

Development of the Threats to Wildlife and Wildlife Habitat Models (draft)

Important threats to Arizona's wildlife and wildlife habitat were identified as part of the initial development of the State Wildlife Action Plan (SWAP, formerly known as CWCS). At that time, 85 individual threats were assessed for the magnitude and urgency of their impacts on Arizona's wildlife and wildlife habitats. Of those 85 threats, 70 were found to have a high level of urgency and or magnitude in one or more vegetation types. That assessment was done at a coarse landscape scale using Brown and Lowe (1983) vegetation classes as the basis for mapping the distribution of the threat. The coarseness of the threat assessment has proven limiting to the Department's ability to perform meaningful risk and cumulative effects analyses. A finer scale analysis is necessary to fulfill the intent of the Department's planning effort which is to evaluate landscapes as they exist today and develop strategies on how best to make meaningful improvements to benefit species of greatest conservation need.

The Department mapped the location of each of the 70 significant threats identified in the 2005 SWAP. We used a 30 meter pixel as a mapping unit to be compatible with the United State Geological Survey's Southwest Regional GAP Analysis (SWReGAP) vegetation layer that was used in the species distribution models. Upon closer examination, however, the Department realized that some threats occurred in the same areas as other threats and that some threats were interrelated. Those threats were combined and mapped together. In addition, threats determined to exist statewide were not mapped (e.g. soil erosion).

The following includes a description of each threat, a discussion of the data and methodology used to map each threat, and the assumptions and recognized errors in each threat model.

1 DRILLING FOR FUELS

This threat includes the impacts associated with light and noise pollution from drilling for fossil fuels, CO₂, methane, helium, etc.

Point data on oil, natural gas, helium, and carbon dioxide wells were obtained from the Arizona Geological Survey. The data include all wells permitted within the state of Arizona and were last updated in January of 2005. The threat from the wells was distributed by running a density kernel over the points with a 2 mile (3218.6 m) search radius. This method effectively places the highest threat in areas with a high density of wells and gradually diminishes to 0 at two miles from the well

All wells, including test and other non-producing wells, were weighted equally and are treated as a "high" threat designation. A review of individual wells should be conducted to determine which wells actually pose a threat to wildlife.

2 GROUNDWATER DEPLETION & SPRINGHEAD USE

After numerous discussions, the Department recognized its lack of expertise necessary to model the dependence of surface water on ground water. As a result, the Department decided to use the simplest model possible and assume that all surface water is dependent to a certain extent on ground water. Therefore all streams, springs and washes could be affected by ground water pumping. Wildlife could be affected either through diminishing surface water availability or degradation of habitat due to the effect of the lowering water table on hydrophytes and phreatophytes. The influence of diminishing surface water in perennial and intermittent streams and springs was assumed to affect wildlife up to three miles away since this is the distance large ungulates have been shown to travel to water. The effect of ground water pumping on xeroriparian washes was assumed to affect wildlife up to a distance of one mile.

The model was built by placing a point every 30 meters along perennial and intermittent streams. That point layer was merged with the springs layer and a kernel density was run with a search radius of 4828 m (approximately 3 miles). The same procedure was done for large desert washes with a search radius of 1609 m (approximately 1 mile). The two resulting layers were combined by normalizing each to 0 – 1, adding them together and dividing by 2.

Some places where the ground water is too high, such as around Yuma, were not considered. This model over-estimates surface impact and should be redone as more accurate information becomes available.

3 MINING

Included in the effects of this threat are: the added threat of new roads, groundwater pumping, and water pollution associated with mineral districts; noise and light pollution created from mining activity (not included in threats #57 or #58); mining contaminants from wastewater, runoff, heavy metals, and mine tailings (not included in threats #52 or #53); and mining equipment left as litter/dumping when the mining activity is complete.

Mine locations were obtained from the Arizona Department of Mines and Mineral Resources and mineral district data obtained from the Arizona Geological Survey. Mineral district polygons were converted to 30 m raster and then to points. Those points were merged with the mine point locations. A kernel density with a search radius of 1 mile was run, resulting in a linearly decreasing gradient of threat intensity from the center of a mine to 1 mile away.

All mines were treated equally whether active or inactive, including past, present, and future open pit and underground. Future iterations should consider different levels of impacts from different mining activities.

4 WATER DIVERSIONS, WATER CATCHMENTS

Combined with #31 Dams/Reservoirs/Impoundments

5-13 BORDER EFFECTS

Border Effects include activities from illegal immigration, drug smuggling, and law enforcement along the Arizona border with Mexico. These threats include light pollution, dispersed camping, illegal dumping and littering, unauthorized roads and trails, altered fire regimes, poaching, enforcement activities, enforcement fences, water use and contamination, disease, and enforcement over-flights. Border threats are roughly mapped in the same area, and they were combined.

Effects are most intense along the border and major roads, and decrease with distance away from the border. We used expert opinion to determine how far from the border impacts are occurring and created a linear gradient of intensity decreasing with distance from the border and falling to 0 north of I-10 and I-8.

14 ALTERED RIVER FLOW REGIMES

Combined with #31 Dams/Reservoirs/Impoundments

15 DOMESTICATION OF WILDLIFE/GAME FARMING

This threat includes the impacts from escaped domesticated wildlife as a result of game farming and from keeping native wildlife as pets. This does not include keeping exotic species as pets, which is covered under Threat #41. Some of the concerns about domestication of wildlife involve the potential for disease transmission (e.g., fish hatcheries, aquaculture, desert tortoise adoption), which is included under Threat #40, or the fear of hybridization with native wildlife (e.g., domestic wolves), which is covered under Threat #42.

Two game farms in Arizona are permitted to keep native cervids. A 5-mile sphere of influence around each of them was used to define the location of this threat. Game farms were located as points as close to the center of the farm as possible. A kernel density was run on the point locations with a search radius of approximately five miles (8045 meters) resulting in a gradient of influence that is strongest at the point location and falls to 0 at five miles away.

These two game farms were included as hot spots since the Department considers keeping native cervids to pose a much higher threat of disease transmission than other species deer species. In addition, fallow and axis deer are not restricted live wildlife (thus they are not tracked) and are covered under the Department's chronic wasting disease rule. Threats associated with game farms with those deer are considered statewide threats. The Department also permits game farms to include non-cervid species of wildlife (e.g. serval cats), but those exotic species are not expected to be a threat to wildlife.

