4.0 How Short-Term Climate Variation Affects Species

Pima County, with its location between the subtropics and temperate climatic zones, hosts a variety of plant and wildlife species. Some are residents, staying all year long, while others migrate here for the summer or winter. To some species, Pima County represents the northernmost limits of their range, while others have their southernmost limits here, and for others Pima County is the center of their range.

The presence of "sky islands" creates a unique situation, where species with similar climatic preferences sort themselves along the elevation gradient based on the blend of temperature and precipitation that best supports them (SIWN, 2000). Species originating in the northern temperate areas tend to congregate in the high elevations, while species from the more tropical south stay near the lower elevations (Lowe, 1985). Many species that might normally be widely separated intermingle in these areas (Felger and Wilson, 1995).

Locations and population sizes of species can be directly affected by changes in climate. Changes in distribution appears to have been the primary way that species have responded to past climate change (Noss, 2001). As climate varies, species may respond by shrinking or enlarging their ranges and seeking appropriate microclimates. Varied elevations, soils and riparian environments may provide options for species' movements in response to climatic variation. However, some species typical of cooler climates might be eliminated during droughts, and recolonization across hot, dry basins might be difficult (McDonald and Brown, 1992; in SRAG, 2000). Aquatic and riparian obligate species are particularly limited, given the regional limitations of suitable aquatic and riparian habitats.

Temperature is not necessarily the defining factor in determining species distributions and population densities in an area. Other climate factors can directly or indirectly affect wildlife and plants, thus changing their behaviors or reducing the numbers observed from year to year. Below are a number of species of concern to the Sonoran Desert Conservation Plan with their potential, short-term responses to climatic change:

Listed cats: Jaguar (*Panthera onca*) and **Ocelot** (*Felis pardalis*) - These species most likely respond to changes in vegetative cover and differences in behavior and movement of their prey species, which are directly affected by seasonal changes in climate.

Mexican gray wolf (*Canis lupus baileyi*) - Most likely responds to movements of large ungulate species, which may be directed by daily and seasonal climate change.

Lesser long-nosed bat (*Leptonycteris curasoae yerbabuenae*) - These bats cannot withstand prolonged exposure to cold. They migrate to Mexico in September or October, where they breed and spend the winter. They return to Arizona in the spring or summer (late April to late July) to bear their young (AGFD, 1998a). Warming trends would most likely extend their time of stay in the summering grounds, and may even extend their range northward. Cooling trends would create

the opposite effect; bats would most likely breed in the southernmost areas of Arizona and stay for shorter durations of time.

Unlike most other bats and rodents in arid and semiarid areas, *Leptonycteris* are not adapted for water conservation and salt excretion. This is related to its feeding on nectar, most especially agaves, with their high water and low salt content. Its diet on nectar allows the lesser long-nosed bat to essentially be independent of free water (AGFD, 1998a). Any climate conditions that affect the production and sustainability of agaves or saguaros will also affect the sustainability of *Leptonycteris* populations.

Mexican long-tongued bat (*Choeronycteris mexicana*) - Like the lesser long-nosed bat, *C. mexicana* is only a summer resident of Arizona, which is the northernmost limit of their range. Females migrate north into the United States from Mexico to bear their young, which are born sometime between mid to late June and early July (AGFD, 1997a). Warming and cooling trends can have the effect of expanding or reducing the range of this species, along with the duration of their stay after breeding has occurred.

The Mexican long-tongued bat feeds primarily on the nectar and pollen of agaves and saguaros (RECON, 2001a). Any climatic changes affecting the production and distribution of these plants will also affect the sustainability of *C. mexicana* populations.

Allen's big-eared bat (*Idionycteris phyllotis*) - This species is known to be dependent on available water (RECON, 2001a). Lack of water resources during times of drought could severely limit the range of this species and make it more susceptible to competition from other species.

Western red bat (*Lasiurus blossevillii*) - The western red bat is known only to occur in broadleaf riparian deciduous forests and woodlands (RECON, 2001a). The loss of riparian vegetation due to reduced water tables from drought or by removal from damaging floods can have a more profound affect on riparian dependent species, such as the western red bat, since this habitat type has been severely reduced over the last century (mostly due to human activities).

