to bats in agricultural areas. As well, agricultural areas are often in the vicinity of natural water sources, such as rivers, streams, and springs.

### Migratory Pathways / Corridors

Buildings in agricultural areas may represent important transitory roosts, and agricultural pests may be a reliable food source during migration, but there has been no research done on the importance of agricultural habitat to migratory bats.

### Species

The dominant species in many agricultural areas are Mexican free-tailed bats and other molossid. Big brown bats are also commonly found in agricultural areas.

### Threats

Increasing human populations often generate more extensive urban sprawl. This destroys habitats, including woodlands, and its effect is compounded by agricultural practices (Fenton 2001). Habitat destruction directly affects bats in one way or another. While some species can adapt to the changes others cannot. Conservation strategies that take into account differences among species in dealing with habitat changes will be more successful.

Bats that take advantage of agricultural habitat for foraging may face the loss of this resource as urbanization and development replace agricultural land uses. Bats that roost in agricultural buildings may lose these opportunities with increased urbanization as well.

Pesticide use on agricultural fields can constitute a great threat to bats. Pesticide residue from insects sprayed with these chemicals can build up inside a bat's fatty tissue. When this tissue is burned during migration or hibernation, these concentrated pesticides can be harmful or even fatal to the bat (Clark 1981). The drastic decrease in the population of Mexican free-tailed bats at Eagle Creek Cave in Arizona has been blamed on pesticide poisoning of the bats (Cockrum 1970).

Research Objectives – (see also Goals and Objectives, Research - Goal 2: Actions 1-3, Goal 4: Actions 1-3, Goal 6: Action 1)

General information on habitat use by bats in agricultural areas is needed in order to better identify management and conservation needs. As well, research into the effectiveness of bats at controlling agricultural pests is needed to assist farmers in determining pest control strategies. The effects of chemical pest-control agents on bats must also be determined.

Inventory and Monitoring Objectives – (see also Goals and Objectives, Inventory and Monitoring - Goal 1: Actions 1-5, Goal 2: Actions 1-2, Goal 3: Action 3)

Surveys of agricultural areas for bat use, particularly for roosting and foraging, will greatly increase knowledge of the species using these areas and their resource requirements. This will also assist in identification of suitable areas for long-term monitoring. In some areas, acoustic techniques should be employed when mist-netting is not appropriate.

Management Objectives – (see also Goals and Objectives, Management - Goal 1: Action 1, Goal 2: Actions 1, 3-9)

As possible, pesticide use should be decreased and natural insect control should be encouraged. The installation of bat houses near agriculture fields may encourage bats to roost and forage in the area. Wooded or natural areas left between fields can act as flyway corridors and roosting habitat. Uncultivated areas should be preserved and allowed to develop naturally.

## URBAN

### Introduction / General Description

As the human population of Arizona increases, more and more natural habitats are being converted to urban environments. Such habitat conversion is generally drastic in the areas immediately affected, with profound changes in vegetation, available water, landform, and disturbance.

Little study has been done on the use of urban environments by bats, especially in the west. O'Farrell has found that activity in the center of Las Vegas has declined, with bats being most active at the edge of the city (Altenbach and others 2002), suggesting that the interface between urban and natural areas may be important in maintaining bat populations. There also appears to be a shift in species composition within urban areas, with diversity declining in areas of greater human activity and development.

In the Tucson metropolitan area, the diversity of bat species also appears to decline with increasing urbanization (Wolf and Shaw 2002). In a study of bridge-roosting bats, Wolf and Shaw (2002) found that the 3 bridges with the highest species diversity (up to 5 species) were located at the edge of the urban area or in outlying areas, and were adjacent to natural open space. In the most urban parts of Tucson, the majority of bridges with bats supported only 1 or 2 species. In Tucson, it is likely that Mexican free-tailed bats and big brown bats are the only true urban bats, and that, with possible exception of western pipistrelles, other species are restricted to the fringe of the urban area or outlying areas. In Orange County, CA the diversity of bats declined as habitat fragmentation occurred, with only Yuma myotis and Mexican free-tailed bats occurring in urban settings (Remington 2002).