16 HABITAT DEGREDDATION/SHRUB INVASIONS

Includes habitats that have been invaded by juniper, mesquite, or catclaw over the last 100 years. These habitats include Madrean oak woodlands, most pinyon juniper woodlands, and grasslands. The SWReGAP vegetation classes that include juniper, mesquite or catclaw include:

- Apacherian-Chihuahuan Mesquite Upland Scrub
- Apacherian-Chihuahuan Piedmont Semi-Desert Grassland and Steppe
- Chihuahuan Creosotebush, Mixed Desert and Thorn Scrub
- Chihuahuan Sandy Plains Semi-Desert Grassland
- Colorado Plateau Blackbrush-Mormon-tea Shrubland
- Colorado Plateau Mixed Low Sagebrush Shrubland
- Colorado Plateau Pinyon-Juniper Shrubland
- Colorado Plateau Pinyon-Juniper Woodland
- Great Basin Pinyon-Juniper Woodland
- Inter-Mountain Basins Active and Stabilized Dune
- Inter-Mountain Basins Mat Saltbush Shrubland
- Inter-Mountain Basins Semi-Desert Grassland
- Inter-Mountain Basins Semi-Desert Shrub Steppe
- Inter-Mountain Basins Shale Badland
- Inter-Mountain Basins Wash
- Invasive Annual and Biennial Forbland
- Invasive Annual Grassland
- Invasive Perennial Grassland
- Madrean Encinal
- Madrean Juniper Savanna
- Madrean Pinyon-Juniper Woodland
- Mojave Mid-Elevation Mixed Desert Scrub
- Rocky Mountain Alpine-Montane Wet Meadow
- Rocky Mountain Subalpine Mesic Meadow
- Southern Colorado Plateau Sand Shrubland
- Southern Rocky Mountain Montane-Subalpine Grassland
- Southern Rocky Mountain Pinyon-Juniper Woodland

17 HABITAT FRAGMENTATION BARRIERS

Fragmentation impacts result from agricultural conversion, off-road vehicles, roads, phone and utility lines, fencing, dams, and stream bank alteration. Each of these has already been addressed and mapped in separate threat classes (see threats #20, #22, #30, #31, #47, #65, #67, #68). Railroads are the only component that have not been covered elsewhere that would fall into this threat class. Therefore, the only impact modeled here is from railroads and associated noise and light pollution.

The impact of railroads was modeled with a 600 m radius kernel density. The effect of this is to create a gradient that is highest at the railroad and declines linearly with distance from the railroad.

The assumption of this model is that the impacts of railroads are very similar to roads. See #67 for a complete description of this method.

18 INSECT INFESTATION

This threat occurs in coniferous forests, including pinyon-juniper woodlands, primarily due to the impacts of bark beetles and other conifer-damaging insects which have the potential to have significant ecosystem-wide impacts. This threat can occur in the following SWReGAP vegetation classes:

- Colordao Plateau Pinyon-Juniper Woodland
- Great Basin Pinyon-Juniper Woodland
- Inter-Mountain Basins Juniper Savanna
- Madrean Juniper Savanna
- Madrean Pine-Oak Forest and Woodland
- Madrean Upper Montane Conifer-Oak Forest and Woodland
- Rocky Mountain Montane Dry-Mesic Mixed Conifer Forest and Woodland
- Rocky Mountain Montane Mesic Mixed Conifer Forest and Woodland
- Rocky Mountain Ponderosa Pine Woodland
- Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland
- Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland
- Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland
- Southern Rocky Mountain Pinyon-Juniper Woodland

19 LOSS OF KEYSTONE SPECIES

While the Department recognizes that all species play an integral role in the functioning of ecosystems, we identified important keystone species based only on the criteria listed below. Nongame taxon “experts” led each review. Upon completion of this exercise by the individual taxon leads, the list of keystone species was reviewed by all taxon leads to ensure consistency and accuracy.

Definition of an Important Keystone Species:

Keystone/Strongly Interactive Species

Description: Species whose impact on a community or ecological system is disproportionately large for their presence or abundance. They contribute to ecosystem function in a unique and significant manner through their activities. Their removal initiates changes in ecosystem structure and often a loss of diversity.

To be included, a species must meet the following criteria:

- Function in ecosystem must not be replaceable by another species
- Effects of loss from ecosystem are disproportionately high relative to their abundance (i.e.. relatively few affect many)

Species (not larger taxonomic groups) that are categorized by one (or more) of the following interactions will be included:

Top Predator: Terborgh and colleagues (1999) describe how the loss of apex mammalian predators can precipitate ecological chain reactions that lead to profound degradation and species loss. Although top-down forcing through three or more trophic levels has been demonstrated for invertebrate taxa (Strong et al. 1996, Terborgh et al.

2001), space constraints and immediate policy relevance preclude a detailed review here. Gray wolves (*Canis lupus*) in Yellowstone are an example in which the extirpation of a large carnivore leads to the ecological release of large terrestrial ungulates and other herbivores, causing changes in vegetation structure, species composition, and diversity.

Mutualistic: Species that, by virtue of their interactions, maintain species diversity. An example is the relationship between the whitebark pine (*Pinus albicaulus*) and Clark's nutcracker (*Nucifraga columbiana*). Clark's nutcracker is strongly dependent on the seeds of the whitebark pine, and the pine depends on the nutcracker for the dispersal of its seeds into caches. These seed caches are also a major food source for both small vertebrates and grizzly bears (*Ursus arctos*) in the Greater Yellowstone ecosystem (Mattson et al. 1992).

Ecological engineer: Species whose activities affect and enhance physical or biological habitat structure have been referred to as "ecological engineers" (Jones et al. 1994). Ecological engineers significantly modify their habitat in ways that affect local species diversity. Examples of ecological engineers include beavers (*Castor canadensis*) that create wetlands by building dams in streams, mound building by termites, burrowing and grazing by prairie dogs (*Cynomys* spp.), or habitat conversion by elephants (*Loxodonta africana*) and bison (*Bison bison*) (Naiman et al. 1988, Detling 1998, Kotliar et al. 1999).

In most cases, prey species are replaceable by other similar species, therefore most prey species do not qualify as keystone/interactive species.

Use these questions to help decide if a species is a Keystone species:

Does the absence or decrease in abundance of the species lead directly or indirectly to a reduction in local species diversity? For example, the absence of coyotes from arid ecosystems can lead to a reduction in bird species diversity via mesopredator release (Crooks and Soulé 1999), or to a reduction in rodent species diversity via competitive exclusion (Henke and Bryant 1999).

Does the absence, decrease in abundance, or range contraction of the species directly or indirectly reduce reproduction or recruitment of other species? For example, the number of forest tree species that successfully reproduced on islands in a Venezuelan reservoir lacking large predators dropped from about 65 to about 10 because of a superabundance of herbivores (Terborgh et al. 2001). Likewise, ungulate herbivory prevented aspen (*Populus tremuloides*) clones from recruiting sprouts into the overstory after extirpation of wolves in the northern range of Yellowstone National Park (Romme et al. 1995, Ripple and Larsen 2000, Ripple and Beschta 2004).

Does the absence or decrease in abundance of the species lead directly or indirectly to a change in habitat structure or composition of ecosystems? For example, excessive elk (*Cervus elaphus*) herbivory on willow (*Salix* spp.) in the absence of wolves in Rocky Mountain National Park (Peinetti et al. 2002) and Yellowstone National Park (Ripple and Beschta 2004) was apparently the major factor in the disappearance of beaver and associated wetlands.

