CHAPTER 2 ENVIRONMENTAL BASELINE AND RESOURCE CONDITIONS

BACKGROUND

Arizona’s natural fish fauna historically consisted of 36 species of fish, only two of which were traditionally sought by early Americans for sport fishing, the Apache and Gila trout. Since the early 1900’s, the AGFD has supplemented recreational angling opportunities by stocking state waters with sport fish species. The AGFD manages sport fishing resources in two broad categories, reflecting cold water fisheries (trout) and warm water fisheries. Management of these waters is based on biology, angler use, partnership commitments and needs, and social demands.

The AGFD has 159 stream management reaches that are managed primarily for trout. Those areas have a combined length of 1470 miles. Four other stream reaches, totaling 34 miles, are managed primarily for warm water species and secondarily for trout. Presently, 64 lakes, comprising approximately 3,000 acres, are managed primarily for trout. Ten other lakes managed primarily for warm water fish also provide trout fishing opportunities, on approximately 30,000 acres. AGFD manages about 354,800 acres of impounded water (lakes, reservoirs, ponds, and tanks) and 35,840 acres of flowing water (about 1400 linear miles) for warm water species. Recreational angling creates a statewide economic impact of more than $1.1 billion annually. In 2007, AGFD sold 375,158 fishing licenses, generating revenue of $8.8 million.

Each year hundreds of thousand Arizona residents and non-residents take advantage of recreational fishing opportunities provided by the sport fish stocking program. In 2006, there were 4,156,000 angler days of fishing in Arizona (2006 National Survey of Fishing, Hunting and Wildlife-Associated Recreation, U.S. Fish & Wildlife Service). Sport Fish Restoration funding would make it possible for AGFD to continue to meet and sustain this demand for public recreational angling opportunities in Arizona waters.

The history of the discovery, identification and documentation of the distribution of fishes in Arizona began before the area became a state. Numerous surveys in the area and along the boundary of what would someday be the United States and Mexico were conducted from 1825-1912. These surveys documented some of the natural aquatic fauna found in the desert southwest prior to occupation by Anglo-Americans. Fish such as the razorback (humpback) sucker, Colorado pikeminnow (aka Colorado River white salmon) and roundtail chub (aka Verde trout) were abundant and common throughout the natural and (relatively speaking) unaffected waterways of the southwest.

Frederic Morton Chamberlain was one of the earliest aquatic biologists to conduct systematic collections of fishes in Arizona, from January through April of 1904 (Brown 2009). By even this
early date in Arizona’s history, Chamberlain documented introduced fishes co-occurring with the native species in many of the habitats in Arizona. In the Colorado River near Yuma, carp and catfish (bullheads) were collected alongside humpback suckers, salmon and bonytail. Carp were also found in the Santa Cruz River near Tucson with longfin dace, suckers, topminnow and chubs. Higher up in the mountains near Tucson, rainbow trout were planted in streams in 1901-1902. At Monkey Spring, formerly the only home known for the Monkey Spring pupfish (now extinct), catfish were introduced by the owner in 1899. Catfish (bullheads) were stocked into ponds along the Gila River near Safford in 1902 followed in 1903 by bass and more catfish. The US Bureau of Fisheries was active throughout this early period in providing fish from back east for introductions throughout Arizona. The attitude towards fish management by early biologists is maybe best represented by this quote from F.M. Chamberlain’s 1904 report: “The only hope for fish in this region lies in pond culture”.

In the mid-1980’s, the late Bill Silvey, Fisheries biologist with the AGFD, created a chronology of fish in Arizona. His effort has been modified and modernized for inclusion (Figure 4). By 1975, only two years after passage of the Endangered Species Act, all nonnative fish currently known from Arizona except inland silverside, alligator gar and gizzard shad had already been introduced to Arizona streams and reservoirs.

Aquatic habitats, also at this early time, were also being adversely affected by man’s attempts to civilize the west. As early as 1904, Chamberlain documented the loss of fish life through landscape level impacts such as ranching that denuded range and riparian vegetation, irrigation diversions that dries reaches of streams and mining waste/sedimentation that killed fish in entire stream reaches. Loss of fish diversity and abundance was also a concern through unlimited harvest of some streams by anglers, primarily harvest of native trout. Subsequent anthropogenic developments and management since this time has resulted the continued destruction, disappearance and modification of aquatic habitats throughout the state.
Figure 1. Chronology of native fish occurrences and nonnative fish introductions in Arizona.
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SPORTFISH MANAGEMENT AND STOCKING

The mission of the AGFD is to conserve, enhance, and restore Arizona's diverse wildlife resources and habitats through aggressive protection and management programs, and to provide wildlife resources and safe watercraft and off-highway vehicle recreation for the enjoyment, appreciation, and use by present and future generations. Achieving this mission requires the AGFD to balance the needs of native aquatic species that are not pursued for sport by the recreating public, with that public’s demand for recreational opportunities. The AGFD provides many different types of recreational angling opportunity for the public.

The AGFD employs a three-tiered planning model. The first tier is the Strategic Plan completed every 6 years. It sets AGFD direction, is approved by the Commission and provides broad direction to the AGFD. The second tier is the Operational Plan. These are Project-level plans developed every 2 years that target the strategies identified in the Strategic Plan. Operational Plans are developed at the sub-program level (i.e. Game Sub-Program, Sportfish Sub-Program, Nongame Sub-Program etc.). The third level is the Implementation Plan. These annual plans are based on available and identified budgets and identify specific activities aimed at achieving the Strategic Plan goals and objectives. Implementation Plans are developed at the work-unit level (Regional and Branch offices).

The mission of the Sportfish Sub-Program, as identified in its related 2007 draft Operational Plan is to: Maintain, manage, and enhance (when appropriate and economically feasible) the quality, abundance, availability, and diversity of sport fishing opportunities; and disseminate information about Arizona's sport fish and sport fishing opportunities for present and future generations.

2007 Sportfish Sub-Program Operational Plan Goals:
- Maintain, manage, and enhance the quality, abundance, availability, and diversity of sport fish opportunities while contributing to the recovery of Arizona’s native fishes.
- Develop integrated, watershed-based fisheries management approaches for watersheds in Arizona and identify reaches or zones for management for sportfishes and native fishes.
- Increase public awareness of Arizona’s sport fishing resources and opportunities.
- Develop and implement actions to increase angler recruitment and retention

2007 Sportfish Sub-Program Operational Plan Objectives:
- Annually, provide sport fishing opportunities to accommodate 1.6 million coldwater and 4.4 million warm water angler days by the year 2012.
- Achieve a 10 percent increase in satisfaction rating among Arizona's angling public by 2012 (i.e. percent of Arizona's anglers indicating they were satisfied with their angling experience, currently 68%, new target 75%).

In order to accomplish these goals and objectives, the AGFD has need to stock through hatchery propagation or contracted vendors sufficient numbers of various sport fish species. Each
identified waterbody in this consultation is managed as a warm or cold water fishery. Stocking activities for sport fish can be described as population augmentation, restoration or maintenance. Furthermore, each water body can be managed as a put-take, put-grow-take, sustained yield or intensive yield fishery. Cold-water trout fisheries are managed under one of six concepts: Intensive Use, Basic Yield, Blue Ribbon, Wildfish, Featured Species or Urban. Concepts are matched to specific fisheries to accommodate biological and social demands. Warm-water fisheries are not managed under these variable concepts, but primarily as sustained yield fisheries with exceptions for preferred or seasonal species (i.e. walleye as put-grow and take or winter trout in otherwise warm-waters).

**STOCKED SPORTFISH SPECIES BIOLOGY**

The list of sport fish species considered in this document is based on the proposed species for stocking. For each species the following discussion includes background, habitat requirements, breeding biology, feeding preference and movement when that information was available.

**APACHE TROUT (ONTORHYNCHUS GILAE APACHE)**

**Background:**
Apache trout were once abundant in high elevation streams in the upper Black, White, and Little Colorado River drainages in east-central Arizona, but factors such as watershed alterations and the introduction of nonnative trout reduced the total occupied range and the ability of Apache trout to effectively persist at all life stages.

The Apache trout was considered endangered under the Federal Endangered Species Preservation Act of 1966, and the species became federally protected with the passage of the Endangered Species Act of 1973. In 1975, it was downlisted to threatened after re-evaluation of its status. The downlisting was accompanied with special rule [4(d)] that enables AGFD to identify populations or waters where Apache trout can support angling without compromising recovery. Apache trout reared in hatcheries are also managed and stocked as a sport fish within Arizona, however, only a few recovery streams are open to angling with special regulations. A Recovery Plan was completed in 1979, and revised in 1983; a draft second revision was published on the Federal Register in 2007.

**Habitat Requirements:**
Information concerning specific stream habitat requirements for all life stages of Apache trout is limited. Apache trout currently exist mainly in headwater areas upstream from natural and artificial barriers. This environment is subject to extreme variations in both temperature and flow. Instream cover and bank cuts are important variables defining Apache trout habitat. In general, Apache trout select areas with the greatest depths and cover in the absence of nonnative trout. The temperature tolerances of Apache trout are similar to other species of trout, with critical limits above 25 °C (Alcorn 1976; Lee and Rinne 1980).
Breeding Biology:
Apache trout spawning in the White Mountains occurs from March through mid-June, and varies with stream elevation. Apache trout begin redd construction and associated spawning during receding flows in the spring, at approximately 8°C (Harper 1978). Redds are constructed primarily at downstream ends of pools in wide varieties of substrates (0.87 mm to 32 mm size), most frequently in water depths from 19-27 cm in areas that receive day-long illumination, with water velocities ranging between 50-110 cfs (Harper 1976). Spawning maturation is estimated to begin at 3 years of age, with eggs hatching in approximately 30 days, and emergence occurring about 60 days after deposition (Harper 1978).

Feeding Preferences:
The Apache trout is largely an opportunistic feeder that eats a variety of aquatic and terrestrial organisms, the utilization of which can vary with the season and fish size. Studies have shown Apache trout to be diurnal feeders, with mayflies and caddisflies dominating their diets in stream environments (Robinson and Tash 1979). In lake habitat, Apache trout have been observed to feed on aquatic and terrestrial insects, zooplankton, crustaceans, snails, leeches, nematodes, and fish (Clarkson and Dreyer 1996). In a 2004 consultation on Apache trout enhancement project, predation or interaction of Apache trout

Sportfish Management:
Apache trout management offers a unique opportunity to accomplish both the recovery of a threatened species and to provide angling opportunities for the public. The AGFD, through collaboration with FWS, U.S Forest Service, San Carlos Apache and White Mountain Apache Tribes has designated angling opportunities for Apache trout in certain waters. Only a few recovery streams are currently open to angling with special regulations, and some streams and lakes are stocked with hatchery Apache trout to enhance angling opportunities. The AGFD under A.R.S. Title 17 and the White Mountain Apache Tribe impose and continue to enforce restrictive angling regulations to protect Apache trout in these streams. All new stocking locations (none are proposed within this consultation) are subject to both the ESA and NEPA consultation. Do we designate recovery streams and high harvest streams?

Arctic Grayling (Thymallus arcticus)

Background:
Arctic grayling is a nonnative fish to Arizona, introduced in 1940. The body has scattered black spots on silver-gray, sometimes pink sides, and has scales larger than trout scales. The dorsal fin is large, dark-gray, blotched with pale spots, with cross-rows of deep blue spots and edged with red or orange. The tail fin is forked. Arctic grayling reach lengths of 12 to 16 inches, and grow to weights over 1 pound.
Habitat Requirements:
Arctic grayling prefer clear, cold, uncontaminated water of lakes and streams with water temperatures between 47 – 52°F spawned (Wydoski and Whitney 2003). High mountain lake habitats and headwater streams are habitats best suited to arctic grayling as they experience higher growth rates at low water temperatures. Grayling are found in Lee Valley Reservoir and a few small high mountain lakes in the White Mountains. They spend most of the year in the lake then "run" upstream to spawn in the spring.

Breeding Biology:
Arctic grayling lifespan is typically 6 – 10 years, and they reach a maximum length of 24 inches, and a maximum weight of 5 pounds. Sexual maturity is generally reached in 2 years. Spawning occurs in spring from March to June over gravel or rocky bottoms. Arctic grayling do not build redds; however fertilized eggs sink into the spaces in the loose gravel, and males defend territories. Egg production varies from 416 – 15,905 eggs, and several spawning acts may occur until all of the eggs are spawned (Wydoski and Whitney 2003).

Feeding Preferences:
Arctic grayling are opportunistic feeders that feed primarily on zooplankton (copepods and cladocerans) and aquatic insects (mayfly and Diptera larvae). Adults feed primarily on insects as well as amphipods, caddisfly larvae, and mayfly nymphs, snails, and small fish such as sticklebacks. Fish are found only occasionally in grayling stomachs.

**Black Crappie (Pomoxis nigromaculatus)**

Background:
Black crappie is native to eastern United States and southern Canada, and has been introduced widely elsewhere (Sublette et al. 1990). In Arizona, it was introduced in 1905, and have established in most warm water reservoirs (AGFD 2003). While crappie is common in lakes and reservoirs, there are very few records of crappie establishing or persisting in streams or rivers in the state. They do not tend to move over long distances, but do exhibit seasonal movements between habitat types through aggregating in large groups, in deeper water during the winter and moving into the shallower waters in the warmer seasons for spawning (Lucas and Baras 2001).

Habitat Requirements:
Black crappie inhabits warmer sloughs, lakes, reservoirs and larger slow flowing rivers. Preferred habitat is lentic habitats with clear water and substantial vegetation (Etnier and Starnes 1993, Pacey and Marsh 1998). Sublette et al. (1990) suggest that compared to white crappie, black crappie is less successful in turbid waters which has limited its distribution in many New Mexico waters; thus, similar environmental limitations are probably limiting its range in Arizona.
Breeding Biology:
Black crappie grows to 15 – 30 cm in Arizona (AGFD 2003). Spawning occurs in late spring and early summer (May or June) when water temperatures are 14 – 20 C (Sublette et al. 1990) in depths of 1-3ft and at ages from 1-2yrs (Minckley 1973; Sublette et al. 1990; LaRivers 1994; Moyle 2002). Spawning occurs in larger groups near submerged bushes or banks and are prolific egg layers. Nests are located in gravel or sandy substrates in shallow water and are guarded by the male. Often the nests are placed in protected areas such as coves or deep pools. Females contain 10,000 – 160,000 eggs and may spawn multiple times annually (Etnier and Starnes 1993).

Feeding Preferences:
Young fish feed on small invertebrates, including microcrustaceans and small insects, but prey on more fishes as they mature (Etnier and Starnes 1993). Sublette et al. (1990) describe adult as mid-water carnivores, feeding on insects, crustaceans, other invertebrates, and small fish. They prefer minnows and small sunfish as adults, planktonic crustaceans and various larval insects in juvenile stages (Minckley 1973; Sublette et al. 1990; Moyle 2002). Minckley (1973) stated that in Arizona, when they achieve 100mm in length they shift almost entirely to threadfin shad.

BLUEGILL (LEPOMIS MACROCHIRUS)

Background:
The native range of the bluegill includes the fresh waters of eastern and central North America (Sigler and Sigler 1987). It was introduced into Arizona in 1932. These fish tend to have small home ranges but may exhibit seasonal movements between habitat types by aggregating in larger groups in deeper water in the winter and moving to the shallower waters during the warmer seasons for spawning (Lucas and Baras 2001).

Habitat Requirements:
Bluegill inhabits lakes, ponds, rivers, and streams in moderate flow to still waters (Sublette et al. 1990, Pacey and Marsh 1998). Bluegill prefer static, clear ponds, reservoirs and sluggish streams with adults preferring warmer waters with rooted aquatic vegetation. Pacey and Marsh (1998) report that bluegill occupy pools associated with cover in lotic habitats. Preferred water temperature is 16 – 32oC, but have been observed between 4 – 34oC. In Arizona, bluegill are found in reservoirs or ponds below 8,200 ft. in elevation, and rarely occur in stream or rivers (AGFD 2003).

Breeding Biology:
Sublette et al. 1990 reports that in New Mexico, maximum standard length of adults does not exceed 16.5 cm (6.5 in). In Arizona, bluegill grows to 10 – 33 cm (AGFD 2003). Spawning occurs from late May through mid-August in water temperatures of 64-80 degrees F at depths of up to 9ft. (Minckley 1973; Sublette et al 1990; Moyle 2002). Incubation periods may be as short as 2.5 days at water temperatures equal to or exceeding 70 degrees F (Minckley 1973; Sublette et
al. 1990; Moyle). No substrate preference has been reported as the reports indicate use in all substrates including mud (LaRivers 1994). Eggs (2,000 – 50,000) are deposited in shallow depressions and guarded by the male (Sigler and Sigler 1987, Sublette et al. 1990). Males continue to guard the newly hatched fry for an additional day and may feed on them with no parental care after hatching.

Feeding Preferences:
Sublette et al. (1990 and citations within) describe ontogenetic and habitat-specific variation in feeding preferences: larvae and juvenile (5 - 10 mm) fish feed on cladocerans and copepod; upon reaching 20 mm, feeding habits become more varied; adults consume copepods and insects (primarily chironomids). Aquatic insects, crayfish, and small fish will also be consumed in particular habitats (Sigler and Sigler 1987, Sublette 1990). Pacey and Marsh (1998) identify consumption of fish and/or fish eggs of largemouth bass (Micropterus salmoides) and sunfishes (Lepomis spp.). Bonar et al. (2004) considered bluegill to be a less significant piscivore in the Verde with less than 4% of fish in their diet.

