DRAFT

Recreation Impacts in Eastern Pima County

Sonoran Desert Conservation Plan

March 2001

Pima County, Arizona
Board of Supervisors

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Chuck Huckelberry

MEMORANDUM

Date: March 20, 2001

To: The Honorable Chair and Members
Pima County Board of Supervisors

From: C.H. Huckelberry
County Administrator

Re: **Recreation Impacts in Eastern Pima County**

Background -- As we begin to draft the Adaptive Management Manual for the Sonoran Desert Conservation Plan and undertake alternatives analysis to complete the Environmental Impact Statement, the issue of recreational impacts becomes increasingly important. The attached study entitled *Recreation Impacts in Eastern Pima County* is a primer on the impacts of recreational activities and types of activities allowed under the current program mandates and management plans of public land entities.

Impacts -- Pages six through fourteen of *Recreation Impacts in Eastern Pima County* define and describe impacts of recreational activities to resources, particularly soil, vegetation, wildlife, water and cultural resources. General mitigation principles are discussed throughout.

Recreational Activities -- A brief outline of recreation activities permitted on public lands in Eastern Pima County is found in pages fourteen through seventeen. This survey includes activities such as hiking, birdwatching, equestrian activities, camping, caving, rock climbing, mountain biking, and off road vehicle use. Maps of Pima County birding sites and recreation sites are included.

Public Lands Recreation Plans and Opportunities -- Pages eighteen through thirty highlight the statutory, regulatory, or policy basis for recreation uses on public lands. After summarizing Pima County's recreation programs in various parks and preserves, the study outlines the rules and recreational types found in the lands owned or managed by the Bureau of Land Management (BLM), the Bureau of Reclamation, the United States Forest Service, the National Park Service, the United States Fish and Wildlife Service, the Arizona State Parks, and other agencies.

Conclusion -- Technical teams have been established in the areas of science, ranch conservation and cultural resource protection. We are now establishing a Recreation Technical Advisory Team to develop the concepts in the attached draft report on *Recreation Impacts in Eastern Pima County* so that further information can be provided to the Steering Committee about both the importance and the impact of recreational activities in the overall Sonoran Desert Conservation Plan.

Attachment

Recreation Impacts in Pima County

Purpose

Outdoor recreation has become increasingly popular, placing tremendous demands on natural resources. This report reviews basic recreation impacts and consequences to the resource base. The report reviews various agency policies on recreational use, and offers a brief summary of recreation issues on federal and county lands within Pima County.

Introduction

In recent decades, outdoor recreation demand has increased greatly (Hammitt and Cole, 1987). Part of this demand, in the case of Tucson, is caused by a growing urban population in greater proximity to national parks and forests. Not only has a greater population contributed to increased outdoor recreation demands, but the public is also demanding new recreation opportunities.

Increased recreational use is a growing concern among public land managers. Managers are faced with visitor overuse and crowding, impacts associated with use, and increased crime associated with increased visitor levels. Public land managers face an increasing challenge in anticipating the public's need for recreation activities and settings. In meeting these needs, managers must have regard for the resource base while also considering visitor satisfaction and enjoyment. The challenge for managers is to manage acceptable levels of change without creating substantial losses of natural resources.

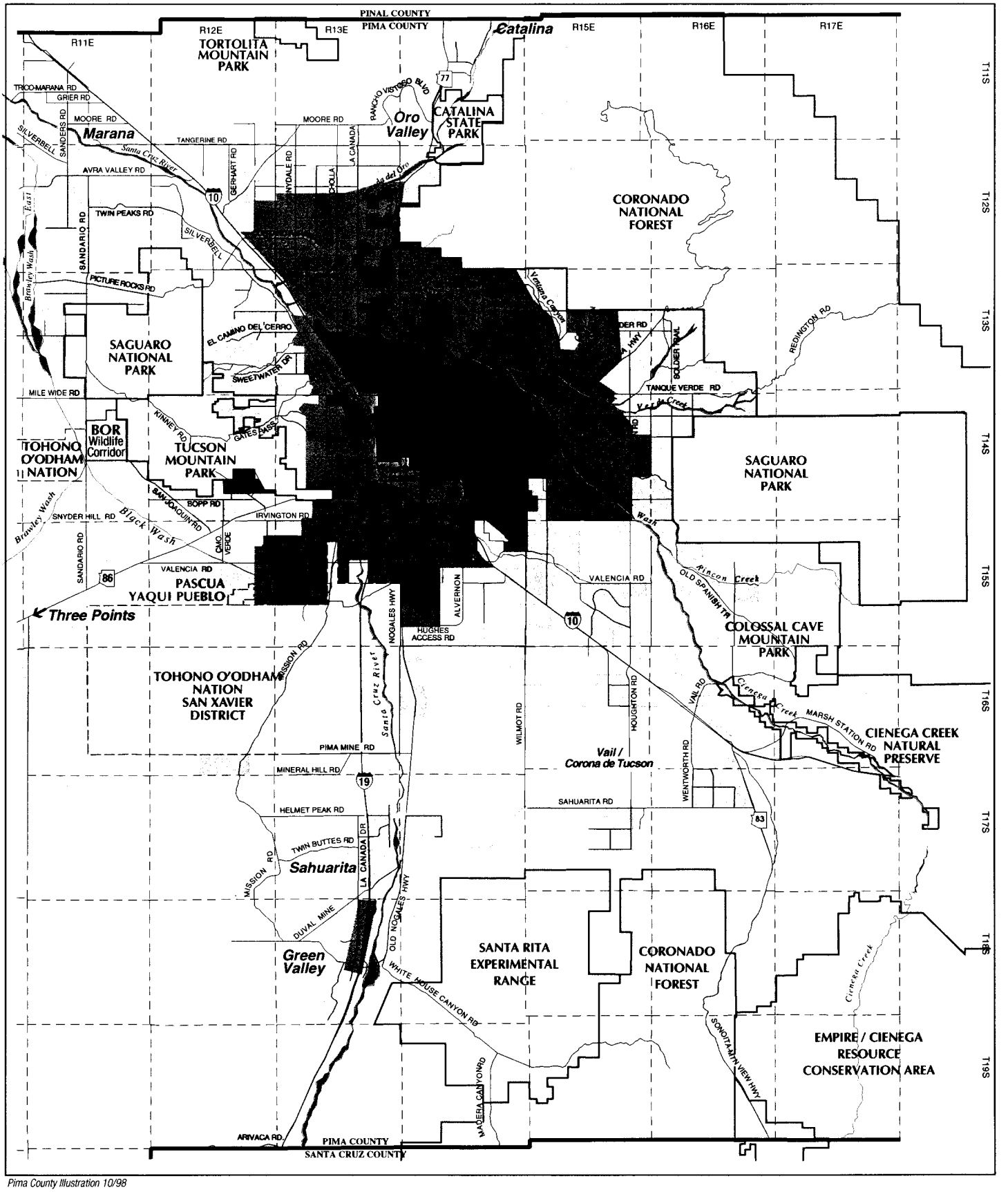
Background

The southwest is one of the fastest growing regions in American, and Arizona is one of the fastest growing states. In Pima County, population has grown 134 percent between 1970 and 1999. Tucson has grown from a population of 325 in 1820, to an estimated 1999 population of 854,329 (Arizona Department of Economic Security).

Population growth has urbanized much of the Tucson Valley, and is bounded by the Santa Catalina Mountains on the north, the Rincon Mountains on the east, and the Tucson Mountains on the west (see Figure 1). The increased urban growth is putting escalating pressure on reserve boundaries. Housing development almost completely surrounds reserves such as the Tucson Mountain Park and Saguaro National Park West.

The clear, sunny skies, pleasant winters, and great natural beauty of Arizona are conducive for outdoor recreation. Many recreation opportunities are available on the public lands found within Pima County. Outdoor recreational activities offered include wildlife viewing, hiking, equestrian trails, skiing, mountain biking, fishing, off-highway driving, and camping. Because of the availability of recreation opportunities, mild weather, and proximity to an urban center, federal land is heavily used for recreational purposes.

All types of recreational activities disturb the natural environment, although the specific impacts associated with each activity varies (Hammitt and Cole, 1987). Recreational activities can potentially affect soil, vegetation, wildlife, and water (see Figure 2).