Does the absence or decrease in abundance of the species lead directly or indirectly to a change in productivity or nutrient dynamics in or between ecosystems? For example, prairie dog colonies shape nutrient cycling, soil chemistry, soil porosity, and the productivity and nutrient content of vegetation through their burrowing and grazing activities (Whicker and Detling 1993, Kotliar et al. 1999, Miller et al. 2000), and sea otters strongly influence algal productivity (Duggins et al. 1989) and therefore food resource availability to herbivores (Konar and Estes 2003).

Does the absence or decrease in abundance of the species change an important ecological process in the system? For example, beavers have a profound effect on stream dynamics, water tables, flooding, and the extent of wetlands (Naiman et al. 1988).

Does the absence or decrease in abundance of the species reduce the resilience of the system to disturbances such as fire, drought, flood, or exotic species? For example, the extirpation of the dingo (*Canis lupus dingo*) in some regions of Australia indirectly degrades habitat quality because dingoes prey effectively on exotic rabbits (*Oryctolagus cuniculus*), red kangaroos (*Macropus rufus*), and other herbivores (Newsome 2001). In addition, dingoes may benefit native fauna, including small, endangered marsupials, by reducing population densities of the introduced red fox (*Vulpes vulpes*) (Newsome 2001). After review by the taxon lead group, only five species were considered keystone under this definition.

Mexican Grey Wolf (Top Predator): Several recent studies have shown the impact that wolf removal has had on the riparian environment and how the reintroduction of wolves has altered the environment and the behavior of numerous other species.

Black-tailed and Gunnison's prairie dogs (Ecosystem engineers): Many studies have shown the dependence of the grassland ecosystem on prairie dogs and their engineering.

American Beaver (Ecosystem Engineer): Many studies have shown that beavers create wetlands by building dams in streams.

Clark's Nutcracker (mutualistic): Studies have shown the importance of this species in dispersing seeds that lead to forest regeneration.

The distribution of these five species combined was used to model this threat.

20 MANAGEMENT FOR GAME ANIMALS & SPORT FISH

Game animals and sportfishes are actively managed through stocking, development of water sources, and permits for harvest and collection. In some cases, these activities promote persistence of native or nonnative species that may displace, compete with, or prey upon native species. Some of these management activities may also negatively impact native wildlife populations through habitat modification.

Abert squirrels: In the 1940s, Abert squirrels were introduced into the Pinaleño Mountains, Catalina Mountains, Pinal Mountains, Bradshaw Mountains, Granite

Mountain, Hualapai Mountains, Mingus Mountain and onto the Hualapai Indian Reservation. There is concern that Abert squirrels compete with Mt. Graham red squirrels, and possibly with native Arizona gray squirrels in the Catalina and Rincon Mountains. The impact from the introduction is modeled over the range of the Mt. Graham red squirrel in the Pinaleño Mountains and the range of the Arizona gray squirrel in the Catalina and Rincon Mountains.

Bison: Management for bison does not pose a significant threat for other wildlife except where fencing is used to contain the bison herd at Raymond Wildlife Area in Region II. In this particular situation, a 6-foot, 8-strand barbed wire fence (with some accompanying high-tensile electric fencing) is used to prevent bison from escaping the wildlife area and moving onto adjacent private lands. Thus, the fence prevents movement of mule deer across the wildlife area (i.e., habitat fragmentation) and potentially results in entanglement and mortality.

Elk: Elk grazing effects are considered under Threat #27 and not included here. Regional Game Specialists and Habitat Programs determined that maintaining high elk populations creates a threat in the winter ranges and in the transitional areas between winter and summer ranges, for both pronghorn and mule deer. In the winter ranges and in the transition zones, elk forage on the same browse shrubs and forbs that mule deer and pronghorn need, causing direct competition between species. The impact from this threat was modeled using big game distribution maps for all three species. The summer distributions were overlaid on winter distributions, and those places where the two distributions overlapped were determined to be transition zones for all three species. The transition zones for elk were overlaid on top of transition zones for both mule deer and pronghorn (separately). This procedure was repeated to find the overlap of winter ranges.

Fish: The overall distribution of sportfish is mapped here, and not only where the Department actively promotes sport fisheries. Sportfish have been mapped for all perennial and intermittent streams layers except those that have been renovated or are managed for native fishes. If a stream has natives and non-natives co-existing, the non-natives are still considered a threat to native fish.

Pheasants: Although an exotic species, pheasants are not considered a threat to native wildlife. The species exists mainly in agricultural fields and does not appear to persist in wildlands. This species was not modeled.

Chuckars: Introduced chuckars occur mostly in areas dominated by cheat grass on the North Rim of the Grand Canyon, and the Department manages them through bag limits. They are not very populous, and they do not compete with other upland game birds in this area. There is the potential for chuckars to increase in number as the distribution of cheat grass continues to spread. However, at this time, the Department's management of chuckars as a game species is not showing a detrimental impact to other species, therefore we have not modeled chuckars as a threat.

Rio Grande Turkey: The introduction of this species is not expected to threaten other species with respect to competition with native species or habitat alteration. There is a potential for hybridization with native turkeys, which is addressed under threat #42). This species was not modeled here.

Predator control: Predator control occurs throughout state, and that activity is not necessarily detrimental, in a general sense, to any particular species. It was not modeled,

21 SOIL EROSION

This threat can cause wildlife effects statewide in all habitats and is ubiquitous. It was not modeled.

22 STREAMBANK ALTERATION/CHANNELIZATION

This threat occurs where stream/river banks have been altered (e.g. rip-rap, soil cement, dredging) in an effort to confine a natural drainage to a particular channel to alleviate overbank flooding. Examples include the Rillito River and the Santa Cruz River through Tucson. The threat includes places where channelization has already occurred and where it likely could occur in the future. There is no existing state database but good data are available for Pima County. The entire lower Colorado River is assumed to be channelized from Hoover Dam down, except for one unchannelized reach. Expert opinion was used to map other known areas of channelization of rivers and streams. In addition, all streams and rivers within 30 miles of the center of Phoenix and large washes within the Phoenix metropolitan area were considered to be channelized or altered. Linear features were buffered by 30 meters and appended to any polygon features. The resulting layer was rasterized with all affected areas given a value of 1.

23 UNNATURAL FIRE REGIMES

The LANDFIRE Fire Regime Condition Class (FRCC) Departure Index was the basis for this model. LANDFIRE FRCC is a database showing the percent departure from normal fire regimes for different habitats (see <http://www.landfire.gov/index.php>). Since neither the Sonoran nor Mohave deserts are considered to have a normal fire regime (i.e., fires are not considered part of the natural processes maintaining these systems), these data show them as being less than 10% departed from normal. Since the creation of this model, large desert fires have clearly demonstrated the ecosystem impacts of unnatural fires in deserts (usually resulting from combustion of invasive exotic plant species). Thus the model was modified to increase the departure for Sonoran and Mohave systems by 70%.