**BROOK TROUT (SALVELINUS FONTINALIS)**

Background:
Brook trout is a nonnative sport fish, which was introduced to Arizona in 1903. Its coloring is gray to olive-green on the back with vermiculations or worm-like markings on the back and dorsal fin, with lighter colored sides having pink or red spots with blue halos around them. Brook Trout lower fins and tail fin have a white edge. In Arizona waters brook trout will grow to 21 inches in length and reach 4 pounds in weight.

Habitat Requirements:
Brook trout are found primarily in cold, clear headwater streams and in cold lakes; in Arizona these include colder streams and lakes in the White Mountains. Preferred brook trout temperature ranges between 13.9 – 15.6ºC (Clark 1969) with a critical thermal maximum of 25ºC (Fry 1951). Brook trout reproduce in streams but are most often found in lakes stocked by the AGFD.

Breeding Biology:
Brook Trout spawn in late fall/early winter. Redds are constructed by females in areas of current, including riffles or spring seepage, and eggs are covered with gravel. After spawning, the male remains to guard the nest. Males reach sexual maturity in first year, females in their second (Becker 1983). Egg counts reported to range from 100 – 5,000 depending on the size of the female (McAfee 1966b). Brook trout are known to hybridize with brown trout S. Trutta.

Feeding Preferences:
Brook trout feed primarily on feed on aquatic and terrestrial insects, and planktonic crustaceans, but larger brook trout will eat small fish if they are available.
Movement:
Kondratieff and Myrick (2006) conducted a study to see how high brook trout could jump over various sized barriers (waterfalls). In a variety of lab experiments they came up with this data:

<table>
<thead>
<tr>
<th>Length of fish</th>
<th>Height of waterfall</th>
<th>Plunge Pool Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>15cm</td>
<td>63.5cm</td>
<td>50cm</td>
</tr>
<tr>
<td>15-20cm</td>
<td>73.5cm</td>
<td>40 or 50cm</td>
</tr>
<tr>
<td>20+cm</td>
<td>73.5cm</td>
<td>40cm</td>
</tr>
<tr>
<td>20+cm</td>
<td>43.5cm</td>
<td>10cm</td>
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</table>

This study showed that shallow pools severely reduce the trout’s jumping ability. Waterfall height, pool depth, and fish size all influence a fish’s ability to jump. The data showed that fish of all sizes need a fairly deep plunge pool (40-50cm) in order to jump a significant height (63.5 - 73.5 cm). Kondratieff and Myrick (2006) also pointed out that physical conditions, particularly fin conditions, affect jumping ability. Considering that the majority of salmonid species stocked in the state come from hatcheries with concrete raceways where fin loss is evident, this should be considered when looking at stocked hatchery fish in systems where there are barriers. Fin loss or damage limits fish ability to jump over barriers for a certain period of time.

BROWN TROUT (SALMO TRUTTA)

Background:
Brown trout are native to Europe, and like the rainbow have been introduced widely in North America, and were introduced into Arizona in 1924. Brown trout are more tolerant of higher water temperatures and heavy angling pressure than rainbow trout (Etnier and Starnes 1993).

Habitat Requirements:
Brown trout typically inhabit small to large cold water streams, lakes, rivers, and reservoirs and have been able to form self sustaining populations in all of the habitat types (Belica 2007). They tend to occupy deeper, lower velocity, and warmer waters than other trout species. The upper incipient lethal temperature for adults is 27ºC; optimal growth and survival is 12 –19ºC (Raleigh et al 1986). Optimal dissolved oxygen levels appear to be at least 9 ppm at temperatures < 10ºC and at least 12 ppm at temperatures > 12ºC (Raleigh et al 1986). The preferred water temperature in reservoirs is ~7.5-21.9º C during the months of July and August and ~8.8-12º C during the month of September (Belica 2007). Incipient lethal dissolved oxygen concentration for adults is approximately 3 ppm (Sublette et al. 1990). Brown trout occur within a range in pH of 5.0-9.5 with an upper lethal limit of 9.2 although optimal growth occurs at a pH of 6.8-7.8 (Sublette et al. 1990). Adults are inclined to be rather sedentary, frequently spending much of their time in the same pool (Etnier and Starnes 1993). They tend to occupy deep water in edge secondary habitat types closer to cover and stream banks at depths of 14-54m in large reservoirs. During
the day they will occupy single boulder and wing dam structures to hind under. At night they can be found in mid-channel clusters or areas without as much structure (Belica 2007).

**Breeding Biology:**
In New Mexico, *S. trutta* on average grow to 206-826 mm TL, with a maximum length of 1,029 mm. Brown trout become sexually mature during 3-5 years. Spawning occurs typically in streams or rocky shoals of lakes during late fall and early winter. Depending on the size of the individual 400 to > 2,000 eggs are produced. Optimal incubation temperatures are 2-13°C.

**Feeding Preferences:**
In streams, young brown trout feed principally on aquatic and terrestrial invertebrates in the drift assemblage; larger individuals (> 25 cm TL) feed primarily on benthic invertebrates and small fish (Sublette et al. 1990). Brown trout are known to prey on fish species such as small suckers, minnows, sculpin, and darters. Trout occupying pools tend to have higher diet specialization than those predominately associated with riffles. Their appetite is greatest at temperatures of 13.3-18.4°C and decreases rapidly at temperatures above 18.4°C and declining slowly at temperatures from 13.3-6-6°C (Belica 2007). Large adults are known to occasionally eat turtles and small mammals (Etnier and Starnes 1993). Sweetser et al. (2002) supported the piscivorous nature of the brown trout in Arizona. They documented brown trout consuming Little Colorado Spinedace in the Little Colorado River, and the species had the highest levels of piscivory of the three species they examined (brown, brook, and rainbow trout).

**CHANNEL CATFISH (ICTALURUS PUNCTATUS)**

**Background:**
Channel catfish is native to central North America and south-central Canada, portions of the Atlantic Coast and to the Rio Conchos drainage in Mexico (Sublette et al. 1990). It has been widely introduced in both western and eastern North America. In Arizona, it was introduced in 1878, and has established in many warm water habitats. Channel catfish are considered sedentary and seasonally migratory. Records of up to 78.3 miles in a Midwestern drainage have been traveled (Lucas and Baras 2001). This strategy allows for them to exploit spawning and feeding habitats of smaller tributaries in the summer months and retreat to the safety of deeper water habitats during the winter months (Lucas and Baras 2001).

**Habitat Requirements:**
Sublette et al. (1990) and Etnier and Starnes (1993) describe this species as the most versatile catfish, which typically inhabits medium to large warm rivers, reservoirs, lakes, stock ponds, and some larger cool water streams. Pacey and Marsh (1998) summarized life stage habitat affinities for native and nonnative fish species in the Lower Colorado River: larvae remain close to adults until moving to riffles; juvenile fish occupy riffle and runs; adults occupy a variety of microhabitats, but generally are found in slower, deep waters with adequate cover.
Breeding Biology:
Etnier and Starnes (1993) found that channel catfish in Tennessee had highly variable growth rates, with expected lengths that ranged from 8.6 – 16.3 in year 1, to 24.1 – 33.3 in year 4, to 46.2-49.5 cm by year 8 and occasionally reach 90.0 cm (36 in) and 11 kg, but on average are 0.9 –1.8 kg (2-4 lbs). In Arizona, fish generally grow to 25 – 99 cm (AGFD 2003). Sexual maturity occurs at 270 mm. Spawning occurs in spring and summer at temperatures of 21-29 C (Sublette et al. 1990). Females may lay from 2,000 – 70,000 eggs per year (Scott and Crossman 1973, Etnier and Starnes 1993). Nests in New Mexico were constructed in burrows in undercut banks, or other protective areas such as rubble, boulders, or logs (Sublette et al. 1990). The preferred or optimal temperature range for the species is 21 – 35°C; adult mortality occurs at 38°C (Pacey and Marsh 1998).

Feeding Preferences:
Feeding is done primarily at night, with most activity from sundown to midnight (Sublette et al. 1990). Juvenile feed on aquatic insects, while adults will also take fish, fish eggs, crayfish, and some plant material (Sublette et al. 1990). Pacey and Marsh (1998) summarized diet studies on the Lower Colorado River, adults have been recorded consuming: small vertebrates, salamanders, fish (including eggs), a variety of terrestrial and aquatic insects, crustaceans (including crayfish), mollusks, terrestrial plant seed and fruit, and aquatic vegetation. Marsh (1981) found that channel catfish primarily fed on Trichopteran, Odonata, filamentous algae, chironomids, and aquatic Lepidoptera in the Cochella Canal, California. Although locally abundant, threadfin shad (Dorosoma petenense) and Asiatic clams (Corbicula fluminea) were not primary food items.

Movements
Studies of the movements of channel catfish in lakes and reservoirs have been limited. Movement of reservoir populations increases during or immediately following periods of increased river flow. Reservoir and river populations of channel catfish show a general trend for upstream migration in the spring, followed by downstream movement in the fall back to their home range (Dames et al. 1989). Dames et al. (1989) reported river populations showing greater movement in spring than in other seasons. Duncan and Myers (1978) attributed these greater movements to high rainfall and high inflows into the reservoirs. Adults are capable of moving considerable distances in streams, though usually not more than 161 km. A reported individual in the Missouri River, Missouri, traveled 469 km upstream in a 72 day period (averaging 6.5 km/day). It has been suggested that channel catfish in the size range of 280-380mm (age 4-6) are more likely to move in and out of tributaries. Similarly channel catfish in the size range of >380mm are more likely to stay in rivers (Dames et al. 1989).
**CUTTHROAT TROUT (ONCORHYNCHUS CLARKII)**

**Background:**
Cutthroat trout is a nonnative Arizona sport fish that was introduced in 1900. Its body shape is similar to that of rainbow trout with lightly spotted back and sides and heavily spotted dorsal, adipose and tail fins. The species is noted for the red or reddish-orange slash on throat. The length and weight range from 8 to 22 inches and 4 ounces to 6 pounds respectively.

**Habitat Requirements:**
Cutthroat trout prefer clear, cold streams and lakes. This species is rarely found in Arizona's streams, but widely occur in the White Mountain lakes, which are stocked by the AGFD. They prefer the same habitat as rainbow trout and are found in similar areas.

**Breeding Biology:**
Cutthroat trout spawn in streams from March – July depending on water temps, runoff, elevation, generally beginning at water temperatures of 5.5 – 9°C (Behnke and Zarn 1976). Females build gravel nests in flowing water where dissolved oxygen concentrations are high, and then lay eggs in the nests. Depending on size of the female, 200 – 4500 eggs are produced. Males mature at 1 to 2 years, while females typically mature at age 3 (Irving 1954; Drummond and McKinney 1965). In cooler waters of headwater streams, trout mature at a smaller size than at lower elevations. Cutthroat trout readily hybridize with other spring spawning trout such as rainbow trout and other sub-species.

Trout survival in May streams is impaired because of lack of productive riffle areas, suitable spawning sites, undercut banks (to escape predation), pools (for resting, feeding and overwintering), and shade. Population densities regulated by stream size and morphology, overwintering habitat, stream productivity and cover.

**Feeding Preferences:**
Cutthroat trout are opportunistic feeders, feeding on terrestrial and aquatic insects, zooplankton and crustaceans, which are most diverse in riffle areas. Consequently, they often feed downstream of these areas. As the fish increases in size, it becomes more piscivorous (Baxter and Simon 1970).

**Survival of stocked trout**
The survival and persistence of catchable-sized trout (8-14 inches) stocked for sport fishing has been evaluated in several studies. Fifty-percent of hatchery-raised brown trout stocked into Norway streams were caught within 15 days, and 90% within 67 days (Skurdal et al. 1989). Hatchery-raised Apache trout stocked into the East Fork White River had a 34% survival rate three months after stocking (stocked May-August) and a 3% survival rate nine months after stocking (Meyer 1995). Approximately 11% were captured in the fishery and it was suggested that natural mortality was most likely the primary cause of mortality for the stocked trout. This is
also a typical finding from other studies, that stocked trout are generally either angled or experience natural mortality soon after stocking (Bachman 1984; Skurdal et al. 1989). Overwinter mortality may also be higher for stocked trout that survive the summer creel (Simpkins and Hubert 2000).

In general, the high natural mortality rate observed in stocked trout is suggested to result from a combination of the following: stocked trout are poorly adapted to stream environments, competition with resident trout populations, high stocking densities, warming water temperatures, foraging techniques and natural feed, appropriate energy expenditures, and seasonal dominance hierarchies associated with drift feeding and territory establishment (Bachman 1984). Stand alone or combined, these adaptations may result in malnutrition and subsequent mortality. In a study examining the interactions between stocked greenback cutthroat trout and wild brown trout, cutthroat trout were typically displaced by brown trout and were at a competitive disadvantage for food and space (Wang and White 1994). In a separate study, cutthroat trout in situ in a linear foraging hierarchy set up with the dominant fish at the front and intermediate and subordinate fish behind. The dominant trout will have a foraging advantage because it can catch the most optimal invertebrates in the drift first (Lewynsky and Bjornn 1986). Foraging dominance hierarchies have also been documented for other salmonids including rainbow trout, brown trout, brook trout, coho salmon (Oncorhynchus kisutch) (Jenkins 1969; Fausch 1984). It is postulated that trout stocked into a stream with previously established resident trout would not be able to establish a superior foraging position and would also be at an aggressive disadvantage (Jenkins 1969). Warm water temperatures has also been implicated as the primary cause of mortality of stocked trout (Runge et al. 2008).

**Variation in trout diets**

Freshwater trout within the *Oncorhynchus* genus (cutthroat, rainbow, Apache, and Gilae trouts) in the contiguous U.S. are opportunistic sight-feeders, with drifting aquatic and terrestrial invertebrates constituting the majority of their diets (Behnke 2002). The diets of brown trout (*Salmo trutta*) and brook trout (*Salvelinus fontinalis*) also feed on drifting aquatic insects, and fish often constitute the majority or a large portion of their diets (Fraser 1981). If stocked catchable-sized trout escape creel and survive to persist in the stocking location, food availability and competitive foraging ability will likely influence survival. Overwinter mortality may also be higher for stocked trout that survive the summer creel, particularly because the abundance of invertebrates decreases in winter (Simpkins and Hubert 2000).

**Gila Trout (Oncorhynchus gilae)**

**Background:**
The iridescent gold and copper-colored Gila trout reaches average total lengths of 300 mm, but has been reported at 550 mm total length. The Gila trout head is yellow with black spots, and a yellowish ‘cutthroat mark’ near the throat. Its back and sides above the lateral line is a golden iridescence color sometimes washed with metallic blue, and scattered with numerous dark spots.
Larger spots are found on the dorsal side, diminishing in size toward the lateral line, which typically has a pinkish lateral band. The lower sides are a deep yellow color, and the abdomen is grayish white to pinkish orange. Gila trout were historically located in high elevation coldwater streams in New Mexico and Arizona, including the headwaters of the Gila River (NM), and the headwater streams of the Agua Fria, Verde, Blue and San Francisco rivers in Arizona. By 1960, Gila trout were restricted to a handful of isolated headwater streams in the upper Gila River drainage system.

As with other native trout in the American southwest, the species suffered extensively from habitat loss and degradation, uncontrolled fishing, and the introduction of nonnative trout that either competed or hybridized with Gila trout. Thus, the species was given protection under the Federal Endangered Species Preservation Act in 1967 and designated as an endangered species under the Endangered Species Act in 1973. Recently, Gila trout were downgraded from endangered to threatened (DOI USFWS 50 CFR Part 17). Downlisting came as a result of restoration efforts by biologists in New Mexico and Arizona, where Gila trout populations now occur in about 68 miles of stream. The downlisting was accompanied with special rule [4(d)] that will enable New Mexico and Arizona state wildlife agencies to identify populations or waters where Gila trout can support angling without compromising recovery.

The historical range of Gila trout has been classified as the headwater streams of the Gila (NM), Agua Fria (AZ), Blue (AZ), and San Francisco (NM and AZ) rivers. Today, four relict populations of the species remain and all lineages have been replicated at least once in 12 streams in New Mexico (n = 10) and Arizona (n = 2). Dude and Raspberry creeks in Arizona were stocked with Gila trout from the Spruce Creek lineage in the early 2000s. A small population of Gila trout remains in Raspberry Creek, but no fish were found in Dude Creek during surveys conducted in 2005 and 2006. A large flood in Dude Creek in 2005 severely altered the most suitable trout habitat, which purportedly compromised the Gila trout population.

Habitat Requirements:
Gila trout are found in small mountain headwater streams in coniferous and mixed woodland, montane coniferous forest, and subalpine coniferous forest that rarely exceed 21 °C. They prefer streams with low siltation and gravels and cobbles as the predominant substrate. Gila trout use cover extensively, and during drought years they will seek refuge in pool habitat. Tolerances to water chemical parameters are similar to other salmonids; Gila trout having critical thermal maxima between 25 – 28 °C.