### Roosts

The primary roost sites found in urban areas are bridges and buildings. Artificial roosts, such as bat houses, may also be available in some areas, although in Phoenix and Tucson, such roosts generally have very low success at attracting bats. Both native and exotic decorative plants, such as palm trees, may also provide roosting sites.

### Foraging

Foraging in urban areas may be concentrated in particular areas with high insect abundance, such as artificial water sources, parks, golf courses and landscaped areas, and around streetlights. Nectar-feeding bats may forage on ornamental cacti or at hummingbird feeders in urban gardens. For species that can persist in urban environments by roosting in man-made structures and tolerating human activity, lack of foraging areas may be more limiting than roost sites (Pierson 1998; Geggie and Fenton 1985). For instance, lower activity levels of foraging big brown bats in urban areas compared to rural areas were attributed to lower insect availability (Geggie and Fenton 1985; Furlonger and others 1987). Mexican free-tailed bats, however, would not be as affected as big brown bats by low insect abundance in inner city areas because they can commute long distances to foraging areas

### Water

Urbanization may actually increase drinking water availability for bats. Swimming pools, golf course ponds, reservoirs, and canals concentrate water into predictable and reliable areas. However, for the most part, these waters lack the surrounding vegetation of natural waters, making them less suitable for foraging and commuting than riparian areas. As well, pollution can be a much greater problem in urban waters than in natural waters.

### Migratory Pathways / Corridors

Bats use buildings and bridges as migratory stopover roosts in the spring and autumn. Cave myotis inhabit Tucson bridges only during the spring and autumn while on their way to summer or winter roosts (Wolf and Shaw 2002). Although Mexican free-tailed bats are present in Tucson all year, some bridges are occupied only during migration time (Wolf and Shaw 2002). Many residents report bats appearing on their porches in late summer and early autumn, when young are dispersing and movement toward winter roosts begins.

### Species

Big brown bats, Mexican free-tailed bats, and western pipistrelles are the most common urban bats in Arizona. Pallid bats, cave myotis, California myotis, and Yuma myotis have been found roosting in bridges and tunnels near the edges of urban areas.

### Threats

Threats to bats in urban areas come from decreases in suitable foraging and roosting areas through urbanization and from increases in potential bat-human conflict. This includes disturbance to roost sites, direct disturbance to bats, exclusions, and disturbance to foraging areas. As noted above, bat activity may decrease with distance away from the urban/natural habitat interface, indicating that even “city” bats may be relying on roosts or foraging areas outside of the urban environment. Big brown bats roosting in Denver’s urban core traveled up to 11 mi (18 km) to foraging areas outside the city (O’Shea and others 1999).

Bats in urban areas may face increased predation pressure from domestic animals, especially cats.

Pollution of both air and water in urban areas may also affect bats.

The general fear and misunderstanding of bats is also a compounding threat as our population increases. The importance of public education regarding the importance of bats will continue to increase with our increasing population.

As the threat of West Nile Virus and other arboviruses increases, increased pesticide spraying in urban areas may negatively affect bat populations.

Research Objectives – (see also Goals and Objectives, Research – Goal 1: Actions 2-3, Goal 2: actions 1-3, Goal 4: Actions 1-3, Goal 6: Actions 1-2)

Research is needed on the use of urban and suburban areas as foraging habitat for bats. Roosting requirements should also be studied, including: comparisons of building use to bridge use for

differences and similarities in species diversity, relative abundance, and relationship to characteristics such as land use; studies of the effectiveness of present designs for structures for retrofitting bridges in desert areas and for their ability to simultaneously support multiple species; and research into requirements for increasing the success of manmade roosting structures in an urban setting.

In order to effectively manage for bats in urban areas, research into the benefits and risks associated with urban bat roosts and assessment of the attitudes of urban residents toward bats are needed.