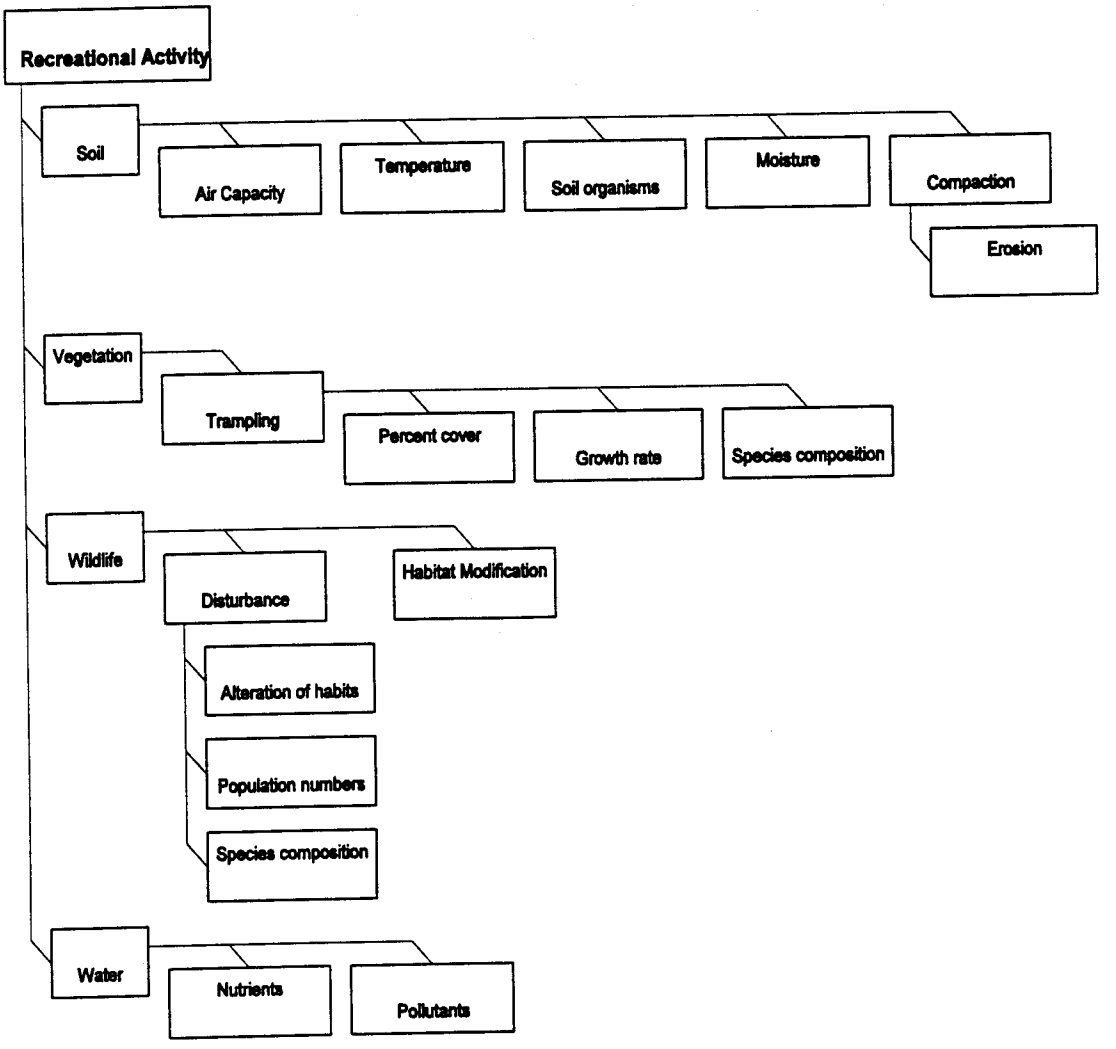
Pima County Illustration 10/98

Urban Expansion in the Metropolitan Tucson Area

1940 1960 1985 1990

Figure 1

Figure 2: Potential Recreational Impacts [1]



Impacts caused by recreation can be direct or indirect, and are often interrelated. Some effects are visible to even the untrained eye (such as vegetation trampling and soil erosion), others can only be seen with a microscope (such as damage to soil organisms), while other effects have not been identified or studied. Several impacts and their interrelationships are described in the following section.

[1]Adapted from Hammitt and Cole, 1987.

Impacts

Disturbance to natural areas as a result of recreation use has been termed a resource or ecological impact (Hammitt and Cole, 1987). Within this report, the term impact refers to an objective description of the environmental effects of recreational use. Of concern to land managers are the type, amount, and rate of undesirable change occurring to the resource base as a result of recreational use. Undesirable change to the resource base can mean changes to the soil, vegetation, wildlife, and water resources of a natural area.

Soil

Both physically and chemically, soil forms the basis for all terrestrial life (Hammitt and Cole, 1987; Hinckely, 1983). Soil consists of four major components: minerals, organic matter, dissolved substances, and air that occupies spaces between solids. These components are present in all soils, though abundance and distribution vary greatly. These differences affect soils capacity to support life and its response to recreational uses (Hammitt and Cole, 1987). Soil impacts are particularly important because they can affect and compound other recreational effects on vegetation, water, and indirectly effect wildlife by altering habitat.

Recreational impacts to the soil occur in two ways: disruption of the surface soil, and compaction of the surface and subsurface soil (Hammitt and Cole, 1987; Dregne, 1983).

Disruption of Surface Soil: Disruption of the surface soil can be caused by horse hooves, shoes, spinning tires, or any sort of contact with the ground. Soil disruption can cause reduction or removal of the organic layer, and can destroy surface soil stabilization.

The organic layer of soil cushions the impact of rainfall and other erosional impacts (including recreation) and are important zones of biotic activity and help in the absorption of water. They are also important source of nutrients and are critical to the maintenance of soil fertility (Hammitt and Cole, 1987).

Loss of organic matter makes the soil vulnerable to soil impacts that follow. Reduced rainwater infiltration and nutrient recycling, and increased surface erosion, soil compaction, and profile truncation are all increased when the organic layer is removed. Pulverization and removal of the litter layer reduces the soils ability to capture rainwater, accumulate and replenish soil organisms and nutrients, and cushion the mineral soil against impact forces causing compaction (Hammitt and Cole, 1987).

In desert environments, the organic layer is generally very thin and patchy, and even light recreational use can rapidly eliminate organic matter (Hammitt and Cole, 1987). In forested environments, such as those found in the higher elevation of the Santa Catalina, Rincon, and Santa Rita Mountains, organic matter loss varies with the amount of use and the recreation activity involved. In a forest environment, lightly used trails and campsites may experience little litter loss if the organic layer is thick. In moderately and heavily used trails and campsites, the organic layer is expected to be significantly reduced after several years of use (Hammitt and Cole, 1987).

Rocky hillslopes in eastern Pima County are often mantled by a plant called *Selaginella sp.*, sometimes called Resurrection Plant for the way it becomes green and mossy after rains. Little is known about the functional contributions or susceptibility to disturbance of this layer, but casual observation suggests *Selaginella* may help stabilize soils on steep, rocky slopes.

In undisturbed arid environments, soil between the relatively sparse plant cover, while appearing bare, is often occupied by biological crusts or held together by extensive plant root systems. Soil not protected by vegetation is often covered by a layer of stones, called desert pavement or may be held together by silt-clay or salt crusts. These surface features all serve as soil stabilizers. Disruption of surface soil stabilizers can lead to increased wind and water erosion for a prolonged period of time (Dregne, 1983).

Biological crusts, also known as cyptobiotic, microbiotic, and microphytic crusts, are formed by living organisms and their by-products, creating a crust of soil particles bound together by organic materials. Crusts contribute to a number of environmental functions, including soil stability and erosion, atmospheric nitrogen fixation, nutrient contributions to plants, soil-plant-water relations, infiltration, seedling germination, and plant growth (Herbert, 1999). While biological crusts are well-adapted to growing in harsh environments, they are poorly adapted to compressional disturbances. Recreational activities such as hiking, biking, and off-highway driving can crush the sheaths and filaments of the soil organisms, drastically reducing the crusts effectiveness in providing soil stability. Recovery of biological crusts after recreational disturbances vary. In areas of slight disturbance, rapid recovery has been noted to occur within several months to a few years (Wilshire, 1983). In areas of heavy impact, such as areas used by off-highway vehicles, biological crusts may be permanently destroyed (Wilshire, 1983).

Inorganic crusts, including desert pavement and silt-clay or mechanical crusts, protect the underlying soil by retarding wind and water erosion (Wilshire, 1983). Desert pavement is a thin surface layer of closely packed pebbles or rocks. Mature desert pavements protect the underlying soil from erosion and also reduce runoff, increase water infiltration, and slow evaporation rates (Wilshire, 1983). Disruption of the stones may increase erosion rates by exposing uncrusted soil and can change the role of the cover from protective to erosion enhancing. While notably more durable than organic crusts, desert pavement can be disturbed by repeated recreational use, including off-highway vehicles (OHVs), horseback riding, mountain biking, and hiking.

Silt-clay, or mechanical crusts occur when rainfall breaks down soil aggregates and redistributes the finer particles. Upon drying, a fairly impermeable crust forms (Wilshire, 1983). This crusting reduces water infiltration rates, while increasing water runoff. Studies have shown that moderate OHV use on mechanically crusted soils reduces water infiltration and increased sediment yield from erosion. While recovery rates of mechanical crusts are not known, the recrusting of disturbed surfaces often occurs rapidly, usually after the first rain, although the extent of recovery of the original function of the crust is not known (Wilshire, 1983).

Soil Compaction: Soil compaction is a commonly documented effect of recreational use (Hammitt and Cole, 1987). Soil compaction can be defined as, "the application of forces to a soil mass which results in an increase in density and strength" (Webb, 1983). Compaction is a known contribute to accelerated soil erosion and can cause decreased plant growth (Webb, 1983). Soil compaction

is measured with varying techniques designed to assign values to soil density, penetration resistance, conductivity, and permeability. These factors are important for land managers to determine the degree and significance of compaction due to recreational use.

Soil compaction reduces the spaces in between soil particles. This reduces soil aeration and affects the way water enters and moves through the soil (Hammitt and Cole, 1987). Reduced infiltration causes increased water runoff, which may cause a change in drainage patterns, accelerated erosion, and reduced soil moisture available for plants. Reductions in infiltration rates can also harm soil microorganisms, which plants are dependent on for nutrient cycling and soil fertility.

The degree to which soil compaction occurs depends on the amount of interstitial space between the soil particles. Loamy sands and coarse, gravelly soils are more susceptible to compaction than the dense, fine particles of clay. Most naturally occurring soil types will compact with recreational use, particularly OHV use, but the least affected soil types are sands and clays where the soil particles are the same size (Webb, 1983).

Research has shown that compaction occurs rapidly at low levels of use (Cessford, 1995; Hammitt and Cole, 1987). Compaction impacts are greatest at the early stages of use, and thereafter the negative impacts of additional use slow considerably (Cole, 1982; Hammitt and Cole, 1987). This relationship is different than litter loss, where the negative impact grows significantly greater as use intensifies.

Erosion: Erosion is a natural process that has formed virtually every element of the earth's environment (Hinckely et al, 1983). The concern is accelerated erosion, which can create aesthetic, environmental, and economic problems due to erosion of thin topsoils, sedimentation of streams, and gullying of landscapes. Because erosion is the most permanent of soil impacts, it is the most serious. Erosion removes soil layers, resulting in the loss of soil and nutrients necessary to support plant life. Erosion can be accelerated by disturbance of the surface soil and by soil compaction. Destablilization of the soil, by the removal of surface stabilizers such as vegetation and their roots, stone layers or soil crusts, allows water, the most erosive agent, to carry the soil away. Soil compaction contributes to erosion by preventing water from entering the soil, causing runoff. Sediment runoff carried by water can bury downslope vegetation (Wilshire, 1983) and can contribute to siltation and pollution of lakes, streams, and rivers. While the effects of trampling such as litter loss and soil compaction can be lessened over time with non-use, erosion usually continues once initiated (Hammitt and Cole, 1987).

Recreational use is seldom the cause of erosion: the main forces of erosion are wind and water. Recreational activities create the circumstances for erosion and its increased rate (Hammitt and Cole, 1987). Erosion on a recreational site or trail is determined by many factors such as slope, drainage, and climate. Erosion can be most serious on steep slopes, where water is channelized, and in climates such as in the Sonoran Desert, where rainfall is infrequent but intense (Hinckely et al, 1983).