Breeding Biology:
Spawning occurs in late spring and summer. Females construct reds in water 2 – 6 inches deep beginning when water temperatures reach 8 °C or higher; as early as March in lower elevation streams. Eggs incubate for approximately 56 to 70 days before larvae emerge. Females reach
Feeding Preferences:
Gila trout are opportunistic feeders utilizing aquatic invertebrates and occasionally small fishes. Adult dipterans, trichopteran larvae, ephemeropteran nymphs, and aquatic coleopterans are the most predominant food items identified during stomach analyses. A foraging hierarchy has been observed in Gila trout, with larger fish aggressively guarding their feeding stations.

Sportfish Management:
The downlisting with special rule [4(d)] of Gila trout offers a unique opportunity to accomplish both the recovery of a threatened species and to provide angling opportunities for the public. On July 1, 2007, special regulation angling for Gila trout opened in Black Canyon Creek in New Mexico. The angling season will occur from July 1 through September 30 as a Special Trout Water; angling is catch-and-release only with artificial flies or lures and a single barbless hook. These regulations were recommended based on the results of a hooking mortality study conducted on Gila trout bloodstock by AZ and NM biologists in 2006. Future streams will open to angling when population numbers are sufficient and can sustain limited angling pressure without compromising recovery.

Grass Carp (Ctenopharyngodon idella)
Background:
White amur typically reaches weights in excess of 25 kg and will reach lengths of more than a meter (Chilton and Muoneke, 1992; Minckley 1973). Terminal mouth, over-all coloration oliveaceous to greenish-brown dorsally, with lines of dots arranged laterally along sides. Its belly and chin are whitish or creamy-yellow. White amur fins generally dark with pigmentation with exception of pelvic fins, which are similar in coloration to belly.

Diploid white Amur were introduced to Arizona prior to 1973 (Minckley 1973); however, current Arizona State law (R12-4-424) requires that white amur cannot be stocked into open systems and that a state permit is required for stocking, and all stocked fish must be triploid.

Habitat Requirements:
In Arizona, white amur are used widely used across the state in canals, golf courses, urban lakes and other private waters for vegetation control. Numbers must be controlled in order prevent habitat degradation and complete loss of aquatic vegetation. Amur are reportedly tolerant of high salinity and temperature extremes (Minckley 1973).

Breeding Biology:
White amur reach maturity at approximately 4 years old (4–5 kg; Chilton and Muoneke, 1992). Spawning occurs when water temperature rises above 20°C; because grass carp eggs are semi pelagic, current during spawning is required to keep eggs in suspension while they incubate. In
general, successful spawning takes place under rising water conditions in very long rivers. Fecundity is very high in normal diploid individuals; females may produce over one million eggs in a season. However as indicated above, all white amur stocked in Arizona must be triploid, and therefore not reproductively successful.

**Feeding Preferences:**
White amur fry begin feeding on microscopic animals and gradually switch to plant material as they grow (Chilton and Muoneke, 1992). Adult diploids, triploids, and hybrids are all herbivorous, and may consume more than their own weight in plant material each day.

**LARGEMOUTH BASS (MICROPTERUS SALMOIDES)**

**Background:**
Largemouth bass are indigenous to eastern and central North America, but has been introduced widely in the United States and around the globe as a game species. In Arizona, it was introduced in 1897, and is widely distributed in warm water reservoirs. The largemouth bass is not known to move extensively within a drainage as most individual home ranges are equal or less than 8 miles in length, potentially due to spawning behavior (Lucas and Bara 2001).

**Habitat Requirements:**
Largemouth bass are considered generalists and can live in a variety of habitats, prefer sluggish waters of lakes and reservoirs, but are able to colonize larger streams that have low gradients and velocity (Etnier and Starnes 1993, Pacey and Marsh 1998). They prefer warmer streams and lakes with lower turbidity and beds of aquatic vegetation (Sublette et al. 1990; Moyle 1976; Bryan et al. 2000). It is more tolerant of turbidity and salinity than other species in the Micropterus (Etnier and Starnes 1993). Pacey and Marsh (1998) report no data to support the occupying higher velocity stream habitats (e.g., riffles, runs, glides, eddies). This bass tends to center around larger rocks or logs, often found close to soft bottoms, stumps and extensive growths of a variety of emergent and sub-emergent vegetation, especially water lilies, cattails, and other pondweeds in water depths generally less than 18 feet which may pertain to its ambush-style hunting tactics (Moyle 1976; Sublette et al. 1990).

**Breeding Biology:**
In Arizona, largemouth bass can grow to 25 – 71 cm (< 7 kg). The optimal temperature for growth is 27-30 C (Cincotta and Stauffer 1984). Sexually maturity is reached at 18 –21 cm in length and spawn occurs from late spring to mid-summer, occurring in water temperatures of 58 degrees F to 75 degrees F and in depths of .5 to 23 ft. and are most active at 18°C. Spawning ceases as temperatures reach 24°C in mid- to late June (Sublette et al. 1990, AGFD 2003). Incubation time for eggs can be as short as 2 days at water temperature of 71.6 degrees F (Minckley 1973; Sublette et al. 1990; Moyle 2002). Nests are constructed by males on firm substrate such as gravel or sand but also over soft, muddy bottoms or other substrata and are often located along shallow margins of rivers and lakes and the male is highly territorial during
the breeding season (Sublette et al. 1990, Etnier and Starnes 1993). Females lay up to 96,000 eggs and require 2-4 days depending on water temperature (Sublette et al. 1990). The eggs are deposited and the male chases the female away, returning to the nest to care for the eggs until they hatch and the young disperse, approximately 13-20 days (Sublette et al. 1990; LaRivers 1994).

Feeding Preferences:
Larvae feed on zooplankton and switch to macrobenthos, and become piscivorous at 3.8-5.0 cm (Sublette et al. 1990). Adults are primarily carnivorous, feeding on insects, crayfish, frogs, snails, small mammals, reptiles, young waterfowl and other fishes (Sublette et al. 1990, Pacey and Marsh 1998). Bonar et al. (2004) considered the largemouth to be the most significant piscivore in the Verde with 16.8% of the diet consisting of other fish (Sonora sucker, desert sucker and longfin dace).

Rainbow Trout (Oncorhynchus mykiss)

Background:
Rainbow trout are originally native to the western North America, primarily from the coastal streams of the Northwest. It is one of the most intensively cultured fish throughout the world. It is one of the most economical and easiest trout to raise, making it a substantial component of a sport fishing program. They were first introduced into Arizona in 1899. Few self-reproducing populations exist in the wild.

Habitat Requirements:
Rainbow trout inhabit cool clear lakes and cool-water streams with larger substrates (gravel-boulder). In New Mexico, the trout are found in streams with pool-to-riffle ratios of 1:1 (Sublette et al. 1990). Deep, low velocity pools are important overwintering habitat and instream cover (overhanging banks, submerged vegetation, log jams, and boulders) is an essential habitat component for escape and resting cover (Sublette et al. 1990).

The species is tolerant of a range of stream conditions including water temperatures from 0 to the upper incipient lethal temperature for adults of 25°C (Embody 1934 Carlander 1953, Piper et al. 1982, Westers 1983, Raleigh et al. 1984) and a pH range of 5.8-9.6. However, the optimal conditions for growth are 13 – 21°C, slightly alkaline waters (pH of 7-8), and ≥ 7 ppm dissolved oxygen concentrations at temperatures ≤ 15°C, and ≥ 9 ppm dissolved oxygen at temperatures ≥ 15°C (Raleigh et al. 1984). May (1973) observed that adults in Lake Powell will avoid water temperatures of 18°C.

Fry will inhabit low velocity waters with substrate ranging from mud and silt to bedrock and cobble. They also utilize protective cover typically found along stream margins and seeps, side channels, backwaters, and small tributaries. Insufficient fry habitat will result in high mortality of this life stage and will reduce the recruitment of juveniles and subsequently adults. During the
summer periods they tend to occupy water with temperatures averaging 13-19º C. Fry are also more likely to be swept away in the event of floods (Montgomery and Bernstein 2008).

Juveniles will move into deeper and more swiftly moving water that has a greater complexity of cover when temperatures increase in the spring. They establish territories in undercut banks but can also be found in open areas over cobble and gravel and near large boulders. They occupy water with summer temperatures between 10-18º C (Raleigh et al. 1984).

In adults there is a direct relationship between annual stream flow and the amount and quality of available trout habitat. Low water levels expose undercut banks, large portions of instream cover and desired shoreline, creating unsuitable habitat for the different life stages of the rainbow trout. The most critical period is during base flows (lowest flows of late summer to winter). Base flows of 50% or more of the average annual daily flow are ideal for maintaining quality habitat. Base flows below 25% are considered poor for providing quality habitat.

Key components of river substrate for adults are large structures (woody debris and boulders) that help diversify local instream flow patterns. This will help produce microhabitats differing in velocity and cover, and pools and undercut banks that provide quiet refuges (Montgomery and Bernstein 2008).

Coldwater species like trout are less likely to form self sustaining populations in reservoirs and ponds in part due to their requirements for clean gravel spawning substrate preferably swept by currents that are not characteristic of pond and reservoir systems (Ross 1997).

**Breeding Biology:**
Rainbow trout average in total length 25.0-75.0 cm, with a maximum of 1 m (Behnke 1980). In Arizona, they generally grow to 20 – 81 cm (AGFD 2003). Rainbow trout are typically spring spawners. Female usually become sexually mature during year 3, whereas male in year 2 - 3 (Raleigh et al. 1984). Fecundity of females averages 2,000 – 4,500. The species is highly territorial, and will aggressively defend feeding areas (Sublette et al. 1990). Females choose spawning sites in water greater than 18cm in depth with greater than average velocities such as 48-91 cm/s. They are primarily stream spawners and require tributary stream with gravel substrate in riffle areas for successful reproduction. However streams in the more arid Rocky Mountain region are likely to experience low flow and higher temperatures which can create a greater threat of fish stranding. As water temperatures increase, dissolved oxygen levels decrease resulting in altered swimming speed, declined growth rates, reduced fecundity, and can constrain spawning (Raleigh et al. 1984). Rainbow trout can spawn in temperatures ranging from 2-20º C but is generally initiated when water temperatures exceed 6-7º C. Trout that spawn in lakes with inlet and outlet stream may spawn as much as one month earlier in the outlet than the inlet due to temperature differences. The period of egg incubation begins at the end of spawning and normally last 30-100 days, however this time period is largely temperature dependent. Rainbow
trout eggs can withstand temperature extremes of ~1.6-16°C, but temperatures of 7-10°C will produce the highest survival rates among embryos. The higher the temperature, within the acceptable range, the faster the rate of development which will lead to a shorter incubation period and time to emerge (Raleigh et al. 1984).

Downstream movement may vary by habitat type (lentic versus lotic systems) and by strain (Moring 1993 and citation therein). Moring (1993) suggested a sizable portion of stocked populations (approximately 22%) frequently move >12 km and average 1.1 – 1.7 km a day. However, few fish (<1%) had moved > 35 km downstream over four years, most moved < 15 km. This species will hybridize readily. Lakes and reservoirs with no inlet or outlet streams generally limit and in most cases inhibit reproducing populations of trout (Montgomery and Bernstein 2008). Rainbow trout populations that successfully reproduce in lakes with inlet and outlet streams typically spend 2 summers in a stream and 2 summers in a lake before they are considered mature.

**Feeding Preferences:**
Rainbow trout are opportunistic feeders and the primary food items depend in part on the stage of the life history as well as the habitat being occupied. Fry restricted to quiet waters feed on small insects and other invertebrates including nematodes, amphipods, cladocerans, terrestrial insects (adult beetles, flies, and larval moths and butterflies), and aquatic insects (larval and pupae of midges, black flies, caddis flies, beetles, crane flies, soldier flies, mayflies, and stoneflies). Juveniles and adults feed on terrestrial and aquatic insects and other aquatic invertebrates such as nematodes, leeches, annelids, gastropods and other mollusks, benthic and planktonic crustaceans (cladocerans, isopods, amphipods, shrimp, and crayfish), small ray-finned fishes fish eggs and larvae, detritus, benthic algae, and occasionally lizards, mice, and bats (Montgomery and Bernstein 2008).

Young feed on immature and emergent aquatic insects and will continue to take insects but become piscivorous when larger (Raleigh et al. 1984, Sublette et al. 1990). In streams, rainbow trout feed primarily on drift organisms. In lakes, they prefer benthic invertebrates and zooplankton (Sublette et al. 1990). During extended periods of low food availability, trout will often exhibit hyperphagia and considerable compensatory growth following these stressful periods (Jobling and Koskela 1996). Sweetser et al. (2002) found this species was least piscivorous of the three trout species (brown, brook, rainbow) they examined in the Little Colorado River in Arizona. Bryan et al. (2000) noted that rainbows can adversely affect the native fish populations through aggressive displacement through interference competition, using resources more quickly and efficiently through exploitative completion, increasing stress hormones, or by opportunistic piscivory. However these interactions are not always negative. Habitat displacement of cutthroats by rainbows results in more piscivory and higher growth rates of the cutthroat (Nilssen and Northcote 1981). by opportunistic piscivory. Bonar et al. (2004) considered rainbow trout to be a less significant piscivore in the Verde River with less than 4%
of fish in their diet in spite if their statement that continued stocking has the “potential to impact abundance and distribution of native fish due to their stocking overlaps with the peak of spawning activities by native fishes”. Competitive interactions of rainbow trout with various fish may be weakened in warm waters (Montgomery and Bernstein 2008).

Survival of stocked trout
The survival and persistence of catchable-sized trout (8-14 inches) stocked for sport fishing has been evaluated in several studies. Fifty-percent of hatchery-raised brown trout stocked into Norway streams were caught within 15 days, and 90% within 67 days (Skurdal et al. 1989). Hatchery-raised Apache trout stocked into the East Fork White River had a 34% survival rate three months after stocking (stocked May-August) and a 3% survival rate nine months after stocking (Meyer 1995). Approximately 11% were captured in the fishery and it was suggested that natural mortality was most likely the primary cause of mortality for the stocked trout. This is also a typical finding from other studies, that stocked trout are generally either angled or experience natural mortality soon after stocking (Bachman 1984; Skurdal et al. 1989). Overwinter mortality may also be higher for stocked trout that survive the summer creel (Simpkins and Hubert 2000).

In general, the high natural mortality rate observed in stocked trout is suggested to result from a combination of the following: stocked trout are poorly adapted to stream environments, competition with resident trout populations, high stocking densities, warming water temperatures, foraging techniques and natural feed, appropriate energy expenditures, and seasonal dominance hierarchies associated with drift feeding and territory establishment (Bachman 1984). Stand alone or combined, these adaptations may result in malnutrition and subsequent mortality. In a study examining the interactions between stocked greenback cutthroat trout and wild brown trout, cutthroat trout were typically displaced by brown trout and were at a competitive disadvantage for food and space (Wang and White 1994). In a separate study, cutthroat trout in situ in a linear foraging hierarchy set up with the dominant fish at the front and intermediate and subordinate fish behind. The dominant trout will have a foraging advantage because it can catch the most optimal invertebrates in the drift first (Lewynsky and Bjornn 1986). Foraging dominance hierarchies have also been documented for other salmonids including rainbow trout, brown trout, brook trout, coho salmon (Oncorhynchus kisutch) (Jenkins 1969; Fausch 1984). It is postulated that trout stocked into a stream with previously established resident trout would not be able to establish a superior foraging position and would also be at an aggressive disadvantage (Jenkins 1969). Warm water temperatures has also been implicated as the primary cause of mortality of stocked trout (Runge et al. 2008).

Variation in trout diets
Freshwater trout within the Oncorhynchus genus (cutthroat, rainbow, Apache, and Gilae trouts) in the contiguous U.S. are opportunistic sight-feeders, with drifting aquatic and terrestrial invertebrates constituting the majority of their diets (Behnke 2002). The diets of brown trout
(Salmo trutta) and brook trout (Salvelinus fontinalis) also feed on drifting aquatic insects, and fish often constitute the majority or a large portion of their diets (Fraser 1981). If stocked catchable-sized trout escape creel and survive to persist in the stocking location, food availability and competitive foraging ability will likely influence survival. Overwinter mortality may also be higher for stocked trout that survive the summer creel, particularly because the abundance of invertebrates decreases in winter (Simpkins and Hubert 2000).

**Migratory Movements:**
(Simpson 2006) found a general pattern in stream movement of rainbow trout during low flows and high flows. During a high flow period the trout typically moved downstream, however they did not stay in a high flow habitat for more than a few days. During a low flow period the trout moved back upstream to reside in riffles or pools.

(Mellina et al 2006) described the typical seasonal movement patterns of stream dwelling rainbow trout. Their behavior in streams show long range movements and restricted movements in any given population. Individual fish will also show signs of switching these behaviors. Furthermore these behavior combinations are presumably adaptive when conditions are often unpredictable and changeable. Typical migratory movement showed predominately lakeward movement during spring and early summer seasons. However, juveniles continued their movement until late August and early September. Long range movements appear to be closely linked to discharge patterns. These long range movements will cease with the onset of low summer flows.