24 DROUGHT

Drought is a long-term decrease in precipitation. Periodic drought is a normal component of the climate system in the Southwest. In combination with other stressors (e.g. grazing or other factors that can cause changes in soil or vegetation characteristics), drought can result in habitat conversion and other effects on wildlife. But, this threat is statewide and in all habitats and was not modeled.

25 SHIFT TO WARMER CLIMATE

This threat can cause wildlife effects statewide in all habitats depending on habitat and species vulnerability and the spatial variability inherent in climate. Due to its complexity, the decision was made not to model climate change until more information is available. The Department is committed to addressing this threat with a much deeper analysis than was appropriate here.

26 FOREST AND WOODLAND MANAGEMENT – CONSUMPTIVE USE

This threat includes threat #32, and refers mostly to timber harvest for consumptive use, but also refers to use of fire to manage the forest. Threat #32 refers to selective harvest that results in type conversion. Thus, these threats occur in all forests and woodlands that are cut or burned for management. This model included all pinyon-juniper and other coniferous woodlands, excluding wilderness lands, which are not managed through forestry practices. The SWReGAP classes that were included are:

- Colorado Plateau Pinyon-Juniper Woodland,
- Great Basin Pinyon-Juniper Woodland
- Inter-Mountain Basins Juniper Savanna
- Invasive Southwest Riparian Woodland and Shrubland
- Madrean Encinal
- Madrean Juniper Savanna
- Madrean Pine-Oak Forest and Woodland
- Madrean Pinyon-Juniper Woodland
- Madrean Upper Montane Conifer-Oak Forest and Woodland
- Mesquite
- North American Warm Desert Riparian Mesquite Bosque
- North American Warm Desert Riparian Woodland and Shrubland, Riparian
- Rocky Mountain Aspen Forest and Woodland
- Rocky Mountain Gambel Oak-Mixed Montane Shrubland
- Rocky Mountain Montane Dry-Mesic Mixed Conifer Forest and Woodland
- Rocky Mountain Montane Mesic Mixed Conifer Forest and Woodland
- Rocky Mountain Ponderosa Pine Woodland
- Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland
- Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland, Rocky
- Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland
- Southern Rocky Mountain Pinyon-Juniper Woodland.

Tamarisk lands were also included because they are sometimes managed by cutting, bulldozing and fire which can have negative impacts on wildlife.

27 GRAZING BY UNGULATES (cows and elk)

This threat can occur anywhere that elk, buffalo or domestic cattle graze and includes all grazing allotments, private parcels inside allotment boundaries and elk range outside of allotments. Only elk range outside allotment boundaries was included because cattle preference calculations on allotments compensates for elk use. Private parcels were included based on the assumption that all these lands were also grazed. Information available to the team indicated that grazing by other ungulates (e.g. deer, pronghorn) does not rise to the level of a threat. Buffalo ranges are not included, because data collected has shown that buffalo grazing on buffalo ranges is negligible.

Although the Department recognizes the value of different management practices by different agencies, we chose not to include those differences in this model due to lack of rigorous data. However, the difference in impacts resulting from different climatic regimes and the presence of sensitive landscape elements such as riparian areas was recognized and used to weight the data accordingly. The PRISM (Parameter-elevation Regressions on Independent Slopes Model) group's 1971 – 2000 average precipitation data (see <http://www.prism.oregonstate.edu/>) were used to weight the grazing allotments by the inverse of precipitation. In other words, the lower the precipitation, the higher the weight of this threat. In addition, the impact to riparian areas was weighted twice that of upland areas. Due to lack of data, the impact to wet meadows could not be modeled but is recognized by the Department.

28 HARVESTING/COLLECTING ANIMALS

Department experts concluded that harvest/collection of wildlife is a threat to only a few species: Rosy boas, ridge-nosed rattlesnakes, banded rock rattlesnake, twin-spotted rattlesnake, massasauga, green rat snake, brown vine snake, New Mexico milk snake, lowland burrowing treefrog, box turtle, Sonoran desert tortoise, Bezy's night lizard and Arizona night lizard. The threat to green rat snake, milk snakes and massasauga, is mainly from road hunting, so the threat for these species was limited to the class 3-5 roads with a 100 meter inverse distance weighted gradient. For all other species the threat was modeled throughout the distribution of the range for the species. All species were given the same weight. The threat was not weighted more if species ranges overlapped, except that roads are considered a higher threat for all species, so were weighted higher.

29 HARVESTING/COLLECTING PLANTS

This threat includes illegal collecting, poaching and overharvest through legal take in specific areas and or particular time frames. This type of take occurs primarily in desert regions with species of cactus being the primary targets of interest, but can also include other desert plants, especially succulents such as Joshua trees, yuccas, and ocotillos. The threat was modeled as all desert vegetation in the Sonoran and Mohave deserts.

30 AGRICULTURAL CONVERSION

This threat was modeled as the Agriculture classification from the SWReGAP vegetation layer. Because of the high value of Arizona land for development today, little natural land is currently being converted to agriculture.

31 DAMS/RESERVOIRS/IMPOUNDMENTS

We combined threats #4, #14 and #31 into one threat for the modeling exercise.

The dam data are a combination of the National Inventory of Dams and the Arizona Department of Water Resources databases. Dams that were off-stream or not on a watercourse were eliminated. The upstream threat from dams was mapped to the reservoirs behind dams using an existing state-wide shapefile of lakes. When National Geographic Topo ArcGIS extension maps showed a reservoir behind a dam that was not in the existing shapefile, a polygon for the reservoir on the topo map was created in the shapefile.

The downstream threat from dams and reservoirs was based upon the impact on the size of the drainage to the dam. If the drainage area to the dam was greater than 50 square miles, the threat was assumed to continue from the dam to the Colorado River delta (at the U.S./Mexico border). If the drainage area to the dam was less than 50 square miles, the threat continued downstream to the first confluence with another watercourse. The existing azhydro shapefile was used to map the downstream threats. Perennial, intermittent, and ephemeral watercourses were included.

Because there is no existing stock tank dataset, they were not mapped. In addition, diversions on some smaller streams and canyons have likely been missed.

32 FOREST & WOODLAND MANAGEMENT – TYPE CONVERSION

See #26 Forest and Woodland Management – Consumptive Use

33 LANDFILLS AND DUMPS

Data containing the point locations of municipal solid waste landfills were obtained from the Arizona Department of Environmental Quality. Landfills are various sizes, and there are no data regarding the size of the landfills. Thus, an arbitrary radius of influence of 5 miles (8046.5 meters) around each point was chosen as the distance to which a landfill had the potential to impact wildlife. The threat is modeled as linearly decreasing with distance from the center point over a 5 mile radius.