Erosion is most likely to affect trails, due to their heavy use, although campsites, overlooks, and launching or boarding areas can also experience sheet erosion. In campsites, erosion leads to

bare soil, exposure of tree roots, campsite enlargement, and proliferation of more campsites (Giongo and Bosco-Nizeye, 2001). Because picnicking and camping concentrate use, soil impacts are severe, though erosion is usually minimized due to the general flatness of these areas. Soil impacts from recreational use vary with soil type, site factors, and recreational activity.

Mitigation of Soil Impacts

General mitigation for soil impacts include the following: (Johnson and Carothers, 1982).

1) initial positioning of campsites, use zones, trails in areas where soil profiles can withstand recreational use;

2) rest/rotation of use areas and identification of sensitive areas;

3) physical aeration and fertilization of impacted areas;

4) establishing threshold levels, or limits on use levels.

Vegetation

Recreational use can impact vegetation in the following ways: vegetation cover; species composition; and vegetative condition (Giongo and Bosco-Nizeye, 2001). Vegetational changes resulting from recreational use are usually in the form of 1) direct physical or mechanical injury or 2) indirect impact--physiological responses to alterations due to soil changes (Johnson and Carothers, 1982). As with soil compaction, research indicates that most vegetation impacts result from initial, light use, while continual or increased recreational use inflicts little additional damage (Johnson and Carothers). Because vegetation can be damaged due to recreational trampling, it is often highly altered on recreational sites (Hammitt and Cole, 1987).

In general, the response of plants to recreational use is a function of: 1) the type of soil compacted; 2) the severity of compaction; 3) the timing of compaction relative to soil moisture (wet soil will compact more than dry soil); 4) the amount and pattern of precipitation falling after the soil compaction has occurred; 5) the chemical and physical properties of the soil; 6) the species of plant; 7) the diversity of the soil substrate; and 8) the way plant response is measured by the researcher (Lathrop and Rowlands, 1983). In the lower elevation desert, vegetation recruitment for some species, such as ironwood and saguaro, is very sporadic and individual plants are long-lived.

Direct Impacts: On most recreation sites, vegetation has shown reduced height, abundance, vigor, and reproductive capacity (Hammitt and Cole, 1987). Plant death can occur with heavy trampling or when fragile plants are trod upon. Death will also occur if plants are ripped out of the ground, or regenerative tissues are destroyed. Less severe trampling can cause limb breakage, and can crush foliage, roots, and seedlings (Lathrop and Rowlands in Webb, 1983). Trees at campsites can experience limb removal, nails driven into trunks, lantern burns, peeling bark for kindling use, rope burns on the trunk and exposed roots from the tying of stock animals, and acts of vandalism such as hacking trees with axes (Hammitt and Cole, 1987).

Vegetation experiences the most direct impact during the construction and maintenance of wildland recreation areas, including trails, campsites, picnic areas, trail heads, and parking areas. Removal of shrubs and tree stems occurs along trails to make trails user friendly (Hammitt and Cole, 1987). In campsites, loss of trees and shrubs may be even more pronounced, due to the initial site development, continual site expansion, and the collection and felling of woody stems for firewood.

Indirect Impacts: Indirect impacts to vegetation resulting from recreational use are primarily the result of soil impacts. Studies have shown that plants growing in compacted soil have fewer roots that extend only a short distance from the plant (Hammitt and Cole, 1987). Compaction makes it difficult for the roots to grow into areas where nutrients and water can be extracted. Additionally, compaction affects the amount of oxygen available to roots; oxygen depletion contributes to inhibited root growth. In arid environments, because moisture and nutrients are usually scarce, these indirect effects can cause more severe problems (Hammitt and Cole, 1987).

Compaction also affects seed germination, emergence, and establishment of new plants. Seeds lying on a compacted soil, without the temperature modifying conditions of organic litter and other vegetation, will not receive sufficient moisture or incubation, and will not germinate. Seedlings that germinate in compacted soil face the effects stated in the above paragraph.

Erosion also affects vegetation by exposing roots and dispersing nutrient elements, not only reducing nutrients available to existing plants, but reducing the number of sites favorable to plant growth (Lathrop and Rowlands, 1983). On steep slopes, particularly where erosion has been caused by off-highway vehicles, roots can be exposed to the point where the plant will topple over and become uprooted. On the bottom of slopes suffering erosion, plants can be covered over with the deposits (Hinckely et al, 1983).

Recreational sites often experience changes in species composition and richness. As native plants decline due to changes in soil conditions, more resistant species have opportunity to invade and spread. Often, these more resistant plants are non-native species (Hammitt and Cole, 1987). At high use sites, only trample-resistant plants are able to survive. Generally, the number of trample-resistant plants is always less than the original occupants of the site (Hammitt and Cole, 1987).

Mitigation of Vegetation Impacts

Under proper conditions, minimizing impact on vegetation is possible. Vegetational changes resulting from recreational use will vary with the vegetation type due to the vulnerability of habitats and species assemblages to alteration (Johnson and Carothers, 1982). Land managers are encouraged to determine the effects of various use configuration on different vegetation types, and to concentrate recreational use in areas where the least amount of impact will occur. With planning, localized impacts can be more effectively managed through proper design and location of facilities, rather than by restrictions and regulations (Johnson and Carothers, 1982).

Wildlife

There are four primary ways in which wildlife may be affected by recreation: illegal activites, disturbance, behavior, and habitat modification. Different species of wildlife have different tolerance levels to humans and human activities. Even at the species level, tolerances vary due to time of the year, season, animal age, habitat type, and individual response and experience with recreationalists (Giongo and Bosco-Nizeye, 2001). In general, the effect of recreational activities in an area on wildlife is the decline in species diversity and a change in species composition and structure (Hammitt and Cole, 1987).

Illegal Activities: Modern wildlife management implements practices such that the legal removal of wildlife and fish through permitted hunting and fishing activities does not adversely affect the long-term health and viability of fish and wildlife populations. Illegal collection of wildlife, or poaching, can, and does in a number of instances, represent a significant threat to fish and wildlife populations. For example, illegal collection is one of the primary reasons behind the decline of many desert reptile species (Ruther, personal comm., 2001).

Although prohibited by law, the transport of exotic, non-native species through bait-bucket transfers from one aquatic site to another is very problematic. This often inadvertent recreation-related activity has greatly contributed to the spread of exotic species that have proven to have decimating effects on native aquatic species.

Animal Disturbance and Harassment: Harassment refers to, "events which cause excitement and/or stress, disturbance of essential activities, severe exertion, displacement, and sometimes death" (Ream in Hammitt and Cole, 1987). Intentional harassment, such as the chasing of deer with OHVs does occur, although the majority of the impact is caused unintentionally and innocently by recreationalists. Unintentional disturbance can take many forms, including mountain biking, hiking, bird watching, and wildlife photography (Miller, 1998). Just the very presence of people has been shown to be sufficient in causing disturbance to certain sensitive species, such as certain nesting raptors or bighorn sheep (Hammitt and Cole, 1987).

Disturbances to wildlife can affect the behavioral responses of wildlife. Wildlife may abandon preferred nesting or feeding areas for less suitable, undisturbed sites (Miller, 1998). Animals in which the sudden flight reaction is incurred due to human disturbance can experience increased heart rates, energy expenditure, and stress, which may produce changes in the productivity of individuals (Hammitt and Cole, 1987 and Miller, 1998). The fleeing response could also result in disruption of territories, a decreased ability to feed young and defend the nest, and an increase in the vulnerability of the adult to predation (Weinstein, 1978).

Behavior Modification: There is evidence that some species will alter their behavior during hunting seasons. Many species are known to avoid areas with significant human recreational activities during hunting season (Hammitt and Cole, 1987). Hunting activities can also frequently involve other recreational activities (eg., camping, use of off-highway and all-terrain vehicles, hiking) that can affect the condition of natural and cultural resources.

Habitat Modification: Wildlife can be impacted indirectly by altering or destroying species' habitats (Giongo and Bosco-Nizeye, 2001). Soil organisms have been shown to markedly decrease in compacted soil (Hammitt and Cole, 1987). Tunnels and burrows of certain species are collapsed by OHVs, particularly in the desert. The collapse of burrows can cause physical damage or death to the animals inhabiting them, as well as eliminating their means of escape from the desert temperatures. An OHV impact study in California documented loss of the desert tortoise, and a reduction in the density and diversity of small mammals and lizard populations (Hammitt and Cole, 1987). Individuals searching for reptiles can break apart rock outcrops, destroying valuable shade and habitat for certain species.

Mitigation of Wildlife Impacts

Recreational impacts to wildlife can be managed by protecting key areas from roads and trails, by locating campsites in appropriate areas, and by seasonally closing critical breeding habitats (Hammitt and Cole, 1987). Recreation activities can be concentrated in areas where minimal impact will take place. User education programs and/or signage can discourage activities that directly influence behavioral patterns of various species, such as feeding animals, leaving garbage, and direct nest disturbance (Johnson and Carothers, 1982).

Water

The severity and causes of recreation related water pollution problems are not yet well understood (Giongo and Bosco-Nizeye, 2001). Wading, bathing, and erosion can increase the load of suspended material solids, greatly reducing the clarity of water and the public's desire to use it. (Hammitt and Cole, 1987). Water sources are rare in the desert, with surrounding vegetation offering cooler temperatures and much needed shade for many plant and animal species. Hikers, backpackers, stock animals, and OHV users often seek the cooler temperatures water and associated riparian zones offer. In doing so, recreationalists can flush wildlife and trample fragile vegetation. In some cases, using rainwater collected from tinajas (rock depressions) may reduce water normally available for wildlife.

Erosion caused by OHV use can increase sedimentation load in streams and other water bodies. Stream crossings by OHV can cause the stream to change course or downstream flow may be altered due to stream pooling in the ruts caused by vehicle tires.

Mitigation of Water Impacts

It is illegal to camp within a quarter-mile of a natural or man-made water hole such that wildlife or domestic stock will be denied access to the only reasonably available water (A.R.S. 17-308). Although the intent here is to maintain accessibility to water for wildlife and livestock, it does provide for protection of water/aquatic sites. To prevent stream bank erosion and defecation directly into water sources, pack animals should be carefully monitored and water should be brought to them away from the actual source (NOLS, 1996).