Little research has been done on specific movements of trout out of reservoirs. However in 2005 the first stocked rainbow trout was captured below Blue Ridge Reservoir. This occurred after a flood event from a heavy winter snow pack in 2004 and 2005 causing Blue Ridge Reservoir and Knoll Reservoir to spill (Rinker 2005).

Kerr and Lasenby (2000) outlined several parameters that could influence post stocking emigration of rainbow trout such as elevated discharge or water or flooding, reductions in water levels, water temperatures, formation of frazil ice, pollution, and genetic strains. These parameters should be considered if emigration is a concern.

**REDEAR SUNFISH (LEPOMIS MICROLOPHUS)**

**Background:**
The redear sunfish’s historically ranged from the southern Atlantic states to Texas and northward in the Mississippi Valley to Indiana and Illinois (Etnier and Starnes 1993). It has been widely introduced throughout the U.S. In Arizona, it was introduced in 1946.

**Habitat Requirements:**
Redear sunfish prefer clear waters of lakes, reservoirs, or ponds and are usually associated with cover (Etnier and Starnes 1993, AGFD 2003). Pacey and Marsh (1998) also include rivers and
streams as potential habitat, with microhabitat preferences of deeper, slow or slack water habitats (e.g., deep pools, eddies, and shoreline cut banks). They are not reported in riffle, run, or glides, and avoid turbidity.

**Breeding Biology:**
Redear sunfish can grow 5 – 10 cm their first year, and 3 – 5 cm per year between ages 2 – 4. After year 5, growth slows and studies indicate that growth may be negatively related to turbidity (Etnier and Starnes 1993). In Arizona, LEMI reach 15 – 35 cm in length. Pacey and Marsh (1998) report that the optimal temperature for LEMI is 24-27°C. Males construct nest, usually in colonies in shallow water. Etnier and Starnes (1993) Females lay 15,000-30,000 eggs in May - June. Redear sunfish are known to hybridize with at least four other species of *Lepomis* (Etnier and Starnes 1993).

**Feeding Preferences:**
These sunfish primarily feed on benthic organisms (midge larvae, snails) and have evolved specialized muscles and molars for crushing mollusk shells (Lauder 1983, Etnier and Starnes 1993). Minckley (1979) report adults consuming Desert Pupfish (*Cyprinodon macularius*) juvenile and eggs, and adult and eggs of threadfin shad (*Dorosoma petenense*).

**SMALLMOUTH BASS (** *MICROPTERUS DOLOMIEU*)**

**Background:**
Smallmouth bass is a Nonnative sport fish introduced to Arizona waters in 1921 and are known from the mainstream of the lower Colorado river, Verde River and throughout the Salt River basin below 7,200 ft. in elevation (Minckley 1973). Smallmouth bass most is bronze to brownish green in color, with dark vertical bars on sides. In contrast to the largemouth bass, the upper jaw does not extend beyond rear margin of eye, which is reddish in color, and it has a shallow notch in the dorsal fin. Smallmouth bass are range from 12 – 22 inches in length.

**Habitat Requirements:**
Inhabit mid order streams and lakes cooler in temperature, free of turbidity with shallow rocky areas, clear and gravel-bottom runs and flowing pools of rivers, cool flowing streams and reservoirs fed by such streams. This bass prefers shady areas with submerged structures of stumps, trees or crevice within clay banks for retreat (Sublette et al. 1990; Moyle 1976). Severe temperature drops and siltation that occur during flood events may result in nest desertion and loss of eggs and fry (Brynildson 1957). They are abundant in the Verde River, Black River, and Apache Lake and to some degree in Roosevelt Reservoir and Lake Powell. They prefer rocky habitats in streams and lakes with clear waters.

Some populations appear to be largely sedentary, occupying a short reach of stream or river for extended periods, possibly their entire lives. In other populations, many individuals undertake long-distance migrations each year to reach spawning or over-wintering habitats. Migration
distance is correlated with winter severity; smallmouth bass move little in streams that do not freeze, but often travel more than 5 km in systems with ice (Lyons and Kanehl 2002). In some systems smallmouth bass occupy the deepest water available or areas of cover (boulders, logs), where they remain inactive for the winter. However, in other systems, smallmouth bass avoid the deepest holes and are often active in areas with little cover. Many smallmouth bass populations undertake spawning migrations in the spring, usually to smaller tributaries. Migration distances vary, but may be greater than 10 km. Many smallmouth bass populations exhibit homing tendencies towards particular habitats; however stocked smallmouth bass usually show little site fidelity, and quickly disperse long distances from the stocking location. Stocked smallmouth bass tend to leave the stocking area rapidly, and often the stream itself, typically moving downstream (Lyons and Kanehl 2002).

**Breeding Biology:**
Spawning occurs in late spring (March through May) when water temperatures warm to between 55 degrees F to 74 degrees F and at depths up to 16ft. (Minckley 1973; Sublette et al. 1990; Moyle 2002). Males generally build nests over gravel substrates, but may use sand, silt and organic material associated with rocky bottoms or woody cover (Scott and Crossman, 1973; Winemiller and Taylor 1982; Reynolds and O’Bara 1991). Nest building usually occurs in the same area where the previous year’s nest was built. The males fan a depression in sand or gravel with violent lateral movements and are highly defensive of the nest (Moyle 1976; Sublette et al. 1990). After spawning, the female leaves the nest and may spawn with another male in another nest. Males guard the eggs and young. Onset and duration of spawning, as well as reproductive success in warm water streams is greatly influenced by water temperature (Cleary 1956; Brown 1960; Coutant 1975; Graham and Orth 1986). The spawning period may last from 1 to 4 weeks depending on temperature. Spawning continues as long as the temperature remains between about 15°C and 20-22°C, a period ranging from about 1 to 4 weeks depending upon the year and thermal regime. Females produce between 2,000 to 20,825 eggs based on body weight (Sublette et al. 1990) and the eggs can take between 2.25 to 9.5 days to hatch in 75 degrees F to 41 degrees F (Minckley 1973; Sublette et al. 1990; Moyle 2002).

**Feeding Preferences:**
Young feed on plankton and immature aquatic insects while adults take in crayfish, fishes (shad), and aquatic and terrestrial insects in lakes; and crayfish and minnows in streams. In streams, smallmouth can be very aggressive when hellgrammites and terrestrial insects are available. Once the bass reaches 8in. in length, the diet becomes nearly exclusively piscivorous when sufficient prey is present (Sublette et al 1990; Moyle 1976). Bonar et al. (2004) considered smallmouth a significant piscivore in the Verde River with a greater than 4% of fish in their diet including Sonora sucker.

**Threadfin Shad (Dorosoma petenense)**
**Background:**
Threadfin shad are a small prey fish found primarily in Arizona reservoirs. Its back is dark gray to bluish black, sides and abdomen is silvery; a distinct post opercular dark spot is present, and the mouth is terminal. Threadfin shad fins, except the dorsal, are yellowish in color with the caudal fin a deeper yellow than the other fins. Adults typically do not exceed 110 mm standard length.

**Habitat Requirements:**
Threadfin shad inhabit large lakes and rivers with moderate current. They usually congregate in schools over deep water during day and into shallower, littoral areas during night.

**Breeding Biology:**
Threadfin shad life span is typically 2 – 3 years with spawning commonly taking place in the second summer; however sexual maturity may be reached in the first year, resulting in a spawn at the end of the first summer (Johnson 1971). Threadfins shad spawn during summer months in open water or along shorelines over aquatic plants at water temperatures between 21 – 26ºC. Females produce between 900 – 21,000 eggs depending on size.

**Feeding Preferences:**
Threadfin shad are feed primarily on plankton in open limnetic waters; however some bottom feeding does occur and adults may prey upon fish larvae (Baker and Schmitz 1971).

*WALLEYE (SANDER VITREUS)*

**Background:**
Introduced to Arizona in 1957, walleye is a nonnative sport fish. Its back is yellow-olive with a brassy cast, its sides are brassy-yellow with dark mottling, and its belly is white. A dark spot can be found at rear of the spiny dorsal fin, with the anal fin and lower lobe of tail fin white in color. Walleye is a spiny fish having moderate canine-like teeth. In Arizona walleye typically reach lengths of 29 inches, and weights just over 12 pounds.

**Habitat Requirements:**
Found in Lake Powell, Saguaro Lake, Canyon Lake, Apache Lake, Lake Mary, Show Low Lake and Fool's Hollow Lake. Bottom oriented fish, due to their sensitivity to light, preferring to stay in deep water during the day, moving to shallow waters during the night. During summer, they preferred gravel-cobble substrates, used a variety of depths, and were near current breaks and upstream edges of pools. When temperatures reached 30ºC, walleye sought deep pools. Generally, walleye prefers moderate current with cobble-gravel substrates (Paragamian 1989). Light conditions are an important factor affecting walleye distribution, abundance and feeding (Ryder 1977).
Breeding Biology:
Walleye exhibit optimal growth at temperatures between 20 – 24°C (Dendy 1948; Kitchell et al. 1977), with critical temperature tolerance ranging between 31-34°C (Hokanson and Koenst 1986). Walleye spawn in spring, in relatively shallow water, over clean gravel or rocky bottoms.

Feeding Preferences:
Walleye prefer fish but will eat crayfish and worms. In Arizona, their main diet is threadfin shad.

*YELLOW PERCH (PERCA FLAVESCENS)*

Background:
Yellow perch is a nonnative sport fish to Arizona, and was introduced in 1919. It has an olive-green back with brassy-yellow sides having 6 to 9 dark vertical bars, a white stomach, and small non-canine like teeth. The anal, pectoral and pelvic fins are amber-orange tinted. Yellow perch will reach lengths of ~12 inches. In Arizona, yellow perch were found in Stoneman Lake but disappeared when it dried up.

Habitat Requirements:
Yellow perch prefer clear water with moderate amounts of aquatic vegetation. Preferred water temperatures are around 70°F. Fingerlings are found in shallow water and move to open, deeper water in fall. Adults generally associate with the lake bottom. When yellow perch spawn in the spring, they move into shallower waters near the shoreline, and then back out to deeper waters in late spring as the water waters. On occasion, yellow perch migrate upstream to spawn. Tagging data indicate that yellow perch do not move much and populations in large lakes remain in a local area, and that individuals generally have a strong homing tendency. Have a strong homing tendency.

Breeding Biology:
Yellow perch exhibits schooling behavior with schools comprised of fish of the same sex, size or age. Spawning occurs in spring on vegetation or submerged brush, sand, gravel or rubble when water temperatures reach ~45 – 52°F. Eggs are deposited in a gelatinous strand with the number of eggs ranging from 18,000 – 140,000 eggs depending on the size of the female. Males mature between 1 – 2 years, and females between 2 – 3 years of age. Females grow faster than males. On average, yellow perch live 7 – 8 years, are very prolific, and can become overabundant or stunted unless suppressed by predation or angling.

Feeding Preferences:
Yellow perch feed on small fish, crawfish and insects (dragonfly, damselfly and caddisfly larvae). Young perch feed on zooplankton, copepods and cladocerans in particular and immature insects as they grow. Adult perch feed on forage fish if available.
Chapter 2 ANALYSIS METHODS AND CRITERIA

INTRODUCTION TO METHODS

Locations proposed for stocking across the state were identified and arranged by major watershed. The watersheds were then divided into sub watersheds for further evaluation of hydrologic connections associated with the stocking sites and instream and/or downstream species.

STRUCTURE FOR ASSESSMENT

The goal of this assessment document is to review and evaluate potential impacts of proposed stocking activities for ten years on any listed, candidate, proposed species and/or critical habitats not addressed through previous assessment and/or consultation efforts. The document incorporates the required information as outlined in the Federal Aid Section 7 Biological Evaluation Form, guidance from the Federal Aid Toolkit and Section 7 Consultation Handbook. For each species, we provide background information, biology, life history, watershed by watershed distribution, direct and indirect effects of the proposed action and an assessment of other effects for those stocking sites where there may be impacts to the species. Further, we identify regulations and fish stocking procedures undertaken by AGFD designed to ensure responsible stocking practices thereby minimizing, reducing or eliminating disease transmission through stocking of fish and unauthorized transportation and release of stocked fish and associated bait (fish, waterdogs, and crayfish) (regulations were identified in Chapter 1). Interdependent, interrelated actions and/or cumulative effects (non-federal fish stocking or riparian projects) of the proposed stocking actions to listed, candidate, proposed species and/or critical habitat are broadly identified and defined within Chapter 4.

WATERSHED ANALYSIS OF HYDROLOGIC CONNECTIVITY

Information guiding this analysis included the descriptions of the watershed, subwatershed and each stocking site. The stocking sites included specific information as to the waterbody, recreational management of the area, existing conditions, management of the waterbody, proposed action and potential impact analysis. The potential impact analysis was extended to a complex level (grouping of sites where appropriate) depending on hydrologic connection and/or stream connections. Complete descriptions of all stocking sites, their history, connectivity and the local conditions are provided in the watershed chapters (Chapters 5-10).

SPECIES AND CRITICAL HABITAT EVALUATED

Primary sources of listed, candidate, proposed species and/or critical habitats distribution include AGFD’s Heritage Data Management System (HDMS), the Nongame and Endangered Wildlife Program’s Native Fish Database, AGFD Riparian Herpetofauna database, and Willow Flycatcher.
Database. The HDMS is part of a global network including over 80 natural heritage programs and conservation data centers. The information comes from published and unpublished reports, data collected by cooperating agencies, museum and herbarium collections, the scientific and academic communities, Federal Register, and many other sources.

The list of species assessed and reviewed through this assessment process includes all listed or proposed species, proposed or designated critical habitat and candidate species associated with aquatic, wetland and/or riparian habitats where sport fish would be stocked or anglers would access in pursuit of stocked sport fish. Analyses of two additional species that are most likely to become listed in the next ten years were also included.

A spatial approach to the analysis was utilized to identify and map species and/or critical habitats in relation to the proposed stocking locations. The multi-step process to develop this spatial representation (maps) included: proximity of stocking locations to habitats occupied (or historical localities) by species and/or critical habitats. Data from numerous sources were incorporated into ArcGIS for use in spatial analysis and included the best information available to AGFD. The HDMS point data is based on representation of occupied areas of breeding populations with a 1-mile buffer around the point (species) for the protection of the exact location. The state was then broken into watershed units using the US Geological Survey Hydrologic Unit Codes (HUCs) at the HUC 6 level and then further divided into subwatersheds at the HUC 8 level.

Recreational angling impacts are limited to the water’s edge or within a reasonable distance from a water source (travel to the water source). This area is referred to as the **stocking area**. Where there is connectivity between stocking locations and waters supporting listed/proposed/candidate species and/or critical habitat, effects from the stocking location may extend further along those waterway connections. This area is referred to as the **connected area**. These areas of potential impact to listed/proposed/candidate species and/or critical habitat by the proposed activities or associated recreational activities are referred to as the **action area**. A GIS product was developed as the framework for the analysis.

The analysis then proceeded species by species within each watershed. The primary analysis tool for the assessment was based on the working maps developed as described above with review from the AGFD Regional Fisheries and Nongame species leads. The review process included AGFD, WSFR and USFWS Ecological Services personnel.

General preliminary criteria questions were developed for taxonomic groups to establish links between the action and potential listed taxons. The first criteria established the geographic link and included connectivity, probability of movement and suitability of habitat (e.g. potential for stocked fish to survive in the habitat it moved to). The second criteria established the link biologically through interactions between stocked fish and listed, proposed or candidate species.
(competition, predation, reproduction, disease, angler access) and impact to critical habitat, where appropriate.

According to USFWS [50 CFR 402.12(g)], it is the responsibility of WSFR to evaluate all potential impacts of funding sport fish stocking activities to all identified listed, candidate, proposed species and/or critical habitat. Species identified by the USFWS as candidates for listing are evaluated based on a standard of “likely or not likely to jeopardize” under provisions for conferences.

Listed, candidate, proposed species and/or their critical habitats are assessed in detail within this document. The review process includes review and assessment with regard to the general analysis criteria as listed above.

**SPECIES INTERACTION APPROACH**

In order to determine the nature of the exposure between stocked sport fish and listed species of concern, it was necessary to consider the biology of each species stocked and the nature of the response or interaction with each of the listed species. Consideration of this biological interaction resulted in the following descriptions, arranged by general taxonomic groupings for the listed species.

**Fish Interactions Background Information**

**Apache Trout**

*Methods & Criteria*

Impacts to Apache trout require a unique evaluation because the species is currently listed as threatened under the Endangered Species Act with a special (4(d)) rule that provides for angling of the species as long as the angling comports with the laws of the state of Arizona. The proposed action includes stocking Apache trout for the purpose of furthering the conservation of the species through supporting angling opportunity for the species.

Currently conservation and/or recovery of the species in Arizona include several management actions. These include designating and managing recovery populations which are primarily located above constructed or natural barriers. Another management strategy is to promote conservation of Apache trout by actively stocking Apache trout for the purpose of angling with anticipated harvest of the stocked individuals as provided by the ESA 4(d) special rule. In some cases other sport fish species are stocked with Apache trout, and/or stocked Apache trout may impact other listed species. As such, there is a need to evaluate potential impacts to the species given several scenarios. These include:

1. Impacts from sport fish species co-stocked with Apache trout in non-recovery areas for the intent of providing angling opportunity.
2. Impacts from stocked sport fish species to recovery Apache trout that escape from recovery areas above barriers.