Inventory and Monitoring Objectives – (see also Goals and Objectives, Inventory and Monitoring - Goal 1: Actions 1-5, Goal 2: Actions 1-2, Goal 3: Action 3)

Inventories of bat use of bridges and buildings in urban areas are needed. Bridge use by bats should be monitored to find seasonal and year-to-year variations that will affect recommendations to departments of transportation.

Management Objectives – (see also Goals and Objectives, Management - Goal 1: Action 1, Goal 2: Actions 1, 3-9)

Bridges occupied by bats should be preserved. This will necessitate communication and working with departments of transportation to schedule bridge repairs and replacement when they are least likely to have negative effects on bats occupying the bridge.

Foraging areas should be preserved and enhanced by preserving natural open space within the urban matrix and corridors of natural vegetation leading from outlying areas into the urban core. Restoration of degraded washes can create corridors and foraging habitat. Creation and maintenance of vegetation adjacent to artificial water sources such as golf course ponds will also increase bat habitat. These principles should be applied to areas of new construction and suburban areas as well.

The public must be educated to eradicate misconceptions about bats and inform people about the beneficial nature of bats. A realistic picture of the risks and benefits of having bats roosting on their property should be presented, and if coexistence is not possible, guidance should be given on how to safely exclude bats. Experimentation with bat houses should be encouraged, particularly in the desert areas.

Bat roosts in urban areas that are protected from vandalism can be designated as public wildlife viewing areas, where people can watch evening outflights. These roosts can be used as educational opportunities to promote positive attitudes toward bats and wildlife in general.

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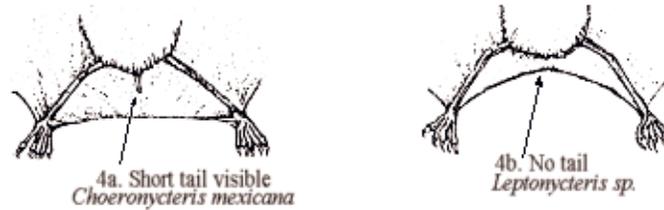
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APPENDIX A - KEY TO THE BATS OF ARIZONA

A millimeter ruler is required in order to use this key. Select the appropriate alternative from each couplet (starting with 1a and 1b). Follow the number for the next pair of choices at the end of each statement, repeating the process until a name is reached instead of a number. Ear length is measured from the notch at the base of the ear. Information enclosed in parentheses is helpful but not essential.

- 1a. Nose leaf present ..... 2
- 1b. Nose leaf absent ..... 3
- 2a. Ear length greater than 25 mm ..... *Macrotus californicus*
- 2b. Ear length less than 17 mm ..... 4
- 3a. Distinctive leaf-like folds on chin stretching from ear to ear, tail projecting 10mm or more above tail membrane, exiting near middle (eyes appear to be located inside roundish ears, forearm 51-59 mm) ..... *Mormoops megalophylla*
- 3b. No leaf-like folds on chin, tail completely encased by tail membrane or extending beyond it but never exiting from middle of membrane .... 6

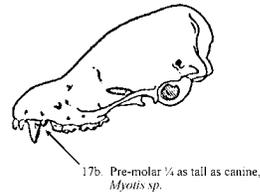
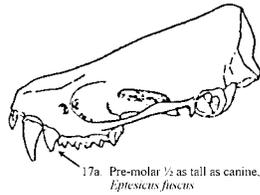