34 LIVESTOCK MANAGEMENT (infrastructure to support grazing)

This is the threat to wildlife from the infrastructure that supports grazing, such as ranch roads, corrals, livestock waters, and fences. The model includes all Bureau of Land Management (BLM), US Forest Service (USFS) and Arizona State Lands Department (ASLD) grazing allotments and private property within allotments with no weighting.

35 MILITARY BASES, DEFOLIATION, MUNITIONS TESTING

This includes threat #45, and mapped as all military lands. Military lands were buffered with an inverse distance weighted gradient up to 2 miles because the impacts (e.g. noise) occur outside of the military land itself. This threat includes any noise and light pollution associated with these activities.

36 RECREATIONAL SITES/FACILITIES (structures)

Currently there is no centralized data source to map this threat at the statewide level. State Parks is now gathering data to map statewide recreational sites and facilities for the Governor's Smart Growth Cabinet. This is a major effort for State Parks because data are currently in a variety of formats that will have to be standardized and upgraded into a GIS format. State Parks hopes to have Maricopa and Pima counties completed first. They will share their GIS products with the Department as they become available, but this could take as long as two years. In the meantime, the threat is considered to be low level and statewide.

37 RURAL DEVELOPMENT

The threat of rural development is present for all private and state trust lands, and any land marked for disposal by BLM throughout the state, but is higher near existing population centers and travel corridors. The model is based on a layer of all developable lands with private land weighted ten times higher than state trust or BLM disposal lands. Urban areas were given an inverse distance weighted gradient of 5 miles (8046.5 m). Road density was calculated using interstates, U.S., State and County highways, and arterials with an 18 km search radius. Interstates were weighted as 10, highways were weighted as 5, and arterials were weighted as 1. All weights were considered additive (urban + road + ownership). Thus the highest weighted areas are near existing urban centers, near large travel corridors, and on private land. The urban growth model (threat # 38) was used to mask urban growth from this model.

This threat includes noise and light pollution associated with rural development.

38 URBAN GROWTH

The Maricopa Association of Governments population projection map is the model of Arizona urban growth that was adopted for this exercise. In the interest of conservation, the 2050 model was chosen, which included the best data available created by experts on this topic. This threat includes any noise and light pollution associated with urban growth.

39 BAIT-BUCKET DUMPING/ILLEGAL STOCKING

The threat is mapped as occurring in all intermittent and perennial streams, and also in lakes and reservoirs and given a background score of 1. However, the Department recognizes that bait bucket dumping and illegal stockings are more likely to occur near urban areas and created an inverse distance weighted gradient of 15 miles around all cities and towns. Known illegal stocking locations were given a score of 2. All weights were considered additive such that the highest level of threat is found in waterbodies that are near urban areas and known to be illegally stocked.

40 DISEASE/PATHOGENS/PARASITES

This threat is complex and can come from many different sources. It includes introduced pathogens and exotic parasites that affect native or game species and/or humans. Examples include West Nile Virus, Chronic Wasting Disease, diseases causing bighorn sheep die-offs such as *Pasteurella pneumoniae*; whirling disease, rabies, Hantavirus, chytrid fungus, various avian diseases (e.g. tricomycetes in doves), plague, and foreign animal diseases. The threat includes spreading respiratory disease to desert tortoises from adopted tortoises, threats to fish from hatcheries (state, federal and private), aquaculture threats, and domestic wolves as a disease threat to wild wolves. Lack of comprehensive spatial data for the spread of disease complicates modeling this threat. Thus, this threat is treated as a statewide issue and not mapped. Fallow deer and axis deer are also covered here because they are not a restricted live wildlife permitted by AGFD (i.e. location data are not available) and threats, if any, would be related to CWD which would be statewide.

41 FERAL ANIMALS

This category refers to escaped or abandoned domestic pets, farm stock, and equines, and includes horses, cats, dogs, burros, hogs, goats, and domestic sheep. Three methods were used to model the distribution of feral animals:

- a. Department personnel mapped “hot spots”, as places where known feral animal populations are threatening wildlife. Places where the feral animal hot spots are identified as goats, sheep, burros or horses were assigned a score of 2. Places where known hot spots were identified as dogs or cats were assigned a score of 1.
- b. A 10 mile gradient around the polygons of current cities and around points of towns was assigned a score of 1 to represent the presence of feral cats and dogs.
- c. The inside of city polygons was given a value of 0.5 because there is a threat to wildlife inside the cities from feral animals, but not as much of a threat as outside of the cities.

42 HYBRIDIZATION

Hybridization is considered a threat for the following species:

- **Wolf:** Department experts believe that the Mexican wolf is threatened with hybridization from domestic wolf mixes. This threat was mapped as the Blue Range Wolf Recovery Area plus a 30 mile buffer.
- **Bighorn:** Some experts believe there is a threat of Rocky Mountain bighorn populations meeting and hybridizing with desert bighorn. Rocky Mountain bighorn transplants and subsequent movements of transplanted animals bring them within range of desert populations. Threat of this is mapped as the bighorn habitat in the areas where the overlap concern exists.
- **Sonoran Tiger Salamander:** The Sonoran tiger salamander recovery plan identifies a threat to this species from hybridization with other tiger salamanders, particularly barred tiger salamanders. This threat is mapped as the distribution of the Sonoran tiger salamander.

- **Leopard Frogs:** Department species experts do not believe there is a significant threat of hybridization among species of native leopard frog, although some distributional overlap exists. However, there is a concern about hybridization of Rio Grande leopard frogs (*Rana berlandieri*) with native leopard frogs (specifically the lowland leopard frog, *Rana yavapaiensis*). This threat is mapped as the northern margin of the current distribution of *R. berlandieri*.
- **Rio Grande Turkeys:** All wild turkeys in Arizona are at risk of hybridization escaped domestic turkeys; wild turkeys on the Arizona Strip are at risk of hybridization with introduced Rio Grande turkeys and neighboring state management. This threat is mapped as the entire range of wild turkey in Arizona. Although the Department has introduced the Rio Grande turkey to a couple of areas in Arizona, experts believe the threat of hybridization from these transplants is lower than the threat of hybridization from the unregulated domestic turkeys in the state and from Rio Grande turkeys in neighboring states.
- **White Sucker:** Department experts believe there is a low level threat to flannelmouth and bluehead suckers due to the potential for introduction of the exotic white sucker. The white sucker currently does not occur in Arizona or is in extremely low numbers (not established yet). This threat is mapped in the upper Colorado River where the native suckers occur.
- **Trout:** There is a threat to Apache and Gila trout from hybridization with rainbow and other non-native trout. This is mapped where Apache and Gila trout occur in close proximity to non-native trout.
- **Pronghorn:** Species experts say that there are no significant concerns about hybridization for pronghorn. Genetic analyses show that the populations south of the Mogollon Rim are not different from one another. This species was not mapped.