Western yellow bat (*Lasiurus xanthinus = ega*) - The western yellow bat is a tropical species, whose range has been increasing into urban areas within the southwestern United States (RECON, 2001a). It is found primarily in planted fan palms within urban settings and in riparian areas. Warming trends may continue to allow this species to expand its range further northward, while cooling trends may force it retreat southward. Its adaptation to the urban setting may allow this species to withstand short-term losses of riparian vegetation.

California leaf-nosed bat (*Macrotus californicus*) - The California leaf-nosed bat is well adapted to the desert due to its ability to conserve water (RECON, 2001a). Lu and Bleier (1981) reported some individuals in captivity lasting for at least six weeks without drinking water. Other sources, including Bell et al. (1986) suggest that this species is well adapted to the desert because they roost in sites with a stable year-round temperature, thus limiting their energy expenditure on thermal

regulation. M. californicus cannot withstand sustained temperatures less than 26 °C (79°F) for longer than a few hours (AGFD, 1997b).

Arizona Shrew (*Sorex arizonae*) - It is speculated that summer rainfall triggers the breeding and dispersal of Arizona shrews (Van Pelt et al., 1994, in RECON, 2001a). The Arizona shrew is a "sky island" species (RECON, 2001a), and it may respond to climatic changes by expanding its range downslope during cooling trends, and retreating back to mountain peaks during warming trends. One threat to this species may be the loss of habitat due to fire, which can be greatly affected by climatic change as mentioned previously within this report.

Merriam's mouse (*Peromyscus merriami*) - Merriam's mouse is heavily dependent on the presence of riparian woodlands and dense mesquite forests (RECON, 2001a). Since these vegetation types have been in serious decline over the years, any further reduction could have severe impacts to riparian dependent species such as the Merriam's mouse. Both droughts and floods can affect the health and extent of riparian vegetation along a watercourse.

Sonoran pronghorn (*Antilocapra americana sonoriensis*) - During a study using collared Sonoran pronghorn in 1984, it was determined that four males had home ranges from 40 square miles to 750 square miles, while six females had home ranges ranging from 25 square miles to 710 square miles. The large variation in home range size appears to be linked to forage and possibly water availability (AGFD, 1998b). Hervert (1996) states that they are exhibiting a "nomadic behavior that is typical of other desert dwelling animals like the oryx of the Sahara Desert or the Dorcas gazelle of the Kalahari Desert. These desert ungulates at times appear to be wandering randomly, but this movement is associated with living in desert conditions, where resources may be widely scattered or ephemeral."

Changes in climate can have a profound affect on Sonoran pronghorn populations. During drought cycles, food and water resources become more scarce, causing herds to expand the size of their home ranges. This puts more physical stress on individuals (especially young), making them more susceptible to predation or disease. It also increases their likelihood of running into movement barriers or hazards (i.e., roads), which increases stress and may lead to higher mortality. In contrast, wet years may allow for populations to reduce their home range sizes, thus reducing stress and allowing for higher survival rates.

Masked bobwhite quail (*Colinus virginianus ridgwayi*) - Breeding normally begins when summer rains commence, generally in July. Nesting success is correlated with the amount of ground cover and distribution of summer precipitation (USFWS, 1995). This species is peripheral to the United States where it is influenced by widely fluctuating summer rainfall, therefore, large annual population fluctuations are likely (Denniston, 1978). Annual mortality rates are believed to be similar to other bobwhite races, approximately 70 percent (Rosene, 1969).

Much of the demise of the masked bobwhite quail is due to the loss of its grassland habitat from overgrazing in the late 1800's, coupled with several years of drought. This statement is backed up

by Brown (1904), who stated: "Causes leading to the extermination of the Arizona masked Bobwhite are due to overgrazing of the country with cattle, supplemented by several rainless years." Past efforts to restore wild populations have met with little success, due in part to grazing pressure and insufficient precipitation to provide adequate brood habitat or winter foods (USFWS, 1995).