- 4a. Short tail easily visible, forearm 43-48mm (very long nose, gray to grayish brown fur) ..... *Choeronycteris mexicana*
- 4b. No tail visible, forearm 51-60mm (moderately long nose, brown to reddish brown fur) ..... 5
- 5a. Length of third finger 92-102 mm, last digit of third finger 10-12mm, no distinct fringe of hair on rear edge of tail membrane, body fur short and dense (forearm 51-56mm) ..... *Leptonycteris yerbabuena*
- 5b. Length of third finger 106-115 mm, last digit of third finger 16-19mm, distinct fringe of hair on rear edge of tail membrane (forearm 55-60mm) ..... *Leptonycteris nivalis*
- 6a. Tail extends one-third or more beyond rear edge of membrane ..... 25
- 6b. Tail never extends more than barely beyond rear edge of membrane ..... 7
- 7a. Conspicuous pair of white spots on shoulders and one on rump, contrast w/black dorsal fur (forearm 48-51 mm) ..... *Euderma maculatum*
- 7b. Lacking white dorsal spots on shoulders and rump ..... 8
- 8a. At least anterior half of dorsal surface of tail membrane heavily furred ..... 9
- 8b. Dorsal surface of tail membrane mostly naked or very scantily furred ..... 12
- 9a. Distinct white patches of fur at dorsal bases of thumbs and often on shoulders, dorsal surface of tail membrane fully furred ..... 11
- 9b. No white patches of fur at dorsal bases of thumbs or on shoulders, dorsal surface of tail membrane ranging from half to fully furred ..... 10
- 10a. Body fur yellowish brown, only anterior half of tail membrane fully furred ..... *Lasiurus xanthinus*
- 10b. Body fur black or dark brown with many hairs distinctly silver-tipped; fur on tail membrane variable, covering at least basal half, sometimes all of dorsal surface ..... *Lasionycteris noctivagans*
- 11a. Light colored ear distinctively edged in black; forearm 46-58mm; dorsal hairs dark gray, tipped with broad band of white (giving hoary colored appearance) ..... *Lasiurus cinereus*
- 11b. Light colored ear never edged in black; forearm 35-45mm; dorsal hairs never dark gray, tipped with broad bands of white (though may be white frosted); fur bright reddish in males, tending toward lighter brownish to grayish in females ..... *Lasiurus blossevillii*\*
- 12a. Dorsal fur lighter at base(pale yellow-blond) than tips (brown); pale translucent ear 25-33mm long; forearm 50-55mm .... *Antrozous pallidus*
- 12b. Dorsal fur darker at base than tips; fur color, ear, and forearm length highly variable ..... 13
- 13a. Ear length 30mm or more ..... 14
- 13b. Ear length 25mm or less ..... 15
- 14a. Prominent pair of lumps above nose on each side of muzzle, no pair of leaf-like structures projecting forward from leading edge of ears over face ..... *Corynorhinus (Plecotus) townsendii*
- 14b. Lumps on nose absent, prominent pair of leaf-like structures projecting forward from lead edge of ears over face ..... *Idionycteris phyllotis*
- 15a. Tragus short, blunt, and club-shaped (body fur medium to very pale brown in sharp contrast to jet black face mask and ears, forearm 27-33mm) ..... *Pipistrellus hesperus*
- 15b. Tragus long and pointed ..... 16

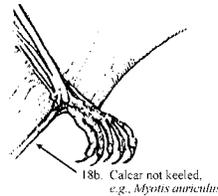
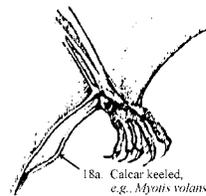
- 16a. Distinct fringe of hair on edge of tail membrane (ears darkly pigmented, 12-22mm, belly fur light, forearm 39-46mm).....*Myotis thysanodes*  
 16b. Fringe absent, no more than occasional scattered hairs on edge of tail membrane ..... 17

\* The eastern red bat (*Lasiurus borealis*) may be encountered in extreme eastern Arizona but cannot be reliably distinguished from the red bat (*Lasiurus blossevillii*) based on external characters.