Cultural Resources

Recreationalists can damage cultural resources in several ways. Cultural sites can be destroyed from damage inflicted by vehicles. Distant sites once isolated from other recreationalists are easily accessible by OHV users, who can cover 20 times more land per day than less mobile recreationalists (Kockelman, 1983). Recreationalists can pick up and take with them artifacts such as arrowheads and pot shards, without realizing the significance of the artifacts. Foot traffic through a site can cause erosion which may undermine the walls of structure above and destroy archeological records preserved in middens-or ancient trash mounds. Direct contact with rock art causes the ancient figures to begin disintegrating.

Protecting Cultural Resources

Archeological sites are protected from damage and theft by the Antiquities Protection Act of 1906, and the Archeological Resources Protection Act of 1979. The ruins, pot shards, arrowheads, and rock art have survived hundreds or even thousands of years, and need special care and attention to preserve within the context of the landscape they have been part of for so long (NOLS, 1996). Recreationalists should view sites from a distance, leave all artifacts in place, and enjoy rock art by viewing, sketching, and photographing it. Visitors to cultural sites should stay on trails.

Social Impacts

Impacts on Local Residents: Many recreational activities that can be pursued in locally protected areas demand equipment costs that support local businesses, providing new jobs and tax revenue (Smith, 1991). The outdoor recreation industry is worth an estimated $132 billion annually to the United States economy (Outdoor Recreation Coalition, 1993). The economic value is based on direct components, money spent on equipment, clothing, footwear, and user fees, and on indirect components, such as money spent on food, transportation, lodging, and miscellaneous items.

While recreation can greatly benefit local businesses and parks, conflicts can occur between recreationalists and land owners. Whether intentionally or unintentionally, recreationalists can trespass onto private property, leave open gates on ranches, increase traffic on private roads, and at times cause destruction of property. Landowners who become sufficiently displeased with recreationalists may withdrawal easements or deny access to trail heads or trail crossings that pass through their property.

Visitor Experience: Visitor experience is often shaped by other visitors and their actions, rather than the natural environment (Giongo and Bosco-Nizeye, 2001). Factors that can affect visitor experience include the desire for solitude, the possibility of visitor conflicts, and the different perception of other visitors' behavior.

> *Crowding*–Crowding can negatively affect visitor experience. Levels of perceived crowding vary with factors such as number of encounters, expectations, motivations, size of group, perceived environmental disturbance, and type of encounter (Moore, 1994).

Conflict–Conflict can occur among different types of recreationalists, especially in multiple use areas, or between recreationalists and non-recreation users (Giongo and Bosco-Nizeye, 2001). The level and degree of conflict felt depends on individual interpretations and predispositions. Activity style, resource specificity, mode of experience, and tolerance for lifestyle diversity have been cited as factors that will produce or determine individual's level of conflict (Moore, 1994).

Patterns of Impact

Recreation impacts often exhibit predictable patterns over time. In general, impact occurs rapidly, with the rate of deterioration slowing over time. Different impacts tend to have varying rates of change: in forested areas, soil compaction will occur more rapidly than loss of organic layers, while in desert environments, loss of the organic layer tends to occur more quickly than compaction (Hammitt and Cole, 1987). During the first several years of site use, vegetation and soil impacts will increase rapidly and thereafter will increase more slowly. Other impacts such as site expansion and certain trail deterioration such as erosion and trail widening, will continue to increase in time. Most impacts are restricted to a small number of travel routes and destination areas (Hammitt and Cole, 1987).

Deterioration of trails can take several forms:

- Gully erosion, which increases the trail depth and width;
- Development of muddy stretches leading to a widening of the trail around the muddy areas;
- development of unplanned, or 'wildcat' trails

The type and amount of use are the principal causes of trail deterioration, although location, design, and maintenance of the trail are also important factors. Trail impacts can be minimized or eliminated with proper trail location and management.

Recreational Activities

The diverse terrain and mild weather of Pima County, coupled with over one million acres of public land and a large and growing urban center, have made recreation very popular. The recreation opportunities are diverse, ranging from hiking to caving to nature watching to skiing. Each activity has impacts associated with it. While at one time, passive activities such as hiking and nature observation were considered non-consumptive, current research has shown that all outdoor recreational activities have associated impacts (Wilkes in Hammitt and Cole, 1987; Widner and Marion, 1994).

Hiking

Hiking is a common mode of travel and its impacts are widespread, although impacts on soil, vegetation, and water are much less severe than for other types of recreationalists (Hammitt and Cole, 1987). Hikers may be considered more of a threat to wildlife because they are more unpredictable and more likely to approach animals than most other types of recreationalists.

Birdwatching/Nature Photography

Birdwatching, nature study, and wildlife photography are generally thought to be non-consumptive activities, but their recent surge in popularity has provoked evaluation of their impacts. These activities often bring humans into close contact with species during sensitive times of nesting, mating, or other unique behavioral activities. Nature study and photography may be of special concern because they tend to repeatedly disturb rare and unusual species (Marzluff, 1997). Repeated intrusions may reduce the productivity of individuals and influence community composition.

Equestrian Use

The major impacts to trails from horse use are soil impacts, resulting in erosion problems and the formation of muddy quagmires (Marion and Widner, 1994). The weight of a horse hoove can exert as much as 1,500 lbs of pressure per square inch (Hendee et al. in Widner and Marion, 1994). Horse traffic tends to compact the sub-surface soil layers, while churning up the soil surface. In a study comparing the erosional effects of hikers, equestrians, mountain bikes, and motorcycles, the sediment yield from horse trails was far greater than any other use (Widner and Marion, 1994). Muddy quagmires are formed from the same process that lead to erosion. Subsoil compaction prevents water infiltration, which forms mud with the loosened soil. This forms an impermeable basin that can retain mud and water for an extended period of time. The impermeable, muddy basin contributes to trail widening, as other users skirt the edges of the muddy areas. Equestrian impacts on trails can be minimized by proper trail design and campsite location (Widner and Marion, 1994).

Manure on trails is an ecological and social problem. Manure often contains the seeds of non-native species, which may contribute to the spread of exotic plants further into non-urban areas. Excessive amounts of manure may threaten water quality (Widner and Marion, 1994), particularly in small spring systems. Other trail users may find the presence of manure undesirable.

Camping

Campsites receive the most impacts due to concentrated use in a limited area. Campsites that have been used before and have already been cleared of brush and rocks are likely to be used over and over again. Typical campers spend over three-quarters of their camping time close to the table, tent pad, and fire grill (Hammitt and Cole, 1987). These areas will most likely be bare of vegetation with severely compacted soil. The surrounding area will be used less frequently and will have less sever impacts. In this area, vegetation loss and soil compaction occurs, but these impacts are only noticeable on informal trail systems that occur. It is into this area that the campsite expansion will occur. Site expansion tends to occur where sites are used by large parties or where conditions are unfavorable (muddy). Site expansion can be minimized by the placement of boulders, logs, or the planting of native vegetation at the edges of campsites. In pristine campsites, it is recommended to camp on surfaces such as rock, sand, or gravel. Stay should be limited to no more than two nights. After use, all traces of human activity should be minimized.

Caving

Caves generally do not recover from human impact, so most impacts are permanent (Tuohy, 1998). Impacts are cumulative, and with growing numbers of people seeking understanding and adventure in caves, damage can be devastating to a cave system. Caves contain fragile, natural diversity that is changed each time it is visited. Human impacts include disturbing cave inhabitants, damaging cave features, removing natural features, historic, archaeological and paleontological artifacts from the cave, and polluting the cave environment. Land managers and caving organizations can work together to significantly reduce recreation impacts to caves. For more information, refer to the caving volume of the Leave No Trace Skills and Ethic Series (Tuohy, 1998).

Rock Climbing

Rock climbing can cause vegetation and soil impacts caused by trampling at the base and summit of the climb. Trash and litter are often left behind (Fincher, 2000). On the rock face, rock can be damage by drilling or chipping for holds or anchors. On extensively used climbs, trash and litter can be found stuffed into crevices (Fincher, 2000). The presence of climbers may threatened sensitive species such as the peregrine falcon, which depend on cliff faces for nesting (Asussen et al, 2001). The presence of climbers and their gear, such as paint, chalk, slings, and chains, can have a negative impact on other recreationalists (Leave No Trace, 1996). Climbing impacts can be reduced by following proper climbing guidelines and etiquette, as well as following local management policies.

Mountain Biking

Mountain biking is a sport that is growing in popularity across the country. The trail impacts of mountain biking are similar to the impacts caused by hiking and equestrian use; all three contribute to loss of vegetation and soil compaction. The distinction between mountain bikes and other non-motorized trail activities lies in the unique effects of wheels on surfaces (Cessford, 1995). Bikes tend to create a linear track, which promotes channeling of water and leads to trail erosion. The greatest potential for environmental impact to the trail is downhill travel, where poor braking skills can result in skidding, which loosens track surfaces and moves material downhill (Cessford, 1995). Wheel impacts are most extensive on wet soil.

Mountain biking is also considered a social impact. Other trail users may disapprove of mountain biking due to safety hazards of fast and silent mountain bikes, and the perception that mountain biking causes greater environmental damage and is inappropriate on multi-use trails (Cessford, 1995). Cyclists following proper trail etiquette will considerably reduce safety hazards. Research has been inconclusive in establishing that mountain bike impacts are greater than impacts from other users (Cessford, 1995). As with other trail uses, impacts can be minimized with proper trail design, maintenance, and management.

Off-Highway Vehicles

The impacts of off-highway vehicle (OHV) use has been studied since the 1960's (Kockelman, 1983). Off-highway vehicles are designed to drive across the natural landscape without the assistance of trails. The effects of OHVs have been well studied and documented. A primary consequence of OHV use is the effect on physical and biological resources, including soil, water, plants, wildlife, solitude, and air (Kockelman, 1983). Other resources affected are archeological and paleological sites, and historic features. Damage to every type of ecosystem in the United States, from beaches to mountains, to deserts, has been documented (Kockelman, 1983).

In desert environments where soils are shallow, the cover of ephemeral vegetation provides no protection against OHVs. A single pass by an OHV can strip vegetation cover and expose soil (Kockelman, 1983). OHV activity almost always results in increased erosion (Hinckely et al, 1983). Observations by the U.S. Bureau of Land Management (1975) and other studies indicate that a single pass of an OHV can destroy all annual flora in the track and substantially impact perennial shrubs (Kockelman, 1983).