With existing populations of masked bobwhite quail severely limited (they are only known within the Buenos Aires Wildlife Refuge in Pima County), climatic changes can have a profound impact on the species. Reproduction activity of the masked bobwhite can be severely depressed during drought years, with drought modeled as resulting in a 75 percent reduction in reproduction success. Individual survival was better, however, with only a 10 percent reduction across all age and sex classes (USFWS, 1995). Several years of sufficient rains (both winter and summer) along with a reduction in grazing pressure would be needed to help restore populations of this species.

Mexican spotted owl (*Strix occidentalis lucida*) - Forests throughout the owl's habitat are at high risk from fire, insects and disease. These conditions exist within the natural range of weather variations and short or long-term climate cycles. Large-scale catastrophic fires destroy habitat components for nesting and foraging. Small-scale fires are beneficial in reducing fuel loading and improve the horizontal diversity, which is an important habitat component for owls. Natural fire regimes prior to 1890 favored frequent small fires (Moody et al., 1992). Insects may produce large scale community changes after periods of climatic stress that predispose forests to insects or pathogenic occurrences (Colhoun, 1979). Both large-scale fire and insect damage are more common in seral tree stands than in climax tree stands. Seral stands generally provide habitat where the greatest concentrations of spotted owls occur.

Southwestern willow flycatcher (*Empidonax traillii extimus*) - Climatic factors (any climate induced change in the riparian forest communities) affect suitable flycatcher habitat and include inundation, massive annual floods that scour habitat, lack of flooding and widely fluctuating water levels. Flycatchers require dense riparian habitat of intermediate sized shrubs or trees often with an over-story of scattered larger trees usually with water or moist soil beneath the canopy (Tibbitts et al., 1994).

Swainson's hawk (*Buteo swainsoni*) - The Swainson's hawk primarily nests in grassland and semidesert grassland vegetation communities (RECON, 2001a). Fire and winter rains are two components necessary for a healthy grassland community. Any climatic factors that affect these activities will affect the production of native grasslands and, subsequently, affect the breeding range of Swainson's hawks in Pima County.

Bell's vireo (*Vireo bellii*) - Bell's vireo is generally found in dense shrubland or woodland along lowland stream watercourses (RECON, 2001a). Considering that much of these riparian areas have been in serious decline over the years, what remains is crucial for the continuing existence of riparian dependent species such as Bell's vireo. Climatic factors that affect riparian habitats, most notably droughts and floods, will in turn affect the range and distribution of this species.

Abert's towhee (*Pipilo aberti*) - Abert's towhee is found within Sonoran Riparian Deciduous Woodland and Riparian Scrubland communities (RECON, 2001a). As mentioned previously, these communities have been in serious decline over the years (mostly due to human intervention). Climatic factors, such as drought and floods, can affect the health and extent of these communities, thus affecting the distribution and range of Abert's towhee.

Rufous-winged sparrow (*Aimophilia carpalis*) - Nesting of rufous-winged sparrows if timed with the summer rains, so there is extreme fluctuations in populations from year to year (RECON, 2001a). There are historical records that this species had been extirpated from Arizona for at least some period of time, indicating that it is an extremely rare species. Populations of this species may reduce their size significantly during periods when there is little to no summer rains, and regain their numbers during periods of high summer rainfall.

Chiricahua leopard frog (*Rana chiricahuensis*) – One suspected threat for adult Chiricahua leopard frogs is oxygen depletion. Drought conditions, silt-laden runoff, vegetation die-off and other factors could result in oxygen depletion in still-water habitats such as stock ponds. The result could prove fatal to adult leopard frogs as they spend their winters in the mud bottoms of a pond. This "winterkill" has been documented in other *Rana* species and appears to be a viable hypothesis for *R. chiricahuensis*, which is probably better adapted to stream habitats than to artificial ponds subject to events of extreme oxygen depletion (NMGF, 2000). Currently 70% of the population exists in dirt stock ponds (Stredl, 1993).