- 17a. First upper premolar at least half as tall as canine (forearm 42-51mm, calcar keeled, fur color medium to dark brown) .....*Eptesicus fuscus*  
 17b. First upper premolar less than one-fourth as tall as canine ..... 18



- 18a. Calcar keeled ..... 19  
 18b. Calcar not keeled ..... 21



- 19a. Body fur uniformly dark brown or grayish brown with no distinctively darker face mask, forearm 38-42mm ..... *Myotis volans*  
 19b. Body fur medium to very light tan or reddish brown with clearly darker face mask, forearm 29-36mm ..... 20

- 20a. Thumb length greater than 4.2mm, dorsal fur slightly shiny, color pale, sharply contrasting face mask ..... *Myotis ciliolabrum*<sup>†</sup>  
 20b. Thumb length less than 4.2mm, dorsal fur dull, color pale, face mask distinctive but often less contrasting ..... *Myotis californicus*<sup>†</sup>

- 21a. Ear length 19mm or more ..... 22  
 21b. Ear length 18mm or less ..... 23

- 22a. Ears, wing, and tail membranes blackish and opaque, ear length 22-24mm ..... *Myotis evotis*  
 22b. Ears, wing, and tail membranes brownish and translucent, ear length 19-21mm ..... *Myotis auriculatus*

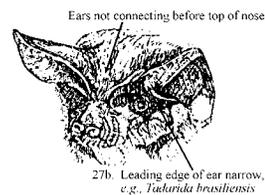
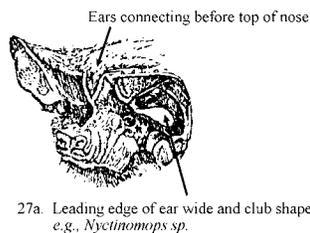
- 23a. Forearm 32-36mm, ventral fur with whitish tips ..... *Myotis yumanensis*  
 23b. Forearm 37-47mm, ventral fur sometimes lighter than dorsal but lacking whitish tips ..... 24

- 24a. Body fur gray to gray brown, dull; ears usually light colored, forearm 40-45mm ..... *Myotis velifer*  
 24b. Body fur brown to reddish brown, glossy; ears always dark, forearm 36.5-40.5mm ..... *Myotis occultus*

- 25a. No vertical wrinkles on upper lips, forearm 66mm or more ..... 26  
 25b. Deep vertical wrinkles on upper lips, forearm 64mm or less ..... 27

- 26a. Ear length between 28-32mm, forearm 65-74mm, tragus small and rounded, distinctive long guard-hairs on rump ..... *Eumops underwoodi*  
 26b. Ear length 36-47mm, forearm 73-83mm, tragus broad and square, no obvious long guard-hairs on rump ..... *Eumops perotis*

- 27a. Leading edge of ear widening to become club-shaped above and behind eye, ears connecting before reaching top of nose ..... 28  
 27b. Leading edge of ear narrowing to a point above and behind eye, ears not connecting before reaching top of nose (forearm 36-46mm) .....  
 ..... *Tadarida brasiliensis*



- 28a. Forearm 44-50 mm ..... *Nyctinomops femorosaccus*  
 28b. Forearm 58-64 mm ..... *Nyctinomops macrotis*

<sup>†</sup> Some individuals overlap in characters and may be hybrids. Those with thumbs clearly less than 4mm or more than 5mm typically exhibit the remaining diagnostic characters of *Myotis californicus* and *Myotis ciliolabrum*, respectively. See BCI *Myotis* key for more details.



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Illustrations: nectar bat tails, calcars, and free-tailed bat ears -- Christine Setter in Schmidly, D.J., 1991. *Bats of Texas*, Texas A&M University Press, 188pp., bat skulls -- Hall, E.R., 1981. *The Mammals of North America, Volume 1*, John Wiley and Sons, New York, 600pp.

KEY TO THE MYOTIS SPECIES OF ARIZONA

General Characteristics

*Facial Adornment:* None; no facial flaps or nose-leaves.

*Size:* Weights = 5-14 g. Wingspans = 212-315 mm. Small to medium compared to other Arizona bats.

*Tail:* Enclosed in interfemoral (tail) membrane and extends no more than 8 mm beyond edge of interfemoral membrane.