3. Impacts from stocked sport fish species to recovery Apache trout if those stocked species move above a failed barrier or into recovery reaches.

4. Impacts from Apache trout stocked into recovery Apache trout populations with the intent that the entire population be fishable by the public (this only occurs in 1 case).

5. Impacts from stocked Apache trout on other candidate or listed species and critical habitat.

6. Impacts on stocked Apache trout from wild fish populations present in the receiving waters.

The analysis approach was informed and developed in the following manner:

- Reviewing the down listing packages for Apache and Gila Trout, both of which have been down listed from Endangered to Threatened, are managed as sport fish in the State of Arizona, and have a 4(d) special rule.

- Identifying possible scenarios that could result in impacts to Apache trout.

- Reviewing the applicability of Section 6 of the Endangered Species act, the Apache trout 4(d) special rule and 10(a)(1)(a) permit.

- Developing an impact analysis for each of the scenarios identified above and applying them to applicable stocking reaches or complexes.

In evaluating impacts to Apache trout, two separate proposed actions are considered, first the action of stocking nonnative sport fish (rainbow trout, brook trout, arctic grayling, etc.), and second, the action of stocking native Apache trout into non-recovery streams or waters to provide angling opportunity. The action of stocking Apache trout is considered a conservation action in furtherance of the Endangered Species Act whereby a special 4(d) rule is in place. The States have specific authority for management of endangered species, in part, manifested through State Section 6 Cooperative Agreements, which authorize management activities for threatened and endangered species. AGFD may take any federally listed threatened fish or wildlife for conservation purposes that are consistent with the purposes of the Act and the Section 6 Cooperative Agreement between USFWS and AGFD. Because stocking of Apache trout is for conservation purposes and consistent with the Act and the Cooperative agreement, take of Apache trout from the proposed stocking of Apache trout is legally permitted. The action of stocking all other nonnative sport fish and potential effects to Apache trout, impacts from...
stocked Apache trout on other listed species, and any impacts to critical habitat are analyzed under Section 7 of the Act. Under the ESA, Apache trout hybrids are not protected as a threatened species (FWS Arizona Ecological Service Memo, September 2008) and impacts to hybrid Apache trout are therefore not evaluated.

**Bird and Mammal Interaction Methods**

**Bald Eagle**
The bald eagle was delisted during the development of this BA. An analysis of the bald eagle will be included in the Environmental Assessment.

**Mexican Spotted Owl**

*Range wide Discussion:*
The Mexican Spotted Owl (MSO) is one of three spotted owl subspecies widespread and occurring in a wide variety of habitats and occupying a broad geographic area but occurs inconsistently throughout its range in Arizona with distinct localities corresponding to pockets of appropriate habitat in mountains and canyons (USFWS 1995). The largest concentrations of MSOs in Arizona occur in the central and east-central forests along the Mogollon Rim, the White Mountains, and volcanic peaks near Flagstaff. The MSO is known from the Colorado Plateau in northern Arizona, areas along the Mogollon Rim, and from “sky island” mountains in the southeastern part of the state. The vegetative communities vary across the range of the owl from pinon juniper, mixed conifer forests to Madrean evergreen and woodland. At lower elevations, the owls are found in steep forested canyons with rocky cliffs. The characteristics of the habitat include high canopy closure, high stand density of multi layered uneven aged stands, numerous snags and downed woody matter in old growth mixed conifer forests. Nesting is more common in the mixed conifer community types, but nesting also occurs in the pine oak riparian and white fir community types. Owls may remain within their respective breeding area throughout the year, but some may migrate outside of the area opportunistically (USFWS 1995). Studies have suggested winter migrants move into the lower, warmer elevations into more open habitats (USFWS 1995).

Recovery units (RUs) were designated based on several factors (physiographic provinces, biotic regimes, perceived threats, administrative boundaries and know patterns of distribution). Arizona contains three of the four physiographic provinces which are identified RUs: Colorado Plateau, Upper Gila Mountains and the Basin and Range West.

Three levels of habitat management were established within the Recovery Plan: protected areas, restricted areas and other forest and woodland types. Protected areas receive the highest level of protection and other forest and woodland types as the lowest. Protected Activity Centers (PAC) protects all MSO sites known from 1989 through the life of the Recovery Plan. The identified activity area is defined as the nest site, a roost grove commonly used during the breeding season.
in absence of a verified nest site, or the best roosting/nestng habitat if both nesting and roosting information are lacking. The delineation of an area no less than 600ac around the activity center using the boundaries of known habitat polygons and/or topographic boundaries, such as ridgelines were identified as appropriate. The boundaries of the PAC should enclose the best possible habitat configured as compact as possible with the nest or activity center located near the center to include as much roost/nest habitat as reasonable, supplemented by foraging habitat where appropriate (USFWS 1995). All PACs should be retained for the life of the Recovery Plan, regardless if the owls are not located within them in subsequent years.

The stocking locations identified with overlap for MSO for this consultation are located mostly on Forest Service managed lands. The PACs are incorporated with recommendations from the Recovery Plan in the South Western Region Forest Service Land Resource Management Plans (USFWS 2004) that provides a level of protection for these owls and their habitat. Further, Restricted Areas (defined as other areas of use, unoccupied areas) were additionally incorporated into the planning efforts by the Forest Service in order to maintain and develop potential nesting and roosting habitat now and into the future providing an additional level of protection.

**Critical Habitat**

Critical habitat for the owl was designated in 2004 (re-designation from 1995 and 2001) based on the recovery needs and guidelines identified in the Recovery Plan. The designation considered currently suitable habitat, large contiguous blocks of habitat, occupied habitat, range wide distribution, need for special management or protection, and adequacy of existing regulatory mechanisms when identifying the critical habitat units and primarily relied on the Recovery Plan and Primary Constituent Elements (PCEs) (USFWS 2004).

The PCEs are identified as those physical and biological features necessary to ensure the conservation and may require special management considerations or protection including those that support nesting, roosting and foraging. General requirements include space for individual and population growth and for normal behavior; food, water or other nutritional or physiological requirements; cover or shelter; sites for breeding, reproduction, or rearing of offspring; and habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of a species (USFWS 2004). Included in the designation are both the protected and restricted habitat areas as defined within the Recovery Plan and areas containing the PCEs.

The majority of owl records are on federal and tribal lands; therefore, state and private lands were not considered essential to the conservation of the species and were not designated as critical habitat (USDI 2005).
Home Range Size:
Home range is defined as the area used by an animal during its normal activities (Burt 1943) and territory is defined as a defended area within an individual’s home range (Nice 1941). The territories for MSO are smaller than the home ranges with the relationship not known and consistency to territories being high with most owls remaining on the same territory in subsequent years (USFWS 1995). There is considerable variability among the habitats and/or geographic areas monitored owls displayed (Ganey and Dick 1995). Home ranges sizes vary among areas studied, potentially dependent on cover types (Ganey and Balda 1989b). Estimated home range size comparisons are difficult due to the variability in sampling methods. Results for individuals and pairs varied (USFWS 1995):

- 2,282-3,672 acres for individuals on three study areas in the Colorado Plateau RU (Wiley 1993)
- 645-2,601 acres for individuals on five study areas in the Upper Gila Mountains RU (Ganey and Balda 1989a, Ganey and Block, unpublished data, Peter Stacey, Univ. of Nevada, Reno, pers.com)
- 1,116-2,314 acres for individuals on two study areas in the Basin and Range East RU (Zwank et al. 1994, Ganey and Block, unpublished data)
- 941-3,831 acres for pairs on five study areas in the Upper Gila Mountains RU (Ganey and Balda 1989a, Ganey and Block, unpublished data, Peter Stacey, Univ. of Nevada, Reno, pers.com)
- 1,415-3,461 acres for pairs on two study areas in the Basin and Range East RU (Zwank et al. 1994, Ganey and Block, unpublished data)

Identified Recreational (Angler) Related Impacts:
The stocking locations identified with overlap for MSO for this consultation are mostly located on Forest Service managed lands. Sport fish stocking sites covered by this consultation may be in proximity to Mexican spotted owl (MSO) habitats, and the presence of anglers drawn by the continued fishing opportunities may result in potential disturbances to MSO and/or their habitats. Sport fish stocking sites, or the stocking reach (which includes those areas where anglers may move up, down or around waterbodies and/or stream reaches) may be in or near MSO PACs or designated critical habitat. Sport fishing activities in general are close to the stocking waterbody or stream reach; though anglers may move throughout fishable areas of the waterbody or stream reach. In addition, recreational angling is part of the larger recreation presence, with developed campgrounds, roads, parking areas, or other amenities present contributing to potential disturbance of MSO.
Recreational activities, including angling, may impact MSOs directly by disturbing owls at nesting, roosting, or foraging sites. The magnitude of the impact is influenced by the location, intensity, frequency, or duration of the disturbance to the particular MSO (USFWS 1995) and/or habitat. Recreational activities in general can also have indirect impacts if habitat is altered by trampling of vegetation, soil compaction, or other physical degradation. Increased fire risk from inappropriate disposal of smoking materials or campfires is also a concern. If a particular recreational activity does not result in habitat alteration, the activity generally is considered to have a relatively low impact potential (USFWS 2004).

**Critical habitat**

Indirect impacts to habitat within designated critical habitat may include some of those identified above. In addition, indirect impacts to foraging as identified in the PCEs and related to the disturbance or altering of habitat associated with the maintenance of adequate prey species may include trampling of vegetation, soil compaction, removal of woody debris or other physical degradation potentially altering the productivity and succession/regeneration of the vegetation.

The South Western Region of the Forest Service Land Resource Management Plans (LRMPs) associated Biological Opinion, issued by the FWS contains reasonable and prudent measures necessary and appropriate to minimize impacts of incidental take of MSO on FS lands that include the protection of the owl and its habitat and monitoring of occupancy. The terms and conditions further identify the designing of projects within the various programs including but not limited to recreation to minimize or eliminate adverse effects and reduce negative effects with the goal of implementing projects that will have beneficial, insignificant or discountable effects within occupied habitat. The incidental take amount was identified to be in the forms of harm or harass occurring through direct habitat alteration and disturbance to owls from roosting or nesting sites. Both forms would be of limited extent and intensity. Below are the forest programs in Arizona that addressed standards and guidelines in the LRMPs providing a level of protection specific to MSO (note-not all of the forests addressed these Programs specifically).

**Apache-Sitgreaves**

The Engineering Program seasonally or permanently closes access roads where owls are known to occur, reducing the amount of potential disturbance particularly in the breeding season.

**Coconino**

The Engineering Program identifies the relocation roads outside of riparian areas and obliterating unnecessary roads in riparian areas to reduce impacts to MSO. The Recreation Program identifies camping areas to be located outside of PACs. Further, specifically identifies increases in day use opportunities emphasizing nature based activities in the area of Oak Creek Canyon with some behavioral disturbance potentially anticipated as a result.
Coronado
Recreation program identifies disturbance from hikers, campers and bird watchers on the various districts and activities such as those not causing habitat alteration and generally a low potential for impacts to MSO.

Kaibab
The engineering program identifies the need to obliterate unneeded system roads in areas that would access owl PACs and reducing the disturbance from human presence.

Criteria
A total of 32 proposed sport fish stocking locations are in proximity to Mexican spotted owl (MSO) habitat. The presence of anglers drawn by the fishing opportunities provided by the stockings may result in two types of potential effects: noise/human presence that may result in disturbance of MSO and physical effects to habitat components that may result from anglers creating or using trails or paths to access the fishing opportunity. All the identified stocking sites have been stocked in the past and do not represent new areas of potential disturbance. To determine where such disturbance and/or habitat effects may occur, maps containing the stocking sites were overlain by maps showing where MSO habitat exists.

For management purposes, MSO habitat is categorized as protected or restricted (USFWS 1995), with designated critical habitat overlain on those categories. Protected habitats include the Protected Activity Areas (PACs) which contain known nesting and roosting habitats and are mapped in GIS layers. The PACs are an area of approximately 600 acres and are where activities during the breeding season are concentrated. All PACs are considered to be occupied by MSO. The PAC is not the home range of an MSO; home ranges are larger and contain additional areas used by MSO outside of the breeding season and, to some extent, during the breeding season.

Other protected habitat areas include steep canyons and reserved lands (e.g., wilderness, Research Natural Areas) that are outside of PACs. Restricted areas, as described in the Recovery Plan (USFWS 1995) are areas outside of PACs where additional guidelines should be implemented to maintain or develop potential nesting and roosting habitat now and into the future. Neither other protected areas nor restricted areas are included on GIS layers available for this analysis. However, most of these identified areas were included within the boundaries of designated critical habitat (CH), which is an available map layer and is used in determining exposure potential. However, the map layer does not provide guidance on whether or not a particular parcel of land within the boundaries actually contains the primary constituent elements (PCEs). In this analysis, we assume those are present unless a site is specifically examined.

For the purposes of this analysis, the CH boundaries are considered to include any other protected or restricted habitats that might be affected by anglers accessing fishing opportunities resulting from stocking. There is use by MSOs of forested areas outside of the PAC boundary.
and outside of critical habitat; however, the intent of the PAC and restricted area management guidelines is to protect the most likely areas used by the MSO from significant effects from land management activities. While assuming that CH contains this entire habitat around the stocking site, there may be a small amount of habitat area not in CH that would be excluded from this analysis. The amount of such habitat is likely to be very minimal and not significant to the outcome of this analysis.

**Critical Habitat**

The critical habitat boundaries designated by the USFWS (2005) was also incorporated into a usable GIS layer for spatially analyzing the stocking locations within the designated areas. If a waterbody or stream reach was located within the boundary impacts were evaluated. Those waterbodies or stream reaches outside of the boundary were not analyzed further.

Based on existing data, limiting potentially disturbing activities to areas greater than 0.25 mile from MSO nest sites during the breeding season (March 1 through August 31) is beneficial to MSO. This corresponds well with the Delaney et al.’s (1999) 0.25 mile threshold for alert responses to helicopter flights. The additional 0.25 mi buffer provides a conservative approach in that it extends the potential use area to account for MSOs use along the edge of the PAC and nearby protected or restricted areas during the breeding season. The potential area for angler disturbance was also extended along the stream above or below the stocking site if fish could move from the site and angler access was available (called herein the fishing opportunity area). This extension was evaluated on a site-by-site basis. If the fishing opportunity area or identified access to it was within the 0.25 mile buffer area or the PAC itself, the potential for disturbance effects during the breeding season was deemed possible. If the fishing opportunity area or identified access to it was outside the 0.25 mi buffer or the PAC itself, disturbance effects during the breeding season were deemed unlikely. If the fishing opportunity area or identified access to it was inside CH or in a PAC or buffer area, habitat effects were deemed possible.

Anglers may access PACs, buffer areas or CH by moving through the area to reach a fishing opportunity area or the fishing opportunity area may be in the PAC, buffer, or CH unit. It must be noted that stocking sites are often in conjunction with other developed recreational sites that include developed campgrounds, roads, parking areas, or other amenities present that may affect MSO use of the area. Anglers are only one component of the recreational use of the PACs, buffers and CH surrounding stocking sites.

The critical habitat designation final rule also identifies actions not likely to destroy or adversely modify critical habitat to include most recreational activities, including hiking, camping, fishing, hunting, cross-country skiing, off-road vehicle use, and various activities associated with nature appreciation as not expecting restrictions to any of those identified activities as a result of the
ruling. In addition, within the 2005 BO for continued implementation of the LRMP for the 11 NF of the SW Region, program standard and guidelines incorporated additional protection for MSO.

**New Mexico Meadow Jumping Mouse**

*Methods and Criteria*

Sportfish stocking sites covered by this consultation may be in proximity to New Mexico meadow jumping mouse (MJM) habitats and the activities of anglers drawn by the fishing opportunities may result in impacts to resident MJM. To determine where such impacts may occur, information on location of stocking sites and occupied/potentially occupied MJM habitats was compared to determine areas of potential impact (Table 14).

*Table 1. Stocking sites with potential New Mexico meadow jumping mouse exposure for impacts related to sport fish stocking*

<table>
<thead>
<tr>
<th>Stocking site</th>
<th>Season of use for stocked species</th>
<th>Stocking site at or near habitat</th>
<th>Human activities likely during breeding season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Little Colorado River sites</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>West Fork/East Fork Little Colorado River at Greer</td>
<td>Summer</td>
<td>On site</td>
<td>Yes</td>
</tr>
<tr>
<td>West Fork Little Colorado River at Sheep’s Crossing</td>
<td>Summer</td>
<td>On site</td>
<td>Yes</td>
</tr>
<tr>
<td>Lee Valley Lake</td>
<td>Summer</td>
<td>Off site</td>
<td>No</td>
</tr>
<tr>
<td>Black River sites</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>West Fork Black River</td>
<td>Summer</td>
<td>On site</td>
<td>Yes</td>
</tr>
<tr>
<td>East Fork Black River</td>
<td>Summer</td>
<td>Off site</td>
<td>No</td>
</tr>
</tbody>
</table>

**Southwest Willow Flycatcher**

Methodology and Criteria for Evaluating Sport Fish Stocking and Potential Effect this may have on Southwestern Willow Flycatchers
General Information
The southwestern willow flycatcher is a small grayish-green passerine (Family Tyrannidae) measuring approximately 5.75 inches. The song is a sneezy “fitz-bew” or a “fit-a-bew”, the call is a repeated “whitt”. It is one of four currently recognized willow flycatcher subspecies (Phillips 1948, Unitt 1987, Browning 1993). It is a neotropical migrant that breeds in dense riparian habitats in the southwestern U.S. (from sea level in California to approximately 8,500 feet in Arizona and southwestern Colorado) and migrates to Mexico, Central America, and possibly northern South America during the non-breeding season (Phillips 1948, Stiles and Skutch 1989, Ridgely and Tudor 1994, Howell and Webb 1995). The historical breeding range of the southwestern willow flycatcher included southern California, Arizona, New Mexico, western Texas, southwestern Colorado, southern Utah, extreme southern Nevada, and extreme northwestern Mexico (Sonora and Baja) (Unitt 1987).