All Hybridization threats were weighted the same and modeled as presence or absence. Additive effects were not considered.

43 NUISANCE ANIMALS

Nuisance Animals are defined as introduced populations of animals that are a threat to wild animals. This threat does not include wild animals that are considered a “nuisance” to people. Thus, the threat was identified in the SWAP as American bullfrogs, crayfish, nonnative fishes, starlings, cowbirds, ravens, and non-native bees (which could replace native pollinators and potentially impact vegetative communities). However, some specialists in the Department believe that ravens and corvids are not a significant threat to wildlife in Arizona. After much discussion, we decided that the most significant threats to wildlife were from crayfish, bullfrogs, and quagga mussels. There is not a complete database of where these threats occur, and in fact, these species threaten all waters at some level, even stocktanks which are so numerous that they cannot be mapped. Therefore, this threat is treated as ubiquitous for now and mapped statewide. The Invasive Species Council is developing a database and plan that may give future direction to how to better map this threat.

44 NUISANCE PLANTS

Nuisance plants include but are not limited to tamarisk, Russian thistle, cheatgrass, purple loosestrife, giant salvinia, iris, skunk cabbage, sneezeweed, Kentucky bluegrass, exotic grasses in the desert, dwarf mistletoe on conifers. This threat does not include juniper invasion, which is addressed separately under #16 Habitat Degradation/Shrub Invasion. The team searched for the most current data on nuisance plants. Northam et al. (2005) identifies 19 species as the highest threats to Arizona. These species have severe ecological impacts on ecosystems, plants and animal communities, and vegetational structure, their invasiveness attributes are conducive to moderate to high rates of dispersal and establishment, and those species are usually widely distributed both among and within ecosystems/communities. However this study did not provide data on where those species exist. Another study (Thomas and Guertin 2007) provided a database of known records of invasive species. The team reviewed these data and realized that the distributions were highly biased by where sampling occurred (along roads) and did not truly represent where the threats occur. The Invasive Species Council is currently working on assembling more comprehensive data. Until those data become available, this threat is treated as statewide.

45 BATTLES, MANEUVERS, WAR GAMES, MILITARY CAMPS, GUERILLA INSURGENCIES.

See threat #35 Military bases, defoliation, munitions testing.

46 DISPERSED CAMPING

Dispersed camping occurs statewide on State Trust Land and public lands (forest, BLM, some military, national refuges, park service, etc.), primarily along roadsides. The team modeled the impacts with a 200 foot buffers along rural and primitive roads on public lands, and then applied an inverse distance weighted gradient to ¼ mile from the buffer. This threat includes all noise and light pollution associates with dispersed camping.

47 MOTORIZED RECREATION OFF-TRAIL

Includes the impacts of any motorized travel off-trail including but not limited to the use of All Terrain Vehicles (ATV) and Off Highway Vehicles (OHV). There are 4 main components to this threat and they are all of equal weight in the model:

1. Land ownerships that are open to public OHV travel

All lands protected from motorized off-trail recreation, or so highly managed as to preclude trail proliferation and unmanaged volumes of traffic, are **not** included in this threat and are listed below:

- Roadless areas
- Nature Conservancy properties
- Wilderness
- Game & Fish Department properties
- BLM Natural Conservation Areas (NCA)
- Military Lands (excluding Barry M. Goldwater range)
- National Monuments

- National Wildlife Refuges*
- National Historic Sites and Parks

*Except Kofa, Buenos Aires, Cibola, and Imperial where ATV/OHV travel is permitted on designated roads and trails only.

All lands that have restrictions on public access due to ownership are also **not** included. They are listed below:

- Private Lands
- Indian Reservations
- Local or State Parks

2. Influence of urban and road proximity

The greatest amount of OHV activity is found in close proximity to urban areas, where day or weekend OHV users can quickly access public lands via paved and dirt roads. Many of the OHV hotspots fall within close proximity of urban areas. Therefore, a 5 mile inverse distance weighted gradient was included around towns and a 15 mile inverse distance weighted gradient was included around cities.

Class 1 roads (interstates) are weighted as 4, class 2 roads (highways) are weighted as 2, and smaller roads are weighted as 1. Road density was calculated using a 5 mile search radius.

3. OHV hot spots (includes perennial/intermittent riparian areas and long term visitor areas)

OHV hotspots defined as areas of high trail proliferation and traffic volume to the extent that impacts to wildlife and habitat extend beyond the footprint of the trail. Impacts include habitat destruction, fragmentation, and wildlife disturbance. Perennial and intermittent stream locations are mapped as hotspots at specific locales. Each region mapped these hotspots based on expert opinion. Some areas are actually designated for the use and are published destinations; other areas are currently unmanaged. Hot spots include a few private land parcels. Long term visitor areas are associated with BLM lands.

4. Use of xeric riparian (washes)

Xeric riparian areas are included as a threatened area. These areas are often broad sandy washes that are highly used for off-trail recreation. Riparian areas with intermittent and/or perennial flows are not included unless they have been designated as an OHV hotspot. The impacts of OHV travel in these areas are considered of the highest threat level.

Data Mapping: The map components were considered additive, rather than weighted. Roads, xeric riparian, towns, and cities were added together and additive to land ownership. Hotspots are weighted equal to all four of the previous components combined. Lands not accessible to ATV/OHV use were masked out.

BLM and Forest Service are currently in the process of developing motorized road plans. After these planning processes are complete, more accurate data on places where motorized recreation off trail occurs may become available.

This threat includes all noise or light pollution associated with motorized recreation off-trail.

48 NON-MOTORIZED RECREATION OFF-TRAIL

This threat includes #69 Trails for foot, bike, or equine use.

The SWAP defines these threats together as impacts due to foot-bike-equine trailing in fragile habitats; trespassing in restricted natural areas; or the effects on wildlife and wildlife habitat from authorized paved and dirt trails, meant for foot, bike or equine use, that currently exist or are planned.

This map was constructed utilizing regional expertise to identify localized areas where non-motorized impacts were significant such as urban parks. Polygons were hand drawn around these areas and converted to a shapefile.

49 OFF-RANGE RECREATIONAL SHOOTING

This threat has the potential to occur on all accessible public and private lands, and is closely tied to motorized vehicle access and urban and rural development. There is no way to map specific locations for this threat because they are widely distributed over nearly the same areas as motorized recreation off-trail (threat #47). Therefore this threat was mapped similarly to threat #47. Land ownerships open to the public, where recreational shooting is not prohibited by law or by federal or county land use designations will be included in this threat. A buffer zone was drawn around urban development (15 miles for cities and 5 miles for towns) and is included as an additive impact area, similar to Threat #47. However, the incorporated area for cities and towns was clipped out so that the impact is represented as the area around cities and towns, but not within the cities and towns. This was done by buffering cities by 1/2 mile and towns by 1 mile. Roads will not be included as an additive impact area.