*Tail Membrane:* Naked to partially furred.

*Fur Color:* Brownish; ranging from pale or yellowish to grayish to reddish brown; dull to glossy; not black or silver-tipped.

*Teeth in Upper Jaw:* 6 teeth behind canine (2 small premolars, 1 large premolar + 3 molars), except for *M. occultus*, which has 5 (1 small premolar, 1 large premolar + 3 molars).

*First Visible Tooth Behind Canine:* <1/3 as high as canine, if 1/2 as high as canine there is a noticeable gap between canine and first visible premolar.

*Tragus of Ear:* Pointed, straight and > 6 mm long.

*Ecological Distribution:* At least one species (often several) found at all elevations and in all biomes (except those above timberline). Each species has generally preferred habitats, roosts (e.g. crevices, trees, caves, mines, or man-made structures), and roosting sites within roosts.

*Food and Feeding:* All feed on flying insects and forage by aerial pursuit, gleaning from plant and other surfaces, or

*Migration and Hibernation:* All species probably migrate latitudinally or elevationally between summer and hibernation roosts. During winter months, individuals in hibernation revive and become active periodically. Apparently, those in warmer areas of the state are the most active during winter. Little is known of the winter habits of most species.

Key to the Nine Arizona Myotis

A. Keel on calcar visible to naked eye; hind foot length variable.

- 1. Forearm >37 mm long; hind foot ≥ 8 mm long; underside of wing furred from side of body to elbow; anterior 25% dorsal surface of tail membrane furred..... *Myotis volans*
- 2. Forearm <36 mm long; hind foot ≤ 8 mm long; underside of wing not furred.
  - a. Fur on back glossy pale brown; black mask usually visible; ears dark colored; thumb >4.2 mm; [braincase rises gradually, not abruptly, from rostrum] ..... *Myotis ciliolabrum*
  - b. Fur on back dull pale to yellowish brown; black mask not visible; ears usually dark colored; thumb < 4.2 mm; [braincase rises abruptly from rostrum] ..... *Myotis californicus*

B. Keel on calcar not visible to naked eye; hind foot ≥ 8 mm.

- 1. Ears (bottom of notch to top margin) usually ≥ 19 mm long; or tail membrane fringed.
  - a. Fringe of hairs on trailing edge of tail membrane visible to naked eye; forearm >40 mm long; ears, wing and tail membranes dark; ears usually 16-21 mm ..... *Myotis thysanodes*
  - b. No fringe of hairs on tail membrane; forearm 36-40 mm long; ears, wing and tail membranes dark or brownish; ears 19-24 mm.
    - 1. Ears, wing and tail membranes blackish and opaque; ears usually longer (20-24 mm); [braincase rises abruptly from rostrum] ..... *Myotis evotis*
    - 2. Ears, wing and tail membranes brownish and translucent; ears usually shorter (19-21 mm); [braincase rises gradually, not abruptly, from rostrum] .. *Myotis auriculus*
- 2. Ears (bottom of notch to top margin) ≤ 18 mm long; tail membrane not fringed.
  - a. Forearm < 37 mm long; fur color dull, light to dark brown; ears usually light colored [skull with no sagittal crest; 2 small upper premolars] ..... *Myotis yumanensis*
  - b. Forearm >36 mm long; fur color dull or glossy, grayish to reddish-brown; ears light or dark; [skull with or without distinct sagittal crest; 1 or 2 small upper premolars].
    - 1. Color dull grayish to grayish brown; usually a bare patch between shoulder blades; ears usually light-colored; forearm 40-45 mm long; [skull with distinct sagittal crest; 2 small upper premolars] ..... *Myotis velifer*
    - 2. Color glossy brown to reddish brown; no bare patch between shoulder blades; ears always dark-colored; forearm 36-41 mm; [skull without sagittal crest; 1 small upper premolar] ..... *Myotis occultus*

Revised April, 1994, AGFD, HDMS.