Certain sensitive species may be severely impacted by OHV use (Bury and Luckenbach, 1983). Many desert creatures bury themselves during the day. These animals are easily crushed by the passing of an OHV (Kockelman, 1983). In heavily used OHV areas, habitat loss is complete, with greatly compacted soils with no vegetative cover. Local ecosystems can be destroyed.

OHV damage in arid environments may last hundreds or even thousands of years (Kockelman, 1983). Natural recovery is extremely slow (Dregne, 1983). Loss of soil and changes in land surface will rarely, if ever, completely recover from intensive OHV use (Kockelman, 1983).

OHVs can be noisy, create fumes, produce large quantities of dust, and can be dangerous to other slow-moving recreationalists. Hikers and other trail users often consider OHV use as incompatible with a high quality outdoor experience (Kockelman, 1983). Areas selected for and managed for OHV use cause the fewest user conflicts.

OHV users who remain on paved roads or paved facilities or confine their activities to 'sacrifice' areas designed for off-highway vehicle use will cause no additional damage.

Commercial Enterprise

Throughout the county are several commercial enterprises which are intended for visitor recreation. These include Arizona Sonora Desert Museum and Old Tucson, Mt. Lemmon Ski Valley, Tanque Verde Guest Ranch, various archery and rifle ranges, and other areas leased to private enterprises. Besides the obvious impacts of development of the facilities associated with these enterprises, the developments cause increases in traffic, human presence, and associated noise.

Conclusion

Recreational use can and will alter elements of the natural environment. Factors such as environment, slope, and soil features influence the type and magnitude of the impacts. In most

natural environments, very little use causes substantial damage in the form of soil compaction and vegetation disturbance (Hammitt and Cole, 1987). Most impacts display predictable patterns that vary with use, environmental resistance, and the type and mode of use (Hammitt and Cole, 1987). Therefore, land managers can control impacts by manipulating the factors that influence impact patterns, such as trail widening and erosion (Hammitt and Cole, 1987).

Management practices applicable to recreation programs of federal, state, and local agencies of government include: meeting user needs; making land-use and resource inventories; selecting recreation sites; designating recreation areas for various users; designing and constructing facilities; managing facilities; and monitoring, closing, and reclaiming overused areas (Kockelman, 1983). Ideal management programs depend on accurate and adequate scientific information and well designed monitoring programs that can be used evaluate the severity of recreation impacts.

Recreation Opportunity Mandates

Most federal agencies have mandates requiring them to provide recreational opportunities for the public. Several examples are provided in the below section.

Pima County

Pima County Natural Resources, Parks and Recreation Department manages mountain parks, a natural preserve, and several other properties for the purpose of resource conservation. Tucson Mountain Park and Colossal Cave Mountain Park, both contain commercial enterprises and experience heavy recreational use. Other areas such as Bingham Cienega and Cienega Creek Natural Preserves have limited allowed recreational uses.

Currently, the Natural Resources, Parks and Recreation Department performs some trail maintenance within resource parks to minimize recreational impacts. Wildcat trails are covered, vegetation replanted, and "no access" signage installed. Rangers regularly patrol the parks and provide education and enforcement of all park rules and regulations. The department needs additional funding in order to enhance a trail monitoring and maintenance program.

Bingham Cienega and Cienega Creek Natural Preserves have sensitive riparian habitats and perennial water flows. Bingham Cienega is not open for recreational use, but can be accessed by appointment (Pima County, 2000). Cienega Creek access is limited to 50 people per day, with equestrian and mountain biking limited to trails outside of the creek corridor. OHVs are not allowed in the preserve, although occasionally ATVs will enter the preserve through breached fences or through unlocked gates along utility corridors.

The Pima County Flood Control District owns property along the major flood-prone washes in the Tucson Basin. Much of this land is unmanaged, and equestrian and OHV use is prevalent on several of these properties, including the Tanque Verde, Canada del Oro, and Bear Canyon areas (J. Fonseca, pers.comm., 2001).

U.S. Bureau of Land Management

The U.S. Bureau of Land Management (BLM) was established in 1946. At that time, there were more than 2,000 laws concerning the management of public lands. There was no unified legislation guiding the BLM until Congress enacted the Federal Land Policy and Management Act of 1976. This Act recognized the value of public lands and declared that the lands would generally remain in public ownership. Congress also directed the BLM to manage for multiple-use, defined as "management of the public lands and their various resource values so that they are utilized in the combination that will best meet the present and future needs of the American people" (Congress, 1976). Currently, the BLM manages almost 270 million acres of public land and almost 700 million acres of subsurface mineral estate (BLM, 2000). The BLM is responsible for public land management for a wide variety of resources, including energy and minerals, fish and wildlife habitat, timber, forage, wilderness areas, cultural and historical sites, and recreation sites.

Throughout the west, BLM administers almost 117,000 miles of fishable streams, 2.9 million acres of lakes and reservoirs, more than 6,400 miles of floatable rivers, over 500 boating access points, over 60 National Back Country Byways, and more that 300 Watchable Wildlife sites. Additionally, the BLM manages over 4,500 miles of National Scenic, Historic, and Recreational Trails, in addition to thousands of miles of multiple use trails that are open for equestrians, off-highways vehicles, mountain bikes, and motorcyclists (BLM, 2000). Nearly two-thirds of the BLM lands are within an hour's drive of an urban area, and that, combined with the public's increased appreciation for open space, has resulted in a number of recreational activities and overuse that could cause long-term environmental damages. The BLM's 1999 Performance Plan and the 2000-2005 Strategic Plan both assess recreation goals on BLM lands.

In addition to national policies on recreation, regional and local BLM offices manage recreation through administratively designated Special Recreation Management Areas (SRMAs). SRMAs are areas that require a recreation investment, where more intensive recreation management is needed, and where recreation is a principal management objective. SRMAs are usually described in the regional Resource Management Plans.

BLM Lands in Pima County

The BLM lands in Pima County offer a variety of outdoor recreational activities, including hunting, camping, hiking, off-highway vehicle trails, mountain biking, birding, and visiting natural and cultural resources. Within the county, the BLM administers several nationally designated areas, the Ironwood National Monument, the Las Cienegas National Conservation Area, and two wilderness areas-the Coyote and Baboquivari Mountain Wilderness.

U.S. Bureau of Reclamation

Established in 1902, the U.S. Bureau of Reclamation (BOR) is currently the second largest wholesaler of water in the country, bringing water to over 31 million people. The BOR has several authorities directing its overall responsibilities for managing recreation. In addition to the legislative authorities listed below, the BOR has site-specific project authorities for recreation as well.

The Federal Water Project Recreation Act of 1965: This Act states that Federal agencies must consider the potential outdoor recreational opportunities and potential fish and wildlife enhancement when planning for water resource projects, including flood control, hydroelectric, or reclamation projects. The Act recognizes recreation as a purpose for developing water.

The Reclamation Recreation Act of 1992: The Act amends the Federal Water Project Recreation Act of 1965 and recognizes the Federal responsibility to provide opportunities for public recreation at Federal water projects. Additionally, the Act expands BOR authority to cost share with non-Federal public entities for operation and management of recreation facilities.

Recreation Manual: The Recreation Manual defines the BOR's overall responsibilities and establishes the basic principles for planning, development, management, and protection of public recreation resources on BOR lands and waters. Several important principles include:

- Fulfill BOR's stewardship responsibilities by providing appropriate recreation opportunities, facilities, and services on BOR land and water.
- Conduct studies, research, assessments, and public involvement processes to provide recreation opportunities.
- Ensure that recreation facilities, services, and activities are compatible with other project operations, proposes, and benefits.

The Bureau of Reclamation has one reserve, the Tucson Mitigation Corridor, within Pima County. The corridor is managed by the Pima County Natural Resources, Parks, and Recreation Department as part of Tucson Mountain Park. The corridor experiences very little recreational pressure.

U.S. Forest Service

The U.S. Forest Service (USFS) was established by Congress in 1905 for the purpose of providing quality water and timber for the nation's benefit. In 1960, the Multiple-Use Sustained Yield Act was passed, expanding the purpose of national forests. With direction from this act and the mission of "caring for the land and serving people," the USFS manages the national forests and grasslands for outdoor recreation, range, timber, watershed, and wildlife and fish purposes.

The national forests offer a diverse array of outdoor opportunities, providing natural scenic beauty, spiritual renewal, important natural resources, protection of rare and endangered species, and vast wilderness areas. Recreation is the fastest growing use on the national forests and grasslands, with recreation generating an estimated $110.7 billion on USFS lands (USFS, 2000). Timber harvests on the national forests amounts to $3.5 billion (Holguin, 1998). During the next 50 years, recreation demand is expected to increase from 800 million visitors a year to 1.2 billion visitors to the national forest (Holguin, 1998).

The Forest Service has set a primary goal to protect and restore the settings for outdoor recreation. The USFS Recreation Agenda addresses this goal as a component of the Forest Service's Natural Resources Agenda.

The recreation agenda attempts to meet the demands of the deteriorating infrastructure and recreation customers with the highest quality experiences and within ecological and social limits. Limits include impacts on the resource, impacts on experiences of other visitors and limits of the recreation infrastructure. The goal of the agenda is to find innovative and long-term strategies to these challenges.

To better understand the needs of visitors and the impacts of increased visitation to the national forests, the USFS is involved in several areas of research, including outdoor recreation research. The USFS recreation research mission is to apply research theory and methodology to assessments of outdoor recreation and wilderness, with emphasis on supply and demand trends, economic values, and benefits to rural communities. Another component of recreation research is the National Recreation Survey. The survey will be used to estimate the total number of national forest visits. The survey process will be developed and applied in a consistent matter across individual national forests. The results are intended be statistically credible and is necessary for reasons such as forest planning and budget allocation.

In addition to USFS nation-wide policies on recreation, individual national forests administer recreation activities and impacts varying degrees through management plans. Pima County has national forest unit: the Coronado National Forest.

Coronado National Forest

The Coronado National Forest Plan was approved in 1986 and was intended to define management direction for 10 to 15 years. The Forest Service anticipates issuing a Notice of Intent to prepare an EIS and Plan in fiscal year 2002 (10/1/2001-9/30/2002). Several recreation issues were brought forth in the 1986 Plan (USFS, 1986):

- Identification of potential overuse areas and establishment of carrying capacities (number of people who can use an area without damage to natural resources).
- Regulation of off-highway vehicle use to protect other Forest resources and uses, while continuing ton provide this much demanded recreation opportunity.
- Use of land for recreational development and dispersed uses, and establishment of equitable fees for recreational use.
- The role of the private sector in providing recreation services on and adjacent to the National Forest mush be reassessed.
- Inventory and management planning for the Coronado's many caves and location of this resource to recreational, scientific, and wilderness uses.