Lowland leopard frog (*Rana yavapaiensis*) - The lowland leopard frog is highly dependent on aquatic ecosystems. Historically, aquatic ecosystems were more prevalent along streams and rivers in the Tucson Basin, but many of these areas have since disappeared (mostly due to groundwater pumping and channel changes). Populations are now mainly limited to small, upper canyon watersheds and stock ponds. These isolated populations are subject to extinction during times of drought as reported by Rosen for Alamo Canyon (personal communication in RECON, 2001a) and Hall for the population in Cargodera Canyon (pers. communication in RECON, 2001a).

Sonoyta mud turtle (*Kinosternon sonoriense longifemorale*) – "Aquatic habitat in the Rio Sonoyta is extremely dynamic due to climatic extremes (Ives, 1936; Hendrickson and Varela-Romero, 1989)." "Because turtle populations have a low growth rate, they are incapable of expanding rapidly during periods of high precipitation but populations can decline rapidly during drought years".

Giant spotted whiptail (*Cnemidophorus burti stictogrammus*) - The giant spotted whiptail is active during the daytime from spring through early autumn, and hibernates in the winter (RECON, 2001a). This species will emerge from hibernation in April or early May, depending on yearly climatic conditions (Goldberg, 1987 in RECON, 2001a). Although not much is known specifically for this subspecies of Cnemidophorus, survival and reproduction rates for the other Arizona subspecies of this lizard have been linked to weather conditions (Rosen and Lowe, 1996).

Red-backed whiptail lizard (*Cnemidophorus burti xanthonotus*) - Red-backed whiptails are active during the daytime, from mid-spring through early autumn. They are normally inactive during the remainder of the year (RECON, 2001a). Both survival and reproduction rates for this species are believed to be related to weather conditions (Rosen and Lowe, 1996).

Mexican garter snake (*Thamnophis eques megalops*) - The Mexican garter snake is primarily found within areas of permanent water ranging from desert grasslands to oak-pine communities, including cottonwood-willow riparian communities (RECON, 2001a). Since these habitats have been in serious decline, the range and distribution of the Mexican garter snake has also been in decline. Since its numbers are low and distribution limited, climatic factors such as drought and flooding could have damaging effects to the continued existence of this species within Pima County.

Desert box turtle (*Terrapene ornata luteola*) - Box turtles breed in both the spring and autumn (RECON, 2001a). Sex of the species is determined by temperature at which the egg was incubated, with lower temperatures producing more males and warmer temperatures producing more females (Degenhardt et al., 1996). Thus, changing air temperatures can have a profound affect on populations of this species.

In general, the desert box turtle occurs in grassland and desert grassland communities of arid and semi-arid, treeless plains and rolling grass and shrub land (RECON, 2001a). As mentioned previously, fire and the amount of winter rainfall (which are affected by climate) can affect the health and distribution of these types of communities.

Gila topminnow (*Poeciliopsis occidentalis*) - These fish are found in two different habitats, springs and streams. Desert springs and streams are characterized by infrequent and unpredictable water inputs. Climatic factors differ between the two and affect the populations and life cycles differently. Topminnows can tolerate temperatures from 0° C (32° F) to 37° C (99 °F), but respond to temperature ranges differently, both in growth and reproduction.

The temperature of spring flows are generally more stable year-long, while streams are more variable. There is a difference in topminnow growth and reproduction between springs and streams. Springs and their immediate outflows are ecosystems that fluctuate less with weather changes. In springs, topminnows exhibit different external morphology, mature at an earlier age and reproduce yearlong producing large numbers. Seasonal changes appear to be affected primarily by changes in the solar cycle, an exceedingly gradual and predictable progression (Brown, 1971; Constantz, 1976; Cox, 1966; Deacon, 1968).