The primary constituent elements of critical habitat are based on riparian plant species, structure and quality of habitat and insects for prey. A variety of river features such as broad floodplains, water, saturated soil, hydrologic regimes, elevated groundwater, fine sediments, etc. help develop and maintain these constituent elements (USFWS 2005). The primary constituent elements are:

1. Riparian habitat in a dynamic successional riverine environment (for nesting, foraging, migration, dispersal, and shelter) that comprises:
   a. Trees and shrubs that include, but are not limited to, willow species, box elder, tamarisk, Russian olive, cottonwood, stinging nettle, alder, ash, poison hemlock, blackberry, oak, rose, false indigo, Pacific poison ivy, grape, Virginia creeper, Siberian elm, and walnut;
   b. Dense riparian vegetation with thickets of trees and shrubs ranging in height from 2 to 30 meters (m) (6 to 98 feet (ft.)). Lower-stature thickets (2 to 4 meters or 6 to 13 feet tall) are found at higher elevation riparian forests, and tall-stature thickets are found at middle- and lower-elevation riparian forests;
   c. Areas of dense riparian foliage at least from the ground level up to approximately 4 m (13 ft) above ground or dense foliage only at the shrub level, or as a low, dense tree canopy;
   d. Sites for nesting that contain a dense tree and/or shrub canopy (the amount of cover provided by tree and shrub branches measured from the ground) (i.e., a tree or shrub canopy with densities ranging from 50 percent to 100 percent); or
e. Dense patches of riparian forests that are interspersed with small openings of open water or marsh, or shorter/sparser vegetation that creates a mosaic that is not uniformly dense. Patch size may be as small as 0.1 ha (0.25 ac) or as large as 70 ha (175 ac).

2. A variety of insect prey populations found within or adjacent to riparian floodplains or moist environments, including: flying ants, wasps, and bees; dragonflies; flies; true bugs; beetles; butterflies/moths and caterpillars; and spittlebugs.

A variety of river features such as broad floodplains, water, saturated soil, hydrologic regimes, elevated groundwater, fine sediments, etc. help develop and maintain these constituent elements (USFWS 2005).

**Abundance and distribution in Arizona**

In Arizona, southwestern willow flycatchers breed at the lowest elevations along the lower Colorado River to the high elevation White Mountains of central-eastern Arizona. The peak nesting period for southwestern willow flycatchers in Arizona is from approximately 15 May through 31 July, with limited nesting activity occasionally noted before and after these dates. Flycatchers nest very locally along most of the major perennial rivers below 4000 ft (1219 m) elevation such as the Colorado, Big Sandy, Bill Williams, Gila, Santa Maria, Salt, San Pedro and Verde rivers (McCarthy 2005). They also nest locally from 7900 to 8300 ft (2408-2539 m) elevation along the upper Little Colorado and San Francisco rivers. Within Arizona, nesting at mid-elevations between 4000 and 7000 ft (1219-2134 m) has yet to be recorded, and would expected to be infrequent due to the lack of preferred nesting habitat (flat broad floodplains and expansive riparian habitat).

Likely due to a more concerted survey and monitoring effort, the number of known southwestern willow flycatcher territories has significantly increased in Arizona (145 to 459 territories from 1996 to 2007) (English *et al.* 2006, Durst *et al.* 2008), but the overall distribution of flycatchers throughout the state has not changed much over this time frame. Currently, population stability in Arizona is believed to be largely dependent on the presence of two large populations (Roosevelt Lake and San Pedro/Gila River confluence).

Willow flycatchers are also statewide migrants in Arizona. They begin to arrive in late April, with peak migration in May and early June, with north-bound stragglers still regularly passing through the state into mid-June (McCarthey 2005). Like many passerine neotropical migrants, when available these flycatchers often occur in riparian areas during migration. However, in contrast to the more habitat specific requirements for nesting, habitat use and quality during migration is more varied and broad. Willow flycatchers are regularly encountered in all habitats with scattered trees including desert washes and shaded urban parks and residential backyards. Migrant flycatchers are often found in isolated small stands of trees or foraging along edges of
more extensive woodlands. However, they are seldom encountered in heavily forested habitats, particularly higher elevations conifer forests, or those open habitats lacking trees or tall shrubs. Depending on weather and several other factors such as the amount of available food, cover and water, stopover sites are typically utilize by individual passerine migrants for one to three days before moving on (Carlisle et al. 2009). Willow flycatchers are likely to use a similar variety of habitats in Arizona during fall migration which begins in late July and August, peaking in early September with stragglers through mid-October (McCarthey 2005).

**Nesting habitat**

Historical egg/nest collections and species’ descriptions throughout its range describe the southwestern willow flycatcher's widespread use of willow (Salix spp.) for nesting (Phillips 1948, Phillips *et al.* 1964, Hubbard 1987, Unitt 1987, San Diego Natural History Museum 1995). Currently, southwestern willow flycatchers primarily use Geyer willow (Salix geyeriana), coyote willow (Salix exigua), Goodding’s willow (Salix gooddingii), boxelder (Acer negundo), live oak (Quercus agrifolia) and such widespread exotic species as tamarisk (Tamarix sp.) and Russian olive (Elaeagnus angustifolia) for nesting. High elevation willow species and nesting habitat is shorter in stature and typically cannot grow as quickly as habitat at lower elevations due to shorter growing seasons and colder winters (USFWS 2002). In Arizona, high elevation thickets used for nesting include Geyer (Salix geyeriana) and Bebb (Salix bebbiana) willows. Other plant species less commonly used for nesting include: buttonbush (Cephalanthus sp.), black twinberry (Lonicera involucrata), cottonwood (Populus spp.), white alder (Alnus rhombifolia), blackberry (Rubus ursinus), and stinging nettle (Urtica spp.). Based on the diversity of plant species composition and complexity of habitat structure, four basic habitat types can be described for the southwestern willow flycatcher: monotypic willow, monotypic exotic, native broadleaf dominated, and mixed native/exotic (Sogge *et al.* 1997).

Tamarisk is now an important component of the flycatcher’s nesting and foraging habitat in much of Arizona and other parts of the bird’s range. In 2001 in Arizona, 323 of the 404 (80 percent) known flycatcher nests (in 346 territories) were built in a tamarisk tree (Smith *et al.* 2002). Tamarisk had been believed by some to be a habitat type of lesser quality for the southwestern willow flycatcher, however comparisons of reproductive performance (USFWS 2002), prey populations (Durst 2004) and physiological conditions (Owen and Sogge 2002) of flycatchers breeding in native and exotic vegetation has revealed no difference (Sogge *et al.* 2005).

The flycatcher’s habitat is dynamic due to it being subjected to river flooding and therefore its quality and location can change rapidly: nesting habitat can grow out of suitability; tamarisk habitat can develop from seeds to suitability within five years; heavy runoff can remove/reduce habitat suitability in a day; or river channels, floodplain width, location, and vegetation density may change over time. The flycatcher’s use of habitat in different successional stages may also
be dynamic. For example, over-mature or young habitat not suitable for nest placement can be occupied and used for foraging and shelter by migrating, breeding, dispersing, or non-territorial southwestern willow flycatchers (McLeod et al. 2005, Cardinal and Paxton 2005).

Specific habitat used for nest placement is denser, typically more interior with the height of nests primarily in the mid to lower portions of trees. At lower elevation in Arizona (below 4000 ft), willow flycatcher nest heights averages approximately 15 ft (4.6 m) and range from 4.8 to 38.7 ft (1.5-11.8 m), but nests are found lower in the trees 3-10 ft (1-3 m) in the shorter-statured, higher elevation habitat (above 7500 ft) sites (McCarthey 2005).

**Occurrence in the action area**

In order to determine where suitable flycatcher nesting habitat may be found within the action area, a collection of sources were examined. Information sources used for evaluation included HDMS data (occurrences), FWS designated critical habitat polygons, range wide WIFL database of nesting flycatcher territories and the WIFL Recovery Plan’s Table 10 description of important streams, as well professional opinion of the FWS and AGFD where known territories and habitat were found. We then selected segments of streams that can support nesting habitat (instead of patches of habitat), understanding that flycatcher nesting habitat is dynamic and can shift location over time due to floods, drought, fire, and land uses (river diversion, agriculture return flow, etc.).

After placing these information sources together and compared to the proposed stocking locations, suitable southwestern willow flycatcher nesting habitat was determined to occur in two general areas (Verde River and the White Mountains). Along the middle Verde River, flycatcher nesting habitat can be found throughout the Verde Valley (i.e. towns of Clarkdale, Cottonwood, and Camp Verde). Land ownership throughout this stretch of river is primarily privately owned, however some state (Dead Horse State Park), tribal (Yavapai and Apache) and Forest Service (Prescott NF) land exists. At higher elevation in the White Mountains, nesting flycatcher habitat can be found within the action area along the upper Little Colorado River (and a portion of its forks) downstream to the Town of Greer area (Map x). These areas primarily occur within the Apache Sitgreaves National Forest, although private land parcels are also included.

Consistent breeding areas were identified through HDMS data and analyzed site by site by species experts for evaluation. Documented occurrence sites were only included if they were designated as a territory (singing or paired birds after 15 June) or if nesting activities were actually observed. Southwestern willow flycatchers have been documented nesting at four sites in the Verde Valley between Clarkdale and Camp Verde and three sites in the upper Little Colorado River drainage downstream to Eager.

Because migrant willow flycatchers can occur statewide and are most frequently found along aquatic habitats (rivers, creeks, etc.), it is difficult to identify areas where willow flycatchers
could not occur. Additionally, the habitat requirements for migrant flycatchers are not as specific as nesting birds and specific stopover locations used are unpredictable in timing, duration, location, and abundance. In fact as noted before migrating passerines typically remain at one location for only one to three days before continuing their journey to breeding or wintering grounds (Carlisle et al. 2009).

Flycatcher nesting habitat can quickly change and vary in suitability, location, use, and occupancy over time (Finch and Stoleson 2000). As a result, it is important to reiterate how this may influence the location of southwestern willow flycatchers with respect to the proposed action. The preferred nesting and migration habitat of southwestern willow flycatchers shifts over time in location and quality which subsequently influences the locations and densities of flycatchers. Flooding, drought, fire, lake levels, etc. can help to accelerate the recycling, growth, and/or shift in location and abundance of riparian vegetation. As a result, past or current nesting flycatcher locations may not be the same exact locations used by flycatchers in the future. Evaluating nesting flycatchers across river segments that can support suitable nesting habitat helps to ensure that future unknown locations are considered in this analysis.

Critical habitat occurrence in the action area
Designated southwestern willow flycatcher critical habitat maps were compared to stocking locations to identify which river stretches of critical habitat are within the action area. Similar to areas where suitable nesting habitat occurs, critical habitat occurs within the action area along the Verde River in the middle Verde Valley and in the White Mountains along the Little Colorado River drainage downstream to the Town of Greer. However, because of specific methodology used to designate critical habitat, it does not mirror all the locations where suitable nesting habitat is found or where all territories have been located. Therefore, critical habitat is a smaller area to evaluate.

Potential effects
Angler activity/behavior along rivers
Riparian areas receive disproportionately high recreation use in the arid Southwest, when compared with other habitats. Not surprisingly, riparian areas near cities receive greater use than those farther away from development (Turner 1983). The demand for recreation in riparian areas will continue to increase in proportion to increasing human populations. Impacts can be more devastating in the Southwest, where riparian habitat tends to be more linear, narrow, and dissimilar to adjacent habitat than in other parts of the country.

Anglers for stocked trout are a subset of the variety of activities and management actions that may affect riparian areas and flycatcher habitat. For example, those activities include, but are not limited to water management actions (i.e. water diversion, groundwater pumping, etc.), livestock grazing, housing, woodcutting, vehicle use, road development, hiking, camping, shooting, day-

**Recreational impacts flycatcher habitat**

Riparian habitat impacts from recreation, as described in the Southwest Willow Flycatcher Recovery Plan (USFWS 2002) include: loss of surface soil horizons, soil compaction, altered soil moisture and temperature, altered soil microbiota, habitat fragmentation, reduced dead woody debris, altered plant species composition, altered foliage height diversity, reduced plant diversity/cover, lack of plant regeneration, erosion, increased sedimentation/turbidity of water, altered organic matter content of water, altered water chemistry, altered flow regimes, pollution, increased risk of accidental fire, increased trash, increased human waste and diseases, increased feral domestic animals and pet dogs, increased native predators, displacement of wildlife by facilities, unauthorized roads and trails, human presence and noise disturbance. The potential for the recreational activity to produce negative impacts is highly dependent on the frequency, intensity, location and type of use the area receives. Infrequent but unpredictable recreational actions without patterns can cause more negative impacts per event than those predictable and frequent.

Impacts to streams and stream side habitat have been attributed specifically due to angling. Some of these impacts include: water turbidity, erosion of banks, pollution, over water movement disturbance and reduced stability of habitats (USFWS 2002). Changes in the structure, density and composition of vegetation can occur from recreation induced soil compaction and erosion. Locally, day-use recreation such as angling could reduce or fragment regenerating or growing riparian habitat due to trampling and soil compaction (USFWS 2002). Fragmentation of habitat due to the development of trails can cause habitat to not be suitable for birds requiring dense contiguous vegetation. Where vegetation is sparse, even light use can prevent further development of dense lower strata which are important to flycatchers (USFWS 2002). During spring and summer, cottonwood and willow seedlings often establish on open, unvegetated sand or gravel bars and shorelines which are attractive to anglers as they provide unobstructed locations for casting.

As the number of recreation users increases, so does the probability of an accidental fire (USFWS 2002). Fire within the riparian areas have become more frequent due to the combination of increased drying of riparian areas, increased distribution and growth of flammable exotic plants adapted to these drier conditions, and an increased distribution and abundance of ignition sources (largely man-caused). Fire can devastate southwestern willow flycatcher nesting habitat.
**Flycatcher behavior toward human activity/recreation**

The types of possible direct recreation impacts to animals, also described in the Flycatcher Recovery Plan (USFWS 2002) include direct/indirect mortality, low productivity, reduced habitat use, and reduced use of preferred habitat and aberrant behavior/stress resulting in reduced reproductive or survival rates (USFWS 2002).

The flycatcher itself does not appear to be overly sensitive to low level human activity occurring outside of the immediate breeding patch (USFWS 2002). Like the majority of nesting passerines, flycatchers will alter their behavior due to human activity when nesting, but will typically resume normal behavior once the presumed danger has passed. Similarly, migrant and foraging flycatchers will fly a reasonably safe distance to adjacent perches if approached too closely by humans.

Human activity that occurs within breeding patches in close proximity to flycatcher nests has the potential to lead to failure or reduced productivity. Spending long durations of time near nests can cause adults to abandon nesting attempts or prevent adults from returning to nests, causing mortality of eggs/nestlings. Frequently walking to and from and/or through nest areas can attract predators or nest parasites to a flycatcher nest. Bushwacking through dense vegetation can cause the failure of precariously placed nests or nests built low to the ground by knocking the nest and/or its contents to the ground.

**Fishing line and flycatcher nests**

Female flycatchers construct a small cup nest constructed of leave, grass, plant fibers, feathers and animal hair; coarser material is use for the nest base and body with finer material in cup lining (Bent 1963). The use of discarded fishing line for nest construction and subsequent impacts to nestlings has not been documented, even at locations such as Roosevelt Lake where angling activity is extremely high (Pringle 2004).

**Western Yellow-Billed Cuckoo**

**Methods and Criteria**

In order to determine where suitable yellow-billed cuckoo (cuckoo) nesting and foraging habitat may be found within the action area, several sources were examined. Information sources used for evaluation included HDMS data (occurrences) and professional opinion of the FWS and AGFD where appropriate habitat is found. We then selected segments of streams or lake shorelines that can support nesting habitat (instead of patches of habitat), understanding that cuckoo nesting habitat is dynamic and can shift location over time due to floods, drought, fire, and land uses (river diversion, agriculture return flow, etc.).

After placing these information sources together and comparing to the proposed stocking locations, suitable yellow-billed cuckoo nesting or foraging habitat was determined to occur at or adjacent to nine stocking sites (Table 15). Consistent breeding areas were identified through
HDMS data and analyzed site by site by species experts for evaluation. Documented occurrence sites were only included if they were designated as a territory (calling or paired birds between 15 June and 31 August) or if nesting activities were actually observed.