- Visual resource integrity in all land management decisions.

Recreation goals identified in the 1986 Plan include:

- Maintain the current spectrum of recreation opportunities and increase those opportunities within the capability of the resources.
- Establish a dialogue with the public to insure informed participation in management decisions and to increase public awareness of their obligation to the forest resources and their responsibility in caring for it.
- Work with other government agencies and private sector to secure public access to recreational resources and to develop a full spectrum of recreation opportunities.
- Work with the regional office and research in development of process to establish recreation capacities.
- Protect significant cultural resources from damage by project activities or vandalism.
- Preserve and protect cave for their unique environmental, biological, geological, hydrological, archaeological, paleontological, cultural and recreational values.
- Manage caves in partnership with caving organizations, scientists, and outdoor recreationists.
- Coordinate the management of cave and surface resources as a recreational opportunity. Primary emphasis is on dispersed recreation activities compatible with responsible cave management.

The Coronado Forest has over 10 million visitors a year (Roth, 2000). With this many visitors, Forest Service staff have a difficult time keeping up with recreation impacts and mitigation actions. Several actions have been taken to prevent impacts from affecting natural resources (Roth, 2000). Rock climbing areas are closed during peregrine falcon breeding seasons and several dirt roads crossing important riparian areas are planned to be relocated within the next two years. OHV use is concentrated in two areas-the Redington Pass area and Charouleau Gap on the west side of the Santa Catalina Mountains.

The U.S. National Park Service

The National Park Service (NPS) was created in 1916 under the founding legislation created in the Organic Act of 1916. This legislation established the mission and direction of the NPS:

> "The service thus established shall promote and regulate the use of the Federal areas known as national parks, monuments, and reservations hereinafter specified by such means and measures as conform to the fundamental purposes of the said parks,

monuments, and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."

Since the time of its creation in 1916, the National Park System has expanded to include historical parks, scenic riverways, recreation areas, and a variety of other designations. Each national park system unit is directed by the legislation, executive order, or administrative action that created the unit. In addition to unit specific management, the operation and administration of the park service unites are influenced by the overall guidance provided by the Organic Act. Various amendments to the original Organic Act have tied each individual national park unit legislation to the overall directives of the Organic Act. The National Park Service has several legislative mandates and authorities that provide for and guide recreational use on a broad, nation-wide level (National Park Service, 1999).

Outdoor Recreation Act of 1963: This act promotes the coordination and development of effective programs relating to outdoor recreation. The Department of Interior is authorized to coordinate federal agencies for programs affecting the conservation and development of recreation resources. The Secretary of Interior is directed to inventory recreational needs, classify recreation resources, formulate and maintain a comprehensive outdoor recreation plan, and provide technical assistance to states, local governments and private interests to promote the conservation and utilization of recreation resources.

Land and Water Conservation Fund Act of 1965: This act establishes a fund, administered by the National Park Service, to assist the states and federal agencies in meeting present and future outdoor recreation demands and needs. The act provides funds for and authorizes federal assistance to the states in planning, acquisition, and development of needed land and water areas and provides funds for the federal acquisition and development of ceratin lands and other areas. Three main sources supply the funds: sales of federal surplus real properties, a part of federal motorboat fuel taxes, and Outer Continental Shelf revenues from leasing of oil and gas sites in coastal waters. A site that has been acquired or developed with this grant money cannot be converted into non-recreational use except where approved by the National Park Service and replaced with lands of equal market and recreational value.

National Trails System Act (1968): The National Trails System Act establishes a system of recreational, scenic, and historical trails. The act also prescribes the methods and standards for adding components to the system.

Wild and Scenic River Act of 1968: This act establishes a system to ensure the protection of each river's unique environment. It also preserves certain selected rivers that exhibit outstanding scenic, recreational, geological, cultural, or historic values and maintains their free-flowing condition.

Wilderness Act of 1964: This act recognizes the pristine, undeveloped condition of qualified public land, and statutorily assures they are maintained in the condition. In this act, Wilderness is defined by the lack of noticeable human modification or presence; a place where the landscape is affected primarily by natural forces and where humans are

visitors who do not remain. Federal officials are required to manage Wilderness Areas in a manner conducive to retention of their wilderness character and must consider the effect upon wilderness attributes for management activities on adjacent lands.

Pima County has two National Park Service units: the Organ Pipe Cactus National Monument and Saguaro National Park.

Organ Pipe Cactus National Monument

The Organ Pipe Cactus National Monument (OPCNM) was established by Presidential proclamation in 1937 to preserve almost 330,000 acres of Sonoran Desert for public interest. Recreation activities pursued in OPCNM consists of camping, hiking, nature photography and interpretation, and scenic driving routes (NPS, 1997).

The biggest human caused impacts are due to the effects of undocumented aliens and drug runners crossing the park (Frank, personal comm., 2000). New trails are created, trees used for firewood, new campsites created, and large piles of trash are left behind.

Recreation impacts are usually limited to campground sites and are not extensive (Frank, personal comm., 2000). All trails have been signed, inventoried, and are in a GIS system. OPCNM receives approximately 200,000 visitors yearly.

Saguaro National Park

The Saguaro National Park was established as a national monument on March 1, 1933 by Presidential proclamation to preserve and protect the exceptional growth of various cacti species, including the saguaro. Total acreage within the park is over 91,000 acres. Recreation activities pursued at Saguaro National Park include scenic driving, visiting the information center, hiking, flora and fauna observation, and simply enjoying the desert (NPS, 1995).

Recreation objectives stated in the Saguaro National Park 1995 Statement for Management include providing opportunities for recreational use of the park consistent with the obligation to protect and perpetuate natural and cultural resources. To achieve this, management will:

- be responsive to changing recreational pursuits and interests generated by adjacent urban development;
- manage visitor use to avoid conflicts between users;
- manage visitor use so that resource protection and high quality experiences are the principal criteria that guide each activity.

Obvious recreation impacts in the park are usually due to unintentional or unauthorized use (Weisner, personal comm., 2000). Trails have been inventoried, signed, and are in a GIS system. The park receives over 2.5 million visitors per year. The most significant recreation concern by park staff is the fear of visitors "loving the park to death "(Weisner, pers comm, 2000). To prevent this, visitors are educated through interpretive signs, stating rules, safety, and backcountry ethics.

U.S. Fish and Wildlife Service

The management of the individual refuge system units of U.S. Fish and Wildlife Service (FWS) is directed by the legislation, executive order, or administrative action that created the unit (USFWS, 1999). In addition to specific executive orders and administrative actions that may range from narrow to broad, the operation and management of the national wildlife refuges are influenced by other important laws and orders. The National Wildlife Refuge System (NWRS) has several legislative mandates and authorities that oversee recreational use on the refuges.

The National Wildlife Refuge Administration Act of 1966: The Act established a unifying mission for the Refuge System, a process for determining compatible uses of refuges, and a requirement for preparing comprehensive conservation plans. The Act states that the first and principal purpose of the NWRS is wildlife conservation (U.S. Code online, 1998). The National Wildlife Refuge System Improvement Act of 1997 amends and builds upon the Administration Act of 1966. This Act builds upon the original mission of the Refuge System, and creates a process for determining compatible uses on the Refuge, that includes wildlife-dependent recreational uses such as hunting, fishing, wildlife observation and photography, and environmental education and interpretation. The Improvement Act goes on to state that "compatible wildlife-dependent recreation is a legitimate and appropriate general public use of the System, directly related to the mission of the system and the purposes of many refuges, and which generally fosters refuge management and through which the American public can develop an appreciation of fish and wildlife" (U.S. Code Online, 1998). The Act states that compatible recreational use is a priority general public use and will receive priority in refuge planning and management.

Executive Order 12996 "Management and General Public Use of the National Wildlife Refuge System (March 25, 1996): The Executive Order (EO) ensures opportunity and direction for wildlife-dependent recreational uses. The EO directs the Secretary of Interior to recognize wildlife-dependent recreational activities as a priority public use of the Refuge System. The Secretary of the Interior is directed to provide expanded opportunities for the priority public uses, and ensure that these uses receive enhanced attention.

Refuge Recreation Act of 1999: The Recreation Act requires that recreational activities be compatible with the primary purpose of the refuge establishment. Additionally, funding must be available for the development, operation and maintenance of recreational uses that are not directly related to the primary purpose of the refuge.

Pima County has two National Wildlife Refuges (NWR): Cabeza Prieta NWR and Buenos Aires NWR.

Cabeza Prieta National Wildlife Refuge

Cabeza Prieta NWR was established in 1939 for the conservation and development of natural wildlife and forage resources (USFWS, 1998). Management was initially designed for the recovery of bighorn sheep populations (USFWS, 1998). Recreation in the Cabeza Prieta NWR consists of camping, hiking, nature photography, limited hunting for desert bighorn sheep, and 4-wheel driving. Papago Well, Tule Well, are camping areas with some facilities. Fires must be contained in fire pans.

Buenos Aires National Wildlife Refuge

Buenos Aires National Wildlife Refuge was established in 1985 for the primary purpose of establishing a breeding population of the endangered masked bobwhite (*Colinus virginianus ridgwayi*). Recreational activities allowed on the refuge include hiking, horseback riding, mountain biking, camping, nature photography and bird watching, and 4-wheel driving. Several nature trails are located in the refuge, and primitive camping sites are found throughout.

Recreation has caused little damage to the resources at BANWR (Swarbrick, personal comm., 2000). The refuge has about 100 primitive campsites, some of which show some signs of accumulating litter and other signs of campsite abuse. OHV use is limited to designated roads only. Four hiking trails have been inventories and signed. Driving trails are minimally signed, with plans to sign more. The refuge receives about 35,000 visitors per year.

Arizona State Parks

Off-Highway Vehicle Program: The mission and intent of the Arizona State Parks' Off-Highway Vehicle Program is to guide outdoor recreationalists and land managers in making responsible choices in developing and enhancing off-highway vehicle recreation opportunities while promoting educational programs that encourage resource protection, social responsibility, and interagency cooperation (Arizona State Parks (ASP), no date).