Desert streams are generally characterized by short reaches with pools that are relatively closed ecosystems except during periods of runoff. Most of the year there is little or no in-flow or out-flow, and pools show stratification of temperatures and oxygen. Desert springs and streams are characterized by infrequent and unpredictable water inputs (Greenfield and Deckert, 1973). Discharge is important to fishes in pools. Low flows recharge the detrital cycle in pools. Flash floods rearrange pools, scour algae and invertebrates and may displace fish downstream. Temperatures

fluctuate more with seasonal changes. Water temperature is controlled by local weather and generally restricts the breeding season to a period between March and September. Topminnows are slower growing and reproduce in small numbers in streams. Torrential storms displace fishes into vast temporary reaches. They spread from tiny refugia to repopulate entire drainage systems. In dry periods, they concentrate in the few remaining pools. They exhibit greater variations in population numbers and structures in local abundance and periodic extinction than do spring populations. This results in large inter-annual variations in reproduction and population densities (Lehtinen and Echelle, 1979). Desert streams are affected by variations caused by seasonal changes due to solar input, air temperature and precipitation. Occasional high mortality that results from downstream displacement and desiccation may result in extreme competition with other fishes.

Desert pupfish (*Cyprinodon macularius*) - Pupfish can tolerate great extremes of environmental conditions under desert climatic regimes (Minckley, 1973). They have the ability to survive in water temperatures up to 45° C or 113 °F (Lowe et al. 1967). They survive and reproduce in temperatures (22-26° C or 71.6-78.8°F) that are lethal to most fishes (Kinne 1960, Lowe and Heath 1969; Moyle 1976). Along the Salton Sea in California, Barlow (1958, 1961) observed groups of these fish moving from place to place in response to changes in local temperatures and salinities. By this activity, populations of these fish appear to remain in areas that are the most hospitable throughout the day and season (Minckley, 1973). As with most other aquatic species, increasing temperatures and aridity will reduce the amount and extent of available habitat for pupfish (Doug Duncan personal communication, 2001).

Longfin dace (*Agosia chrysogaster*) - The longfin dace is a hearty native fish, adapted to the harsh desert climate. In response to the onset of floods, the fish will move directly into the current, and then move laterally as the intensity of turbulence increases. The dace will remain in the margins of the current, and then move back into the channel as discharge declines; they are rarely ever caught in flood pools or backwaters (Minckley and Barber, 1971; Rinne, 1975). In response to drought, longfin dace retreat to side pools or under algal mats, logs or stones during the day, and can move and feed at night in water with depths as little as a few millimeters of water (Minckley and Barber, 1971). Even though this species is well adapted to the harsh climate of the desert southwest, increasing temperatures and aridity in the area will reduce the amount and extent of available habits for longfin dace.

Desert sucker (*Catostomus clarkii*) - Like most other native fish species, the desert sucker can tolerate a wide range of water temperatures (RECON, 2001a). Also, like other highly aquatic species, the extent of its available habitat will be reduced by increasing temperatures and aridity in the area.

Sonora sucker (*Catostomus insignus*) - The Sonora sucker is found within a variety of habitats ranging from warm water rivers to trout streams (BISON-M, 2000). This species is intolerant of lake conditions created by dams (Minckley, 1973). Like other fishes, it requires permanent water for survival. Increasing temperatures and aridity can greatly reduce its available habitat.

Gila chub (*Gila intermedia*) - Gila chubs are restricted to streams, springs, and cienegas (RECON, 2001a). Much of their historic habitat, as with other native fishes, has disappeared over the last century. Increasing temperatures and aridity in the area could further limit the extent of available habitat for this species.

Arkenstone Cave pseudoscorpion (*Albiorix anophthalmus*) - This species of pseudoscorpion is only known from Colossal Cave in Pima County, Arizona (RECON, 2001a). Much of the water that enters the cave system is provided by winter rains which soak the soils above the cave. Cave communities are also affected by plant and animal resources outside the cave, which influence the energy input potential for the cave (Muchmore and Pape, 1999). Climate, therefore, has a profound affect on the cave environment, and any change in the available moisture or changes in temperature can influence the status of cave species such as *A. anophthalmus*.

Talussnails (*Sonorella spp.*) - *Sonorella* species apparently live in isolated, undisturbed areas of rocks, usually near hilltops or in rocky canyons (RECON, 2001a). Relatively minor perturbations of their habitat may result in changes that impact the snails. Talussnails are thought to be particularly sensitive to climate change (Terkanian, 1999; in RECON, 2001a).