Table 2. Stocking sites with potential yellow-billed cuckoo exposure for habitat or disturbance effects.

<table>
<thead>
<tr>
<th>Stocking Site</th>
<th>Stocking Season</th>
<th>Breeding/Foraging Habitat</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Salt River</td>
<td>Winter/spring</td>
<td>Y</td>
<td>Habitat</td>
</tr>
<tr>
<td>Patagonia Lake</td>
<td>All seasons</td>
<td>Y</td>
<td>Disturbance, Habitat</td>
</tr>
<tr>
<td>Watson Lake</td>
<td>All seasons</td>
<td>Y</td>
<td>Disturbance, Habitat</td>
</tr>
<tr>
<td>Willow Lake</td>
<td>All seasons</td>
<td>Y</td>
<td>Disturbance, Habitat</td>
</tr>
<tr>
<td>Middle Verde River</td>
<td>Winter/spring</td>
<td>Y</td>
<td>Habitat</td>
</tr>
<tr>
<td>Deadhorse SP</td>
<td>All seasons</td>
<td>Y</td>
<td>Disturbance, Habitat</td>
</tr>
<tr>
<td>Oak Creek</td>
<td>Spring through fall</td>
<td>Y</td>
<td>Disturbance, Habitat</td>
</tr>
<tr>
<td>West Clear Creek</td>
<td>Spring/fall</td>
<td>Y</td>
<td>Habitat</td>
</tr>
<tr>
<td>Wet Beaver Creek</td>
<td>Spring/fall</td>
<td>Y</td>
<td>Habitat</td>
</tr>
</tbody>
</table>

Because migrant cuckoos can occur statewide and are most frequently found in the riparian zones along aquatic habitats (rivers, creeks, etc.), it is difficult to identify areas where they could not occur during migration. Additionally, the habitat requirements for migrant cuckoos are not as specific as nesting birds and specific stopover locations used are unpredictable in timing, duration, location, and abundance. The potential effects of disturbance to cuckoos during migration are discussed separately from disturbance during the breeding season.

Cuckoo nesting habitat can quickly change and vary in suitability, location, use, and occupancy over time. As a result, it is important to reiterate how this may influence the location of cuckoos with respect to the proposed action. The preferred nesting habitat of cuckoo shifts over time in location and quality which subsequently influences the locations and densities of cuckoos. Flooding, drought, fire, lake levels, etc. can help to accelerate the recycling, growth, and/or shift in location and abundance of riparian vegetation. As a result, past or current nesting cuckoo locations may not be the same exact locations used by cuckoos in the future. Evaluating nesting cuckoos across river segments and lake/pond shorelines that can support suitable nesting habitat helps to ensure that future unknown locations are considered in this analysis.

Habitat Impacts
Riparian areas receive disproportionately high recreation use in the arid Southwest, when compared with other habitats. Not surprisingly, riparian areas near cities receive greater use than
those farther away from development (Turner 1983). The demand for recreation in riparian areas will continue to increase in proportion to increasing human populations. Impacts can be more devastating in the Southwest, where riparian habitat tends to be more linear, narrow, and dissimilar to adjacent habitat than in other parts of the country.

Anglers are a subset of the recreation component of activities and management actions that may impact riparian areas and cuckoo habitat. For example, those activities include, but are not limited to water management actions (i.e. water diversion, groundwater pumping, etc.), livestock grazing, housing, woodcutting, vehicle use, road development, hiking, camping, shooting, day-use, horseback riding, etc. (Willard and Marr 1970, Manning 1979, Briggs 1996, Cole and Spildie 1998).

Riparian habitats impacts from recreation, include: loss of surface soil horizons, soil compaction, altered soil moisture and temperature, altered soil microbiota, habitat fragmentation, reduced dead woody debris, altered plant species composition, altered foliage height diversity, reduced plant diversity/cover, lack of plant regeneration, erosion, increased sedimentation/turbidity of water, altered organic matter content of water, altered water chemistry, altered flow regimes, pollution, increased risk of accidental fire, increased trash, increased human waste and diseases, increased feral domestic animals and pet dogs, increased native predators, displacement of wildlife by facilities, and unauthorized roads and trails (USFWS 2002). The potential for the recreational activity to produce negative impacts is highly dependent on the frequency, intensity, location and type of use the area receives. Infrequent but unpredictable recreational actions without patterns can cause more negative impacts per event than those predictable and frequent.

Impacts to streams and stream side habitat have been attributed specifically due to angling. Some of these impacts include: water turbidity, erosion of banks, pollution, over water movement disturbance and reduced stability of habitats (USFWS 2002). Changes in the structure, density and composition of vegetation can occur from recreation induced soil compaction and erosion. Locally, day-use recreation such as angling could reduce or fragment regenerating or growing riparian habitat due to trampling and soil compaction (USFWS 2002). Fragmentation of habitat due to the development of trails can cause habitat to not be suitable for birds requiring dense contiguous vegetation. Where vegetation is sparse, even light use can prevent further development of dense lower strata which are important to flycatchers and cuckoos (USFWS 2002). During spring and summer, cottonwood and willow seedlings often establish on open, unvegetated sand or gravel bars and shorelines which are attractive to anglers as they provide unobstructed locations for casting. These stocking actions are an ongoing action that has a long history of occurring in these areas. As a result, we anticipate that anglers will likely continue to visit areas that they have visited in the past. To facilitate ease of access to the stream, anglers are expected to primarily stay on existing primitive foot trails or cattle/wildlife trails and/or walk between patches of dense vegetation. Additionally, we do not anticipate anglers once they reach
their destination to be fishing in tight areas where vegetation is dense that causes casting to be difficult.

As the number of recreation users increases, so does the probability of an accidental fire (USFWS 2002). Fire within the riparian areas have become more frequent due to the combination of increased drying of riparian areas, increased distribution and growth of flammable exotic plants adapted to these drier conditions, and an increased distribution and abundance of ignition sources (largely man-caused). Fire can devastate cuckoo nesting habitat.

Cuckoo nesting habitat contains dense riparian vegetation in the under- and mid-story levels that make it difficult to create trails and paths through the area. Human traffic can affect tree regeneration in the understory (Corman and Magill 2000, Holmes et al. 2008) and creation of trails can increase potential predator access to the habitat (Corman and Magill 2000). Overuse of riparian areas by livestock, water management actions, vegetation clearing, and woodcutting are more likely to result in fragmented habitats with degraded under- and mid-story conditions that affect nesting habitat quality for the cuckoos than is human traffic. Areas with heavy human traffic may already be impacted by other actions that contributed to the decline of habitat quality that also allows for easier access by humans. In areas without existing trails or paths, the density of cuckoo habitat tends to deter human entrance (Laymon 1998).

As noted earlier, the structural components of cuckoo migration habitat are much broader than for nesting habitat and many riparian areas not suitable for nesting may be used during migration. While the activities described above contribute to degradation of migration habitat, the greater extent of usable migration habitat, that reduction in habitat quality has less impact on cuckoo use of the habitat.

**Disturbance Impacts**

Human-related disturbance during the migration period (either spring or fall) is likely to have a very limited impacts on cuckoos since individuals are highly mobile, do not remain long in one area, and suitable migration habitat is more available than nesting habitat. This reduces the opportunity for exposure, and avoidance of areas of high human use is more feasible. Information from surveys and observations indicate that migrant and foraging cuckoos will fly a reasonably safe distance to adjacent perches if approached too closely by humans.

The information on the degree to which human presence in cuckoo nesting habitat can impact behavior of the adults and thus the success of the nesting attempt is not entirely consistent. Wiggins (2005) noted that any capture of adult birds for banding should not be done at the nest since the danger of abandonment of the nest is high. Similarly, he cautioned against banding the young birds while they are in the nest for the same reason. Latta et al. (1999) reported that cuckoos will abandon nests if disturbed repeatedly and suggested avoidance of intense and repeated human disturbance in nesting areas between May 20 and September 1. Halterman
(2010) indicated that a steady human presence during nest building or normal, regular human activity in the vicinity the effect to cuckoos is low, but more intensive use could result in nest failure. One report from Texas (Luneau 2002) documented nest abandonment during incubation by cuckoos after less than three minutes observation at a distance of 35 feet from the nest. Cuckoos are not likely to abandon the nest once the first egg hatches and foraging birds are largely oblivious to human presence (Laymon 1998). The cuckoo survey protocol notes that adults do not go to their nest if under observation, and that nest abandonment is a concern particularly during the nest building stage.

The types of possible direct recreation impacts to animals include direct/indirect mortality, low productivity, reduced habitat use, and reduced use of preferred habitat and aberrant behavior/stress resulting in reduced reproductive or survival rates (USFWS 2002).

Although reclusive at times, cuckoos do not appear to be overly sensitive to low level human activity occurring outside of the immediate breeding area. Like most nesting birds, cuckoos will alter their behavior due to human activity when nesting, but will typically resume normal behavior once the presumed danger has passed. Human activity that occurs within breeding patches in close proximity to cuckoo nests has the potential to lead to failure or reduced productivity. Spending long durations of time near nests can cause adults to abandon nesting attempts or prevent adults from returning to nests, causing mortality of eggs/nestlings. Frequently walking to and from and/or through nest areas can attract predators to a cuckoo nest.

**Yuma Clapper Rail**

*Methods and Criteria*

Sportfish stocking sites covered by this consultation may be in proximity to Yuma clapper rail (YCR) habitats and the activities of anglers drawn by the fishing opportunities may result in impacts to resident YCR. To determine where such impacts may occur, information on location of stocking sites and occupied/potentially occupied YCR habitats was compared to determine areas of potential impact, including if the habitat was at the site or along an adjacent waterway (Table 16). The potential for impacts at stocking sites vary with the species stocked and if stocking would occur during the breeding season.

*Table 3. Stocking sites with potential yellow billed cuckoo exposure for impacts related to sport fish stocking*

<table>
<thead>
<tr>
<th>Stocking site</th>
<th>Season of use for stocked species</th>
<th>Location of habitat relative to stocking site</th>
<th>Human activities possible during breeding season</th>
<th>Potential for effects</th>
</tr>
</thead>
</table>

Biological Assessment of the Arizona Game and Fish Department’s Statewide and Urban Fisheries Stocking Program

January 2011

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<table>
<thead>
<tr>
<th>Lower Colorado River sites</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>La Paz County Park</td>
<td>Seasonal (fishing derbies only)</td>
<td>No habitat at site; habitat on Colorado River is not adjacent to site.</td>
<td>No</td>
</tr>
<tr>
<td>Hidden Shores Golf Course</td>
<td>Seasonal (fishing derbies only)</td>
<td>No habitat at site; habitat on Colorado River is not adjacent to site.</td>
<td>No</td>
</tr>
<tr>
<td>Yuma West Wetlands Pond</td>
<td>Seasonal (fishing derbies only)</td>
<td>No habitat at site; habitat on Colorado River is not adjacent to site.</td>
<td>No</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lower Gila River sites</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fortuna Pond</td>
<td>Year round</td>
<td>Minimal cattail at site, adjacent portions of Gila River contain marsh habitat</td>
<td>Yes</td>
</tr>
<tr>
<td>Redondo Lake</td>
<td>Year round</td>
<td>Minimal cattail at site, adjacent portions of Gila River contain marsh habitat</td>
<td>Yes</td>
</tr>
<tr>
<td>Wellton Golf Course Pond</td>
<td>Seasonal (fishing derbies only)</td>
<td>No habitat at site; habitat on Gila River is several miles away</td>
<td>No</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Salt River sites</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Apache Lake</td>
<td>Year round</td>
<td>No cattail areas on lake</td>
<td>No</td>
</tr>
<tr>
<td>Canyon Lake</td>
<td>Year round</td>
<td>No cattail areas on lake</td>
<td>No</td>
</tr>
<tr>
<td>Saguaro Lake</td>
<td>Year round</td>
<td>On site</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Lower Salt River | Winter/spring | On site | Yes | Yes
--- | --- | --- | --- | ---
Tempe Town Lake | Winter/spring | No cattail areas on lake. Habitat above lake on Salt River | No | No

Riparian Reptiles and Amphibians Methodology

*Batrachochytrium dendrobatidis* and the spread of Amphibian Chytridiomycosis

The following review and information were prepared to provide an understanding of basic biology, transport mechanisms and impacts to amphibians in Arizona of the amphibian fungal pathogen, *Batrachochytrium dendrobatidis* (sometimes referred to as “chytrid” and hereafter as “Bd”), and to use that information to evaluate current hatchery operations and the likelihood of spread of Bd through fish stocking. This is not meant to be an exhaustive review of the global literature on Bd or chytridiomycosis, instead this will concentrate on those aspects of the biology of the organism that are relevant to its survival and distribution in Arizona, and how those might affect the (AGFD) hatchery operations related to the statewide sport fish stocking program.

Introduction and Basic Biology of Bd

Fungi in the primitive group Chytridiomycota are characterized by uniflagellated reproductive cells, and typically occur in water or moist soils, where they are parasites of protists, other fungi, algae, plants, insects and other invertebrates, as well as biodegraders of plant and animal remains containing cellulose, chitin or keratin (Powell 1993). Only one species, *Bd*, is known to infect vertebrates, and prior to 1998 it was unknown to science (Berger *et al.*1998, Longcore *et al.* 1999). *Bd* causes the serious and sometimes virulent amphibian disease chytridiomycosis (Berger *et al.*1998, Longcore *et al.* 1999, Stuart *et al.* 2004). In the last decade, the role of infectious diseases has been recognized as a key factor in amphibian declines throughout the world, and chytridiomycosis has been linked to much of that decline (Daszak *et al.* 1999, Carey 2000, Collins and Storfer 2003, Daszak *et al.* 2003; Skerratt *et al.* 2007). Recent studies support the contention that Bd is an emerging infectious disease, i.e., a novel pathogen (Vredenburg *et al.* 2010), and not a widespread endemic that has emerged as a result of environmental change (e.g., Pounds *et al.* 2006).

Although many other chytrid species have been well studied as parasites of economically important plants (Powell 1993), surprisingly few studies have investigated the basic biology or ecology of Bd, although significant advances continue to be made (e.g., Woodhams *et al.* 2008, Voyles *et al.* 2009, Briggs *et al.* 2010, Vredenburg *et al.* 2010).

*Bd* has a complex life cycle in which “infective,” free-living motile zoospores encounter, and encyst on the keratinized epidermis of amphibians and then develop into reproductive sporangia.
(zoosporangia) which produce more zoospores through asexual reproduction. The zoospores are then released back into the water through a discharge tube and the cycle continues; no resting spores have been identified in laboratory studies (Longcore et al. 1999). Amphibians (frogs and salamanders) are the only known hosts for Bd; Bd has not been reported in caecilians (Gower and Wilkinson 2005).

There are few data regarding the ability of Bd to occupy alternative hosts (i.e., other than amphibians). Although Bd had been reported from freshwater shrimp in Australia (Rowley and Alford 2006), subsequent work by the same research group falsified their original findings (Rowley et al. 2007). Collins et al. (2005) used PCR to test for the presence of Bd on a variety of plants and animals collected from sites from which Bd was already known. They reported a Bd positive result from a batch sample of 6 wild caught fathead minnows (Pimephales promelas) from Sycamore Creek, Maricopa County, AZ. Whether one or more of those fish was infected with Bd, or simply had zoosporangia or zoospores (or their remains) on the surface of their fins is not known. They also exposed several potential host animals to large quantities of Bd zoospores in a series of experiments. Results suggested that backswimmers (Notonectidae, Notonecta sp.), dragonfly naiads (Odonata, including individuals in families Aeshnidae and Libellulidae) and crayfish (Orconectes virilis) were capable of carrying Bd for several days. Sample sizes in all cases were small and experimental procedures varied considerably (including different species of odonates). Although the authors used terms like “infected” to describe the results, the results were only Bd positive, suggesting that at a minimum zoospores or zoosporangia persisted on an organisms’ surface rather than a host – pathogen relationship. However, the results are suggestive and demonstrate the need for additional rigorous testing.

For the purposes of discussion, unless otherwise defined below, experiments examining basic biological characteristics of Bd use two terms to describe aspects of the life cycle (taken from Johnson and Speare 2003 and Johnson and Speare 2005): 1) “Viability” -- in which flagellated zoospores move freely in the medium (water, growth medium, etc.), or zoospores move within zoosporangia, or growth occurs when aliquots from water with seemingly inactive Bd are subsequently injected into growth media/broth; and 2) “Growth” -- in which zoospores attach to a substrate (sometimes termed “encyst”) and then develop in zoosporangia, or zoosporangia change size and form, or zoosporangia release new zoospores into the medium. Work reported by Longcore et al. (1999) and Piotrowski et al. (2004) quantified growth through optical density of zoospores and zoosporangia grown in liquid medium. Finally, it is important to note that Bd zoosporangia might survive in a “state of arrested or nondiscernable development” for extended time periods in less than suitable environments, and then when inoculated into appropriate growth media growth begins again, i.e., the culture remains “viable” (Johnson and Speare 2003). Therefore, lack of observable activity or growth does not indicate a dead or nonviable culture (Johnson and Speare 2003), nor should that be confused with a resting spore stage, which is
unknown for Bd (Longcore et al. 1999). Also, use of the term “Bd-positive” only denotes presence of the organism or its DNA, and does not necessarily equate with documented chytridiomycosis or mortalities linked to Bd.