The following lands are **not** considered for this threat due to their management status:

- Roadless areas
- Nature Conservancy properties
- Wilderness
- Game & Fish properties
- Park Service National Monuments
- National Wildlife Refuges (except BMGR)

- National Parks
- Indian Reservations
- Local or State Parks

This threat includes any noise and light pollution associated with off-range recreational shooting.

50 SCIENTIFIC RESEARCH AND COLLECTION

This threat is considered to be general, statewide, low intensity, and random. There is a concern for potential of this threat in some high diversity areas e.g. southeastern AZ, however, the Department reviews Scientific Collecting Permit applications and can reduce collecting in potential high use areas through that permit process.

51 WATERCRAFT OPERATION

This threat can occur in any lake or river where watercraft is used. Lakes and rivers that allow motorized watercraft were weighted 10 times the impact of non-motorized waters. This threat includes any noise or light pollution associated with watercraft operation.

52 CONTAMINANTS FROM WASTE WATER AND RUNOFF

This threat includes threat #53 heavy metals/mine tailings.

This threat includes the resulting turbidity and also the impacts of pesticides and herbicides in waterways and bodies of water. Ephemeral streams are not included because they normally do not have water in them. The effects of endocrine disruptors in wastewater were not assessed due to lack of data.

This threat has the potential of occurring statewide within the streams, rivers, and other bodies of water. Data from 2004 were obtained from the Arizona Department of Environmental Quality (ADEQ). ADEQ assessed water quality based on all readily available, credible, and scientifically defensible monitoring data and information pertaining to possible numeric and narrative standards violations. Any stream with more than one exceedance of these measures was assessed as “impaired”. One exceedance was assessed as “inconclusive”, and zero exceedances was “attaining”. These assessments were applied to each designated use of the water. Only the uses that affected wildlife were considered: Aquatic and Wildlife Uses, and Fish Consumption. If there were different assessments for each use, the assessment with more exceedances was used to classify the stream. The assessments were weighted as follows: 1 for attaining, 2 for inconclusive and 4 for impaired. These weights were applied to the section of stream that the assessment indicated. For those sections not assessed and all other perennial and intermittent streams not assessed, they were given a weight of 2 due to their potential of becoming impaired.

53 HEAVY METALS/MINE TAILINGS

See #52 Contaminants from waste water and runoff.

54 HIGHWAY/ROAD DE-ICING

This threat occurs along and adjacent to roads that are treated with deicing chemicals. Impacts leading to plant damage as well as plant mortality and degraded aquatic systems are the primary concern. Arizona Department of Transportation (ADOT) provided information, which was then digitized, regarding which roads and road segments are subject to the application of deicing chemicals. We did not include the application of deicing chemicals by ADOT on isolated underpasses and overpasses in the southern portion of the state, nor the limited chemical deicing activities conducted by the cities and counties. The zone of impact includes the deicer splash zone due to snow plow and passing vehicular traffic along the roadways as well as aerial drift. Literature indicates that the zone of impact can vary significantly based on such things as local topography, highway travel speeds, and wind speed and direction. In order to account for the variability in the size of the potential impact zone throughout the treated areas, we decided to use a 100 meter gradient from the road centerline as the zone of impact.

55 ILLEGAL DUMPING/LITTERING

This threat includes trash that is thrown out or blown out of vehicles, large illegal dumping sites around cities, trash left by recreationists, trash that ends up in lakes and streams from recreationists or from rainfall events and floats downstream, etc. We mapped this threat as follows:

- Existing cities, towns, and BLM long-term visitor areas with a 5 mile gradient = weight of 10
- Major roads (interstates, highways, and major arterials) with a 1 mile inverse distance gradient with an additional weight of 10
- Minor roads (small, rural, and primitive roads) with a buffer of 1 pixel (30m) and a weight of 1
- Lakes and major rivers (Colorado from Hoover Dam down, Salt from Stewart Mountain Dam down, Verde from Horseshoe Lake down) and a weight of 5
- Minor streams with a weight of 1

All weights are additive. Trash associated with illegal border crossings is treated under threats #5 – 13.

56 LEAD SHOT/FISHING LINE

Although these two components are included in the same threat, their spatial pattern is not the same so they were modeled separately. After consulting with eagle and condor experts in the Department, we determined that lead contamination is a statewide threat. Lead in the environment is not necessarily associated with water through the deposition of lead shot. It can also result from spent lead from firearms, as lead fragments in legally taken game animals that are not retrieved or in parts discarded from game animals, through mining and smelting activities, at firearms training facilities, as well as in trace amounts throughout the environment. It is affecting many wildlife species across the state, and therefore should be mapped statewide.

Fishing line pollution is, however, associated with water bodies and all places where angling occurs. Discarded or lost fishing line often causes entanglement or ingestion by riparian birds and raptor species associated with aquatic systems. It is a higher threat in those places where angler use days are high. We mapped the threat of fishing line along all shorelines in the state where angling occurs (sportfish and apache trout habitats). Angler use data show that fishing occurs 2.3 time more often on lakes and reservoirs, so lakes and reservoirs were given 2.3 times more weight than rivers and streams to account for the fact that the amount of fishing line is likely correlated directly with angler use.

57 LIGHT POLLUTION

This threat includes the impacts resulting in altered wildlife behavior patterns and is considered to be covered by other threat models including roads, urban and rural development, camping, mining, wind energy, motorized recreation, air traffic, motorized watercraft, off-range shooting, war games, recreational site facilities, railroads, border threats, and drilling for fuels.

58 NOISE POLLUTION

This threat includes the impacts resulting from altered behavior patterns and is considered to be covered by other threat models including roads, urban and rural development, camping, mining, wind energy, motorized recreation, air traffic, motorized watercraft, off-range shooting, war games, recreational site facilities, railroads, border threats, and drilling for fuels.

59 NUTRIENTS/ALGAL BLOOMS

This threat is mapped as all lakes and streams (intermittent and perennial). Although algal blooms occur less often in moving water, streams are included because they transport nutrients and algae from one body of water to another. Streams are weighted as 1, lakes as 10, and lakes with previous algal blooms as 20.

60 PESTICIDES/HERBICIDES

We mapped this threat in agricultural fields, as identified in SWReGAP vegetation layer. The threat from pesticides and herbicides in waterways and water bodies is captured in Threat #52/53. The threat from spraying herbicides and pesticides along highways is more appropriately included in Threat #67, and the threat of spreading pesticides and herbicides by canals was included in threat #63.

61 SEDIMENT/ASH FLOW

This threat is described as the increase of sediment and ash flow that results from unnatural fire regimes typically associated with high fuel loads. This does not include sediment that is caused from other sources, like overgrazing (threat #27) or soil erosion (threat #21). We mapped Sediment/Ash Flow as the perennial and intermittent streams and lakes in areas where sediment and ash flow from forest fires could impact wildlife. The model is based on the statewide layer of streams and lakes. Waters that are remote and disconnected from forested areas were removed. Although unnatural fire regimes appear in non-forested (e.g. desert) areas, these fires move through fast and do not necessarily result in increased ash flow and sediment.