Tumamoc globeberry (*Tumamoca macdougalii*) - These plants usually spend most of the year in dormancy. Growth and reproduction occur in July and August with summer monsoonal thunderstorms. During periods of drought it may not emerge and give the appearance that the population is extirpated (Reichenbacher, 1985).

Pima pineapple cactus (*Coryphantha scheeri var. robustispina*) - Flowering is likely triggered by rain or humidity. The 1988 blooming period closely followed the first significant rains (Mills, 1991).
With flower production linked to water availability, increasing aridity could reduce natural populations of this species, whereas increasing rainfall could boost its production.

Acuňa cactus (*Echinomastus erectocentrus var. acuňensis*) - Flowering for this species takes place from March to mid-April (AGFD, 1997c). Water availability appears to limit flower production. The primary germination period for the Acuňa cactus is during the summer monsoons (Johnson, 1992 in RECON, 2001a). Increased summer aridity would decrease production of this species.

Pima Indian mallow (*Abutilon parishii*) - These plants can be found flowering throughout the year in response to rains. Flowers open only in mid-afternoon in full sunlight, closing if clouds occur. (AGFD, 1997d). Increasing aridity could reduce natural populations of this species, whereas increased rainfall could boost its production.

Pringle lip-fern (*Cheilanthes pringlei*) - Dormant through the dry seasons, the pringle lip-fern reproduces only when there is sufficient moisture (Phillips and Phillips, 1991; Sue Rutman 1991 personal communications with Arizona Game and Fish Department 1991). Fluctuations in the abundance of this species may result from the amounts of rainfall that occur from year to year.

Nichol's Turks head cactus (*Echinocactus horizonthalonius var. nicholii*) - This cactus is a poor competitor with shrubs and trees for space, moisture, light and nutrients (USFWS, 1986). During years with little to no rain, there may be a decline in the population of this species as a direct result of competition with other species for moisture.

Gentry indigobush (*Dalea tentaculoides*) - As with many other species of *Dalea*, *D. tentaculoides* appears to flower in both the spring after winter rains and again in the fall following summer rains (Gori et al., 1992). Its main flowering season is in the spring, late March to mid-May. Lack of rainfall in either the winter or summer would affect this reproductive behavior.

Based on observations by Toolin (1986), seedling establishment of this species may be dependent on summer rainfall. No seedlings were observed from 1980 to 1983, during which there were drier-than-normal summers and average winter rains. Observations by Gori and others (1992) found that mortality of this species is related to size, with large plants having a better survival rate (>50%) than smaller plants. Although some grazing by cattle was noticed, lack of soil moisture was presumed to be the most likely reason for the loss of small plants.

Presently, the gentry indigobush is only known to occur in Arizona in Sycamore Canyon, which is located in the Atacosa Mountains in Santa Cruz County. Although it occurs in areas subject to periodic flooding, the largest clumps are normally found near obstructions that reduce flow velocities and provide protection from scouring (Gori et al., 1992). A catastrophic flood within this canyon, however, could possibly wipe out the entire population by removing plants and depositing them downstream in soils and elevations that are not suitable for reestablishment.

Kearney's blue star (*Amsonia kearneyana*) - Threats to the species include catastrophic flooding and soil erosion accelerated by losses in plant cover and vigor due to livestock grazing (USFWS, 1993). Kearney's blue star is susceptible to damage from catastrophic floods (Phillips and Brian 1982). Torrential rains during the summer of 1990 destroyed 76% of the plants of the Brown Canyon population. Drought conditions in the Spring of 1998 and 1989 necessitated hand-watering of a transplanted population to ensure survival (USFWS, 1993).

Huachuca water umbel (*Lilaeopsis schaffneriana var. recurva*) - Climate and suitable habitat are closely tied. Suitable habitat requires sufficient perennial base flow to provide a permanently or nearly permanently wetted substrate for growth and reproduction and a stream channel that is relatively stable, but subject to periodic flooding that provides micro-sites for *Lilaeopsis* expansion (USFWS, 1999).