The Arizona Off-Highway Vehicle Program was created in 1991 by the Arizona Legislature. Provisions of the law created an Off-Highway Vehicle Recreation Fund and the development of the Off-Highway Vehicle Recreation Plan. As part of the program, a citizen OHV Advisory Group is appointed by the Arizona State Parks Board. The purpose of this group is to assure public involvement in the implementation of the OHV Program. The group members serve a three year term. Of the seven members, five must be members of an OHV organization, and the remaining two must be casual OHV recreationalists or representatives of the general public. No more than two members can reside in one county.

The state legislature set the funding mechanism for the OHV Program at 0.55 percent of the annual state motor-tax revenue. The tax is paid at the gas pump and raises and average of $1,600,000 annually. Arizona Game and Fish Department uses 30% of the 1.6 million for information, education, and law enforcement activities. The Arizona State Parks Boards uses the remaining 70% for administration of the fund and for grants to eligible applicants (ASP, 1999).

Eligible applicants for the Off-Highway Grant Program funds include cities, towns, counties, tribal governments, and state and federal agencies. Private and non-profit organizations may apply for a grant through the sponsorship of one of the governments listed. Eligible projects include development, construction, enhancement and operation of OHV recreation facilities, OHV use areas and trails, mitigation of damages caused by OHVs, and OHV environmental education and law enforcement (ASP 1999).

The goal of the Arizona OHV Program is to enhance and preserve motorized recreation opportunities. The program seeks to increase public awareness of OHV while minimizing vehicle impacts.

Arizona Trails 2000: The Arizona State Parks is mandated to prepare comprehensive management plans for both the State Trails Program and the State Off-Highway Vehicle Recreation Program. In 1999, both the 1993 OHV Plan and the 1994 Trails Plan were due for updates. The ASP Planning Section combined the final plan for both programs into a single effort, the *Arizona Trails 2000.* The *Arizona Trails 2000* plan was created by Arizona State Parks as required by state legislation (State Off-Highway Vehicle (OHV) Recreation Plan, A.R.S. §41-511.01 and State Trails Plan, §41-511.22) and written primarily for recreational planners and land managers. The plan includes both motorized and non-motorized trail information, public survey results, and recommendations. The plan provides background information on the average trail user, and on current trends affecting OHV and trail opportunities. The purpose of the plan is to provide information and recommendations to guide Arizona State Parks and other agencies in Arizona in their management of motorized and non-motorized trail resources, and to guide distribution and expenditure of funds derived from the Arizona OHV Recreation Fund, Arizona Heritage Fund trails component, and Federal Recreational Trails Program (ASP 1999).

One objective of the *Arizona Trails 2000* plan was to identify the most significant issues related to motorized and nonmotorized trail use in Arizona. Information was obtain through a statewide survey of 10,000 Arizona adults. In addition to the statewide survey, State Parks held a series of 16 public workshops to solicit comments from trail recreationists, recreation planners, land managers, and affected individuals. The survey findings are presented in four categories: trail issues; trail management needs; trail activities/types; and trail support facilities. Results are summarized below.

Trail Issues
Survey participants were asked their opinion of the three most important trail issues in Arizona.

- Motorized: Closure of roads and trails; lack of trail etiquette and environmental ethics; loss of public access to trails.
- Nonmotorized: Lack of trail etiquette and environmental ethics; lack of funding for trails; erosion and deterioration of trails.

Trail Management Needs
Survey participants were asked to rate the importance of specific trail management needs. They were then asked to specify the one issue they felt most important.

- Motorized: Trail maintenance; enforcement of trail regulations.
- Nonmotorized: Trail maintenance; enforcement of trail regulations.

Both motorized and nonmotorized trail users surveyed responded that "maintain existing trails" was the single most important trail management need.

Trail Activities/Types
Respondents were asked to rate the importance of trail opportunities. Many of the motorized trail activities listing received a low ranking. Survey findings show that the motorized users tend to participate in a wide range of motorized and nonmotorized trail activities.

- Motorized: Trail hiking; walking; backpacking; four-wheel driving; horseback riding; and high clearance two-wheel driving. Four-wheel driving and walking rated highest for the most frequent and favorite activities.

- Nonmotorized: Trail hiking; walking; backpacking; jogging/running; horseback riding; hiking with packstock; and mountain bicycling. Trail hiking and walking rated highest for the most frequent and favorite activities.

  Survey respondents were asked what level of difficulty and challenge they prefer on trails. Over 50% of motorized and nonmotorized users preferred a moderate level of difficulty.

  The survey respondents were asked is trails should be designated for multiple use or single use. Over 60% of the motorized users and 70% of nonmotorized users responded they preferred a trail designated for multiple activities, but separated for motorized and nonmotorized uses.

Trail Support Facilities
Survey respondents were asked to rate 16 facilities that may or may not exist where trails are located. Responses were ranked by level of need (no need for this facility; current facilities adequate; moderate/extreme need). The top four ranked trail support facilities used and/or needed by both motorized and nonmotorized users were: 1) trash cans/dumpsters; 2) restrooms; 3) drinking water; and 4) trail signs.

The Arizona Trail

The Arizona Trail will be a 790 mile trail that crosses the state from Mexico to Utah when complete. The Arizona Trail is intended to be a nonmotorized long-distance trail that captures the state's topographic, biologic, historic, and cultural diversity (Arizona Trails Association Online, no date). Primary users of the trail are hikers, equestrians, cross-county skiers, and mountain bicyclists, with opportunities for non-traditional uses such as llama trekking. In early 2000, 73% (575 miles) of the trail was complete.

In 1993, an Intergovernmental Agreement (IGA) was signed by the Arizona State Parks, U.S. Forest Service, National Park Service, and Bureau of Land Management. This group is known as the Arizona Trails Partners. The IGA authorizes these public agencies to cooperatively plan for the development of the Arizona Trail. The IGA also established a cooperative fund to hire an Arizona Trail Steward. In 1995 a Memorandum of Understanding (MOU) was developed for the Arizona Trail and Pima County, Walnut Canyon National Monument, and the Arizona Trail Association became part of the Arizona Trail Partners.

Arizona State Parks houses the Arizona Trail Steward. The trail steward is responsible for preparing the Arizona Trail Management Guide and assumes the lead role in planning segments of the trail. Additional responsibilities include writing grants, working with Arizona Trail Association, the Arizona Trail Partners, and assisting various counties with securing Special Land Use Permits and easements across State Trust Lands.

Pima County Involvement: Several sections of the Arizona have been completed in the Santa Rita and Santa Catalina Mountains of the Coronado National Forest. A portion of the trail running

through Las Cienegas National Conservation Area is proposed. The Sonoita Valley Planning Partnership is in the process of identifying alternative routes for the trail. Pima County's Flood Control District has incorporated a potential route for the Arizona Trail running within or near the Cienega Creek Natural Preserve. The Pima County Natural Resources, Parks and Recreation Department would manage this section of the trail.

State Trust Land

The State of Arizona Land Department administered over 9.4 million acres of State Trust land, representing 13 percent of all land in Arizona. The mission of the Arizona State Land Department is to:

> "Manage state trust lands and resources to enhance value and optimize economic return for the beneficiaries, consistent with sound stewardship, conservation and business management principles supporting soci-economic goals for citizens here today and generation yet to come. To manage and provide support for resource conservation programs for the well-being of the public and the state's natural environment (Arizona State Land Department, 2000)."

The Land Department must manage the Trust lands to assure the highest and best use of the land for the Trust beneficiaries, including state schools, colleges, hospitals, charitable institutions, and specialized schools (Arizona State Land Department, 2000). The Land Department does not have a designated system of trails on its land, nor does it have a mandate to develop and manage trails on its lands. State Trust land is not public land and cannot be accessed without permission from the State Land Department. Recreation may occur on the land with a valid hunting or fishing license or a recreation permit.

The State Land Department has few staff dealing with recreation issues and recreational permits. Recreation impacts to Trust land vary, along with corrective management techniques. Because of understaffing, Land Department staff rely on public input when dealing with recreation issues on Trust land. The Land Department relies on the public's action-reaction response. If public response is high, their actions determine if land will stay open (Thornberg, pers.comm 8/2000).

Arizona Game and Fish Department

Part of the Arizona Game and Fish Department's (AGFD) agency mission is to provide wildlife resources for the enjoyment, appreciation, and use by present and future generations. Although responsibility to promote wildlife-related recreation is generally dispersed throughout all levels of the agency, several Divisions have specific recreation-related respondsibilities:

> Wildlife Management Division: This division includes the Fisheries, Game and Nongame Branches. The Fisheries branch operates the Urban Fisheries Program. The nongame branch provides public information about recreation issues and activities relating to nongame and endangered wildlife (AGFD, 1998).
>
> Field Operations Division: This division administers programs for watercraft and OHVs. The Field Operations Division is organized into six regional offices which are subdivided into Game Management Units overseen by Wildlife Managers. The Wildlife Managers are