62 AIR TRAFFIC CORRIDORS/OVERFLIGHTS

This threat includes all noise or light pollution associated with air traffic corridors or overflights.

This threat consists of the following impacts:

- Military airports plus primary airports including a 10,000 ft radius buffer. Military airports are scored highest at 4. Primary airports are broken down into scores 3, 2, 1, and 0.5, based on their jet capacity and level of activity
- The high impact tourist areas at the Grand Canyon and around Sedona were also scored as a 4.
- Military training routes at or below 2000 ft above ground level, the level recommended by the Bald Eagle Management Program. These were buffered with the distances the Department of Defense uses in their NEPA analysis of wildlife impacts.

63 CANALS/PIPELINES

Water delivery systems (canals, ditches or irrigation delivery) are a threat to wildlife as movement barriers, through the spread of herbicides, pesticides (threat #60) and contaminants that can cause impaired water quality status (threat #52). They also facilitate the spread of invasive exotic aquatic animals (such as nonnative fish and quagga mussels- threat #43) and invasive exotic aquatic plants (such as giant salvinia and golden algae- threat #44). Therefore, this threat accounts for all of those related threats. This threat does not account for the spread of pesticides and herbicides as a result of runoff from agricultural lands into aquatic systems (natural washes, streams or rivers, lakes), a component of threat #60.

Arizona has a vast network of water delivery systems including various irrigation district canal networks, the Salt River Project (SRP) delivery system in central Arizona, and the Central Arizona Project (CAP) that delivers water from the Colorado River to central Arizona. Small regional irrigation systems and canal systems such as SRP are less of a barrier to wildlife primarily due to their smaller size, lack of fencing or urban locations. However these systems still create movement conduits for aquatic plants and animals, for example, the SRP system is hydrologically connected to the Salt and Verde River watersheds at the Granite Reef Diversion Dam. In the future, the team recommends acquiring additional data to map all irrigation delivery systems for the state.

For the current mapping effort we included:

- Large water delivery systems in the state including the CAP, Welton-Mohawk and Dome canals in southwestern Arizona, and CAP laterals to the Tohono O'odham Reservation
- The SRP delivery system throughout the Phoenix metropolitan area and outlying communities.
- Irrigation delivery systems along the Upper Verde River, including irrigation delivery laterals and ditches that are mapped by Northern Arizona University researchers.

- Statewide data from Arizona Department of Water Resources on small delivery systems that include canals and ditches.

Accurately mapping pipelines is problematic due either to a) incomplete data or b) a significant portion of the infrastructure is not available to the public for security reasons. Arizona has a vast network of inter/intrastate natural gas pipelines, crude oil pipelines, product pipelines, and related processing, metering or compression stations. Most pipeline systems are below ground after construction. Related infrastructure, maintenance roads, and construction activities are the primary threat. Pipeline networks are mapped nationally and are available through the Dept. of Transportation Office of Pipeline Safety National Pipeline Mapping System. It would require an official request for the data to secure access and therefore we did not pursue it at this time. However, in the future it may be possible to acquire those data. Because existing pipelines are less of an impact than new pipeline projects, only the following large proposed new pipeline projects and corridors were included: the West-wide Energy Corridors proposed by BLM, Transwestern's Phoenix Lateral, and El Paso's parallel project from San Simon to Tucson.

Pipelines, canals and ditches are buffered by 30 meters. Transwestern and El Paso pipelines are weighted 1, Westwide corridor is weighted 5, and canals and ditches are weighted 10.

64 DREDGING

Regional experts developed a list of lakes that are dredged or have the potential to be dredged. These were then mapped. Although stock tanks are often dredged, we are not mapping stock tanks, because they occur throughout the state and there is no stock tank database. Urban lakes are typically not dredged and therefore are not considered in this threat.

65 POWERLINES/WIND-HARVESTING TURBINES

This threat includes any noise or light pollution associated with wind harvesting.

Powerlines were removed from this threat and added to #68. Wind-harvesting was mapped using wind energy resources (windy areas, i.e. where studies have shown that future wind harvesting turbines would be most productive) that have been mapped by Northern Arizona University in combination with known areas that wind facilities have been proposed. A scale of 1 to 10 was assessed. The wind resources were already rated from 1 to 7 on potential wind resources. The proposed wind facilities were given higher ranks, 8 through 10, depending on where they were in the assessment of the wind resource, with 10 being the most promising, 9 just started but believed to be promising, and 8 is proposed facilities or meteorological towers.

66 RIGHT-OF-WAY FENCING ALONG ROADWAYS

See #67 Roads for Motorized Vehicles

67 ROADS FOR MOTORIZED VEHICLES

Includes #66 Right-of-Way Fencing along Roadways.

Ecological effects of roads are the direct impact within the route corridor (loss of habitat, road kill mortality), indirect effects distributed radiating outward from the route corridors (e.g. impacts to home range of wildlife), and dispersed landscape effects resulting from cumulative effects of multiple routes across the landscape (e.g. habitat fragmentation, population isolation). Evaluation of this threat includes the threat from herbicide or pesticide treatments along roads and noise and light pollution along roads.

The US Census Bureau's Topologically Integrated Geographic Encoding and Referencing system's road layer is the basis for mapping this threat. The layer was cleaned by removing class 5 (primitive) roads that were completely contained within wilderness areas. Many of those roads were known to be trails. Of the remaining roads, interstates were given a weight of 10, highways a weight of 5, and smaller roads a weight of 1. Road density was calculated with a search radius of 600 m which is the average distance roads were found to impact wildlife in at least one study (Foreman and Deblinger, 2000). There are no future roads in this layer because the data are dispersed and hopefully will be collated when the Arizona Department of Transportation's Building a Quality Arizona Plan is released.

68 TELEPHONE LINES/CELLPHONE TOWERS

Includes #65 Powerlines. Power lines, telephone lines, and cell phone towers can occur in all areas of the state, whether in wild lands or in more urban areas and is considered to be statewide.

69 TRAILS FOR FOOT, BIKE, OR EQUINE USE

See #48 Non-motorized recreation off-trail

70 UNAUTHORIZED ROADS AND TRAILS

This threat is statewide in all habitats.

71 SOLAR ENERGY DEVELOPMENT

We used a map published by the National Renewable Energy Laboratory on the feasibility of placing solar panel fields in Arizona (see <http://www.nrel.gov/solar/>). That map showed all land with a slope less than 3% as suitable for solar energy development. We mapped all land in Arizona that met those guidelines, excluding wildlife refuges, state, local and national parks, AGFD properties, urban areas, and wilderness.

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