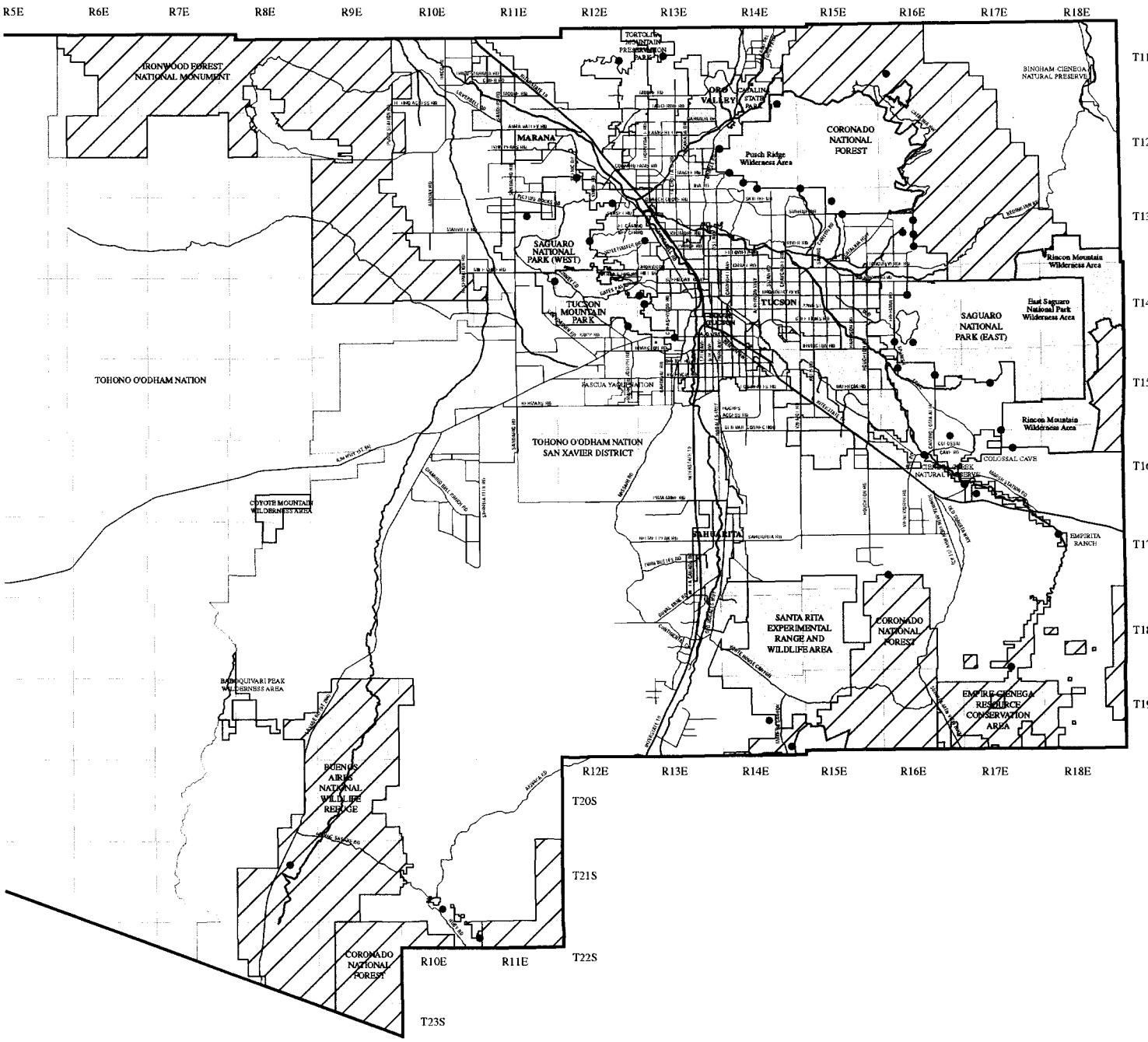
responsible for enforcing many recreational activities such as watercraft, OHV, and game and fish laws and regulations (AGFD 1998).

Information and Education Division: This division has two branches: the Information Branch, and the Education Branch. The Information Branch is responsible for the production and distribution of information on regulations, OHV, Heritage, sportfish, and other department programs. The Education Branch develops and implements hunter, boating, and other department programs. This branch also oversees the coordination of a statewide shooting range program and the operation of the Ben Avery Shooting facility (AGFD, 1998).

Heritage Fund: The money derived from the Heritage Fund is used for a variety of purposes, including public access. Heritage Access funds are used to identify, evaluate, and administer programs for public access. The funds also provide for information on public access and recreational use on public lands. The Heritage Access Program was developed in 1989 in response to land closures at private property boundaries (AGFD, 2000). Heritage Access Funds made it possible for AGFD to re-establish public access to the Charouleau Gap Trail through easement acquisitions, creation of trails, and construction of fencing (AGFD, 1998).

In a similar effort, the AGFD has facilitated an Adopt-A-Ranch Program that works to establish cooperative relationships with sportsmen and ranchers (AGFD, 2000). This program brings ranch/land lessees and sportsmen together for a weekend or two each year to work on ranch enhancement. This involves fence repairs, installing gates or program signs, or picking up and removing litter from previous users (AGFD, 2000).

The AGFD derives much of its funding from the sale of Arizona hunting and fishing licenses.

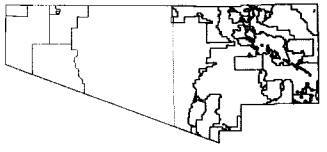


EASTERN PIMA COUNTY BIRDING SITES & TRAILHEADS

- Major Roads
- Major Washes
- Section Lines
- Wilderness Boundaries
- Incorporated Limits
- Forest/National Parks
- Native American Nations
- Off-Highway Vehicle Travel (OHV) (Restricted to designated roads only.)
- Trail Access Points
- Birding Sites

Appendix A

Pima County Index Map

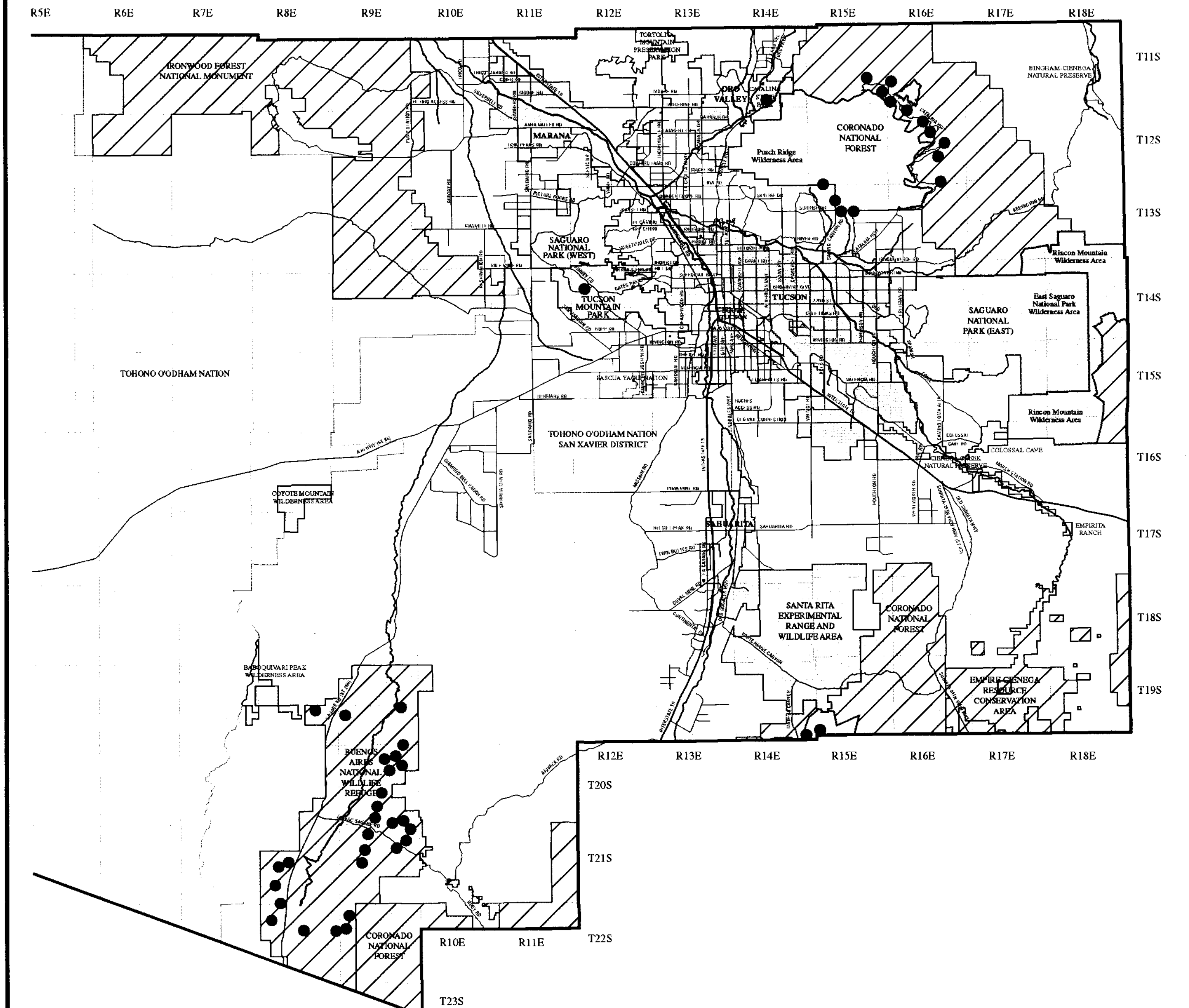


Index Map Scale 1:1,500,000

PIMA COUNTY DEPARTMENT OF TRANSPORTATION
TECHNICAL SERVICES

Pima County Technical Services
201 North Stone Avenue, 9th Floor
Tucson, Arizona 85701-1207
(520) 740-6356 FAX (520) 884-6380
http://www.dot.co.pima.az.us

EASTERN PIMA COUNTY RECREATION AREAS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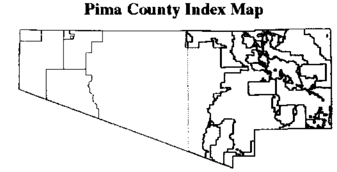
IRONWOOD FOREST NATIONAL MONUMENT
TORTOLITA MOUNTAIN PRESERVATION PARK
MARANA
ORO VALLEY
Pusch Ridge Wilderness Area
CORONADO NATIONAL FOREST
BINGHAM-CIENEGA NATURAL PRESERVE
Rincon Mountain Wilderness Area
East Saguaro National Park Wilderness Area
SAGUARO NATIONAL PARK (WEST)
TUCSON MOUNTAIN PARK
TUCSON
SAGUARO NATIONAL PARK (EAST)
TOHONO O'ODHAM NATION
PASCUA YAQUI NATION
TOHONO O'ODHAM NATION SAN XAVIER DISTRICT
COLOSSAL CAVE
EMPIRITA RANCH
COYOTE MOUNTAIN WILDERNESS AREA
SAHUARITA
SANTA RITA EXPERIMENTAL RANGE AND WILDLIFE AREA
EMPIRE CIENEGA RESOURCE CONSERVATION AREA
BABOQUIVARI PEAK WILDERNESS AREA
BUENOS AIRES NATIONAL WILDLIFE REFUGE

- Major Roads
- Major Washes
- Section Lines
- Wilderness Boundaries
- Incorporated Limits
- Forest/National Parks
- Native American Nations
- Off-Highway Vehicle Travel (OHV) (Restricted to designated roads only.)
- Trail Access Points
- Birding Sites
- Mt. Lemmon Ski Valley

Appendix B

Pima County Index Map



Index Map Scale 1:1,500,000

PIMA COUNTY DEPARTMENT OF TRANSPORTATION
TECHNICAL SERVICES

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