The time and distance that zoospores will swim before encysting on the substrate was measured by Piotrowski et al. (2004). Although exact figures were not reported, the majority of zoospores tested (on 3, 5 cm diameter plastic culture dishes, each of which had about 200,000 zoospores) moved less than 2 cm before they encysted. About 50% had encysted by 18 hours, and 50% remained motile. By 24 hours, only about 5% were still moving; 95% had encysted. These results are consistent with one of the author’s (J.E. Longcore) observations that infected amphibian skin cells often occur in clusters, suggesting that many zoospores do not disperse long distances, but rather they infect cells in the immediate vicinity of the zoosporangia from which they were released. This also suggests that Bd might spread among hosts during close contact, e.g., anuran amplexus, combat, aggregating tadpoles, etc. (Piotrowski et al. 2004).

Experiments by Johnson and Speare (2003) examined the ability of Bd to survive and grow in tap water, deionized water and sterilized “lake” water. Although in all cases, zoospores developed into zoosporangia which attached to the plastic flask in which they were housed, only the lake water treatment subsequently released zoospores, and did so for up to seven weeks. The tap and deionized treatments did not grow, but remained viable for three to four weeks (i.e., when reinoculated in broth). Presumably, unquantified nutrients and organics in the sterilized lake water allowed Bd to survive longer. It is important to note that no experiments have tested the lake water result under “field” conditions, i.e., with living lake, pond, stream water, etc.. Presumably, under those conditions Bd zoospores would be subject to predation by a variety of free-living protists, fungi, zooplankton, etc.

Although Bd is generally considered to be obligately aquatic, it has been reported to survive for at least 12 weeks (= 17 – 21 generations) in sterilized, damp (33% moisture content) sand (Johnson and Speare, 2005). At least one strain grew in sand with moisture contents as low as 10%, but those results were not quantified and need to be repeated (Johnson and Speare, 2005). However, earlier experiments demonstrated that mortality occurred when zoospores were dried (i.e., “complete dessication”) for at least 3 hours (Johnson et al. 2003).

Interestingly, there is a recent report of Bd in the direct-developing plethodontid salamander, *Batrachoseps attenuatus*, a salamander with no aquatic habits nor an aquatic stage in its life cycle (Weinstein 2009), suggesting Bd is spread by direct contact, or that Bd can, in fact, survive and probably disperse in moist soils. Nonetheless, mechanisms by which Bd can infect largely terrestrial amphibians (or disperse through seemingly unfavorable habitats) are not known, and Johnson and Speare (2005) suggest that risk of infection in terrestrial habitats will vary among soil types, moisture content and pH.
Bd appears to tolerate a wide range of pH. Experiments have demonstrated survival and growth from pH 5 through pH 10 (none survived at pH 3 or 4), although the best zoosporangia growth and zoospore activity occurred between pH 6 and pH 7.5 (Piotrowski et al. 2004, Johnson and Speare 2005). At pH 5, 5.5 and 8 growth was slower than between pH 6 and 7.5. At pH 9 and 10 there was early growth, but activity ceased by day 7 and 3, respectively. However, cultures that were grown at pH 9 and 10 for 1 - 2 weeks (during which they were not growing or active) and then inoculated into cultures at pH 6.7 then became active and grew (Johnson and Speare 2005). These results suggest that although Bd does best at near normal pH, moderate extremes do not necessarily kill the fungus, thus Bd can probably survive in a wide variety of aquatic habitats. Further, it is also likely that Bd occurring inside an amphibian host might be buffered from external pH (Piotrowski et al. 2004), including the more basic waters that are common in Arizona.

The biology of Bd is greatly influenced by ambient temperature. In culture, Bd grew at temperatures as low as 4°C (Piotrowski et al. 2004), optimum growth occurred at 23°C but slowed at 28°C, and there was (reversible) cessation of growth at 29°C (Longcore et al.1999). Later experiments indicated that optimal growth occurred at 17° - 25° C (Piotrowski et al. 2004). Bd is sensitive to heat, and in culture isolates maintained at 28°C failed to grow and contained no live zoospores after 2 days (Piotrowski et al. 2004; time of exposure not reported) and at 37°C when exposed for 4 hours (Johnson et al., 2003). Bd is pathogenic over a broad range of temperatures (12° - 27° C) but is most virulent from 12° - 23° C. Both pathogenicity and virulence decrease as temperature increases beyond 27° C (Skerratt et al. 2007 and references therein). In culture, short-term growth was maximal at 17°-25° C, and zoospores encysted and developed faster into zoosporangia (Woodhams et al. 2008). However, at cooler temperatures (7° - 10° C) although zoosporangia grew more slowly, they produced greater numbers of zoospores and they remained infectious longer. Piotrowski et al. (2004) noted that the ability to grow, albeit slowly, at 4° C would permit Bd to survive overwintering in aquatic habitats, and as temperature rose Bd could reproduce rapidly. Also in culture, zoospores can be induced to release by a sudden decrease in temperature (Woodhams et al. 2008). Finally, Woodhams et al. (2008, p.1627) summarized their work by saying, “The effect of temperature on amphibian mortality will depend on the interaction between fungal growth and host immune function and will be modified by host ecology, behavior, and life history. These results demonstrate that B. dendrobatidis populations can grow at high rates across a broad range of environmental temperatures and help to explain why it is so successful in cold montane environments.”

Piotrowski et al. (2004) also demonstrated that Bd responds dramatically to different sources of nitrogen, although how those experimental nitrogen sources translate to environmental sources of
nitrogen is not clear. Experiments testing the effects of phosphorus are underway at Arizona State University (O. Hyman pers. comm.).

The precise mechanism by which Bd kills amphibians is not yet known, but recent work provides important information. The fungus may release toxins that are absorbed through the skin, but since amphibians absorb water and often respire cutaneously, Bd has been thought to affect water uptake, ionic balance or respiration. Voyles et al. (2007) reported that severe chytridiomycosis in Australian green tree frogs (*Litoria caerulea*) causes decreases in blood pH, plasma osmolality and plasma sodium, potassium, magnesium and chloride concentrations, and that this imbalance in osmotic homeostasis is caused by a disruption of normal cutaneous function. Their more recent work has shown that pathophysiological changes associated with electrolyte transport across the epidermis resulted in mortality. These researchers were the first to demonstrate experimentally that disruption of cutaneous function is a likely mechanism by which Bd kills amphibians. They noted that in “diseased individuals, electrolyte transport across the epidermis was inhibited by >50%, plasma sodium and potassium concentrations were respectively reduced by ~20% and ~50%, and asystolic cardiac arrest resulted in death” (Voyles et al 2009, p. 582).

The degree to which Bd affects amphibians at the population level varies considerably, and the factors that influence individual and population responses are incompletely understood (Briggs et al., 2010). Some amphibians appear to tolerate Bd with few negative effects (Davidson et al. 2003, Daszak et al., 2004; Weldon et al., 2004), while its presence has been correlated with high levels of mortality in many species (Stuart et al., 2004, Lips et al. 2006,) and has also been implicated in amphibian extinctions (La Marca et al., 2005). This range of variability is also apparent in populations of Arizona anurans (see below).

In Arizona, Bd has been implicated in mortalities in *Bufo punctatus*, *Hyla arenicolor*, *H. wrightorum*, *Pseudacris triseriata*, *Rana berlandieri*, *R. blairi*, *R. chiricahuensis*, *R. pipiens*, *R. tarahumarae* and *R. yavapaiensis*, and has been identified in *Ambystoma tigrinum stebbinsi* and *Rana catesbeiana* (Bradley et al. 2002, Sredl et al. 2002, Rosen and Schwalbe 2002, Davidson et al. 2003, Garner et al. 2006, Schlaepfer et al. 2007, AGFD unpublished data, O. Hyman pers. comm.). Among these species, Bd has been implicated in severe population declines of *Rana yavapaiensis* (Sredl 2000) and the extirpation of *Rana tarahumarae* from Arizona (T. Jones, P.J. Fernandez unpublished; see also Hale et al. 2005), yet populations of other species seem to have survived despite occasional losses of individuals to Bd. For example, Bd was confirmed in Sycamore Canyon from a 1972 *Rana yavapaiensis* specimen (S. Cashins, E. Davidson, M.J. Sredl unpublished) and from dead and dying *R. yavapaiensis* and *R. tarahumarae* collected in 1974 (T. Jones, P.J. Fernandez unpublished). It is clear that Chiricahua leopard frog populations can coexist with the disease for extended periods, and in this case they have coexisted with Bd in
Sycamore Canyon at least since 1972 (U.S. Fish and Wildlife Service 2007), despite periodic mortalities.

Some amphibian species or populations are known to harbor Bd without evidence of lethal effects (e.g., Longcore et al. 2007). In Arizona, this includes native tiger salamanders (*A. t. stebbinsi*) and exotic bullfrogs (Davidson et al. 2003, Mazzoni et al. 2003). Consequently, through dispersal both species would be capable of moving or maintaining Bd in the environment (Collins *et al.* 2003, Daszak *et al.* 2004). Other native and nonnative frogs that are susceptible to the disease also serve as disease vectors or reservoirs of infection (e.g., Bradley *et al.* 2002).

**Vectors**

The mechanism by which Bd is spread across the landscape is incompletely understood, but we know that Bd can be transmitted in at least two ways: 1) through the movement of infected amphibians, or 2) through movement of water (or mud) that contains zoospores or zoosporangia from infected amphibians.

As mentioned above, the most likely avenue for Bd dispersal is through movement of infected amphibians (either naturally or for management purposes) that then spread the pathogen to previously uninfected amphibians. Through this process the largest numbers of viable zoospores would ultimately be transferred, i.e., living, infected amphibians would continue to shed zoospores into the environment thus increasing densities of free living zoospores, and increasing the likelihood that the zoospores would contact local amphibians; a typical density dependent pattern of pathogen transmission in which an increase in density of the pathogen increases the probability of transmission.

Recent work on mountain yellow-legged frogs (*Rana mucosa* and *R. sierrae*) strongly supports the hypothesis that the frogs themselves were probably the most important agents of dispersal at the local scale (i.e., within metapopulations), although other unknown vectors contributed to movement of Bd across the larger landscape. At one site the data indicated that Bd spread through the metapopulation, mediated by dispersing frogs, in a distinct wave at a rate of approximately 688 m/year (Briggs *et al.* 2010, Vredenburg *et al.* 2010).

In Arizona, dispersal of infected native amphibians across the landscape is limited to some extent by unfavorable (usually arid) habitats that separate many amphibian populations during much of the year, and is limited to some extent by low densities of some native amphibians (e.g., native leopard frogs). Nonetheless, there are some environments (e.g., higher elevation sites, like the Kaibab Plateau, parts of the Mogollon Rim, White Mountains) where there are large contiguous tracts of favorable habitat that might remain sufficiently mesic for periods of time long enough to facilitate dispersal e.g., following snow melt or during the monsoon season. Under those
conditions, infected amphibians, particularly those that harbor sub-lethal Bd infections (e.g., tiger salamanders) can probably move among aquatic habitats, thus dispersing the pathogen.

Invasive exotic bullfrogs are extremely effective dispersers and might also be responsible for the spread of Bd. Studies done by biologists at the University of Arizona suggest that an individual bullfrog might move as much as seven miles over relatively flat terrain during the summer monsoon season (Suhre, et al. 2006. Unpublished abstract. Joint Meeting Of Ichthyologists & Herpetologists, New Orleans, Louisiana). Although bullfrogs can succumb to chytridiomycosis (Pearl and Green 2005), to a large degree they appear to be able to support sub-lethal infections and are therefore probably effective Bd vectors (Daszak et al. 2004). In addition, international trade in bullfrogs for food is likely spreading Bd worldwide (Schloegel et al. 2009).

The AGFD has compiled data for the presence of Bd in bullfrogs from several sites including, San Bernardino NWR, San Pedro River, Mammoth Hot Springs, Cienega Creek watershed, San Rafael Valley, Scotia Canyon (Huachuca Mtns), Sycamore Canyon and Salty Tank (Atascosa/Pajarito Mtns), Tonto Basin, and Bubbling Ponds Fish Hatchery (BPFH) (Bradley et al. 2002, Sredl et al. 2002, Rosen and Schwalbe 2002, Davidson et al. 2003, Garner et al. 2006, Schlaepfer et al. 2007, AGFD unpublished data; P. Rosen pers. comm.). Bullfrogs at all of these sites that might disperse to nearby sites that support native amphibians.

The biology of Bd also suggests strongly that Bd might be spread by people or terrestrial animals that move among sites, one or more of which must support infected amphibians and therefore motile zoospores. Viable zoospores in water or mud could potentially be spread by wet or muddy boots or clothing, vehicles, cattle and other animals moving among aquatic sites, during scientific sampling of fish, amphibians, or other aquatic organisms, or through the direct movement of water (e.g., Johnson and Speare 2003, 2005).

The only experiments of which we are aware that test the hypothesis that terrestrial animals other than amphibians might contribute to Bd dispersal are by Johnson and Speare (2005). They demonstrated that Bd zoospores could quickly (1 minute) associate with bird feathers (chicken and duck down), and those zoospores were viable after the feathers had been removed from media for up to an hour. If given sufficient exposure to feathers (up to 4 days in media), zoospores formed attached zoosporangia. Zoosporangia on duck down survived drying up to 3 hours (note: drying was only defined as removal from media, after which the feathers were placed in a laminar flow hood), thus suggesting the disease could be spread by waterfowl or other water birds moving among wetlands. These results also support the contention that wet clothing or sampling equipment could be effective vectors for zoospores or zoosporangia. In addition, experiments mentioned above by Johnson and Speare (2005) strongly support the hypothesis that viable zoosporangia could survive transport in wet mud or sand, although the
degree to which other microorganisms would affect their survivorship is unknown. Nonetheless, it is still not known how the fungus survives in the absence of amphibian populations.

Carey et al. (2006) tested the effects of Bd zoospore dosage (i.e., numbers of zoospores to which an animal is exposed) and length of exposure on survival time of boreal toads (Bufo boreas). In this experiment, juvenile toads were placed in 236 ml (~ 1 cup) containers, into which a 20 ml solution containing zoospores was added; 20 ml was sufficient volume to immerse the toads ventral side. They found that dosage and exposure strongly influenced survival. Unsurprisingly, at high dosages (i.e., $10^3$ and $10^6$ zoospores) there was 100% mortality, irrespective of exposure time. At low dosages results varied according to exposure time, however, even the lowest doses (1 zoospore/20 ml) often resulted in infection. Significantly, at the lowest doses (1, 20, 40, 60, 100 zoospores) and exposure for 1 day, percentage of toads that survived for 42 days (the duration of the experiment) ranged from 30% (100 zoospores) to 93% (1 zoospore). It is important to note that regardless of zoospore dosage, the toads were sitting in only 20 ml of solution for ≥ 1 day, and therefore could not escape contact with the zoospore(s). That volume of solution in a 236 ml cup would place the toad well within the swimming distance reported by Piotrowski et al. (2004). Nonetheless, there was significant survival at low doses, suggesting that higher doses of zoospores are necessary to cause lethal infections.

In a study that focused primarily on ranavirus screening, Picco and Collins (2008) tested whether the bait trade in larval tiger salamanders (waterdogs) in Arizona facilitated the dispersal of Bd. They used real-time PCR to screen water samples and to test salamander tissue samples from 9 bait shops that sold waterdogs. They reported positive results for Bd from water samples from 3 of the 9 shops, and Bd positive tissue from one of those 3 shops. Importantly, they discovered that many anglers surveyed (67%, n = 27) released tiger salamanders bought as bait into the waters where they fished, and one out of 24 shops (4%) sampled in the entire study released unsold tiger salamanders into the wild after they had been kept in shops with Bd or ranavirus infected animals.

**Bd and fish stocking**
Depending on whether the fish being stocked originated at an AGFD hatchery or from an external vendor, operations vary, but there are three routine stocking operations by which Bd might be transferred from the point of origin to a stocking site. However, in each case the stocking operation process limits the probability of transmission of Bd (see below).

The first operation includes fish raised in open (natural) ponds that are available habitat for amphibians. These activities are limited to “incentive” fish that are raised in “show ponds” on hatchery grounds (e.g., Tonto Creek and Canyon Creek fish hatcheries). Incentive fish are generally larger fish that, when stocked into waters along with “typical” stocked fish, provide an extra incentive for anglers. Stocking incentive fish occurs infrequently, and often those fish are
not stocked, but are provided to commercial entities for display (e.g., Bass Pro Shops, Cabela’s, etc.). Earthen raceways at Silver Creek hatchery are similar to open ponds, although they are flow-through systems and do not provide suitable amphibian habitats.

The second operation includes raceway raised fish (which may also include incentive fish, e.g., at Tonto Creek), in which fish are raised in artificial structures that generally are inhospitable for amphibians (i.e., they might be raised structures, concrete, rubber lined, etc.).

Finally, some fish are purchased from external vendors. These include cold water fish that are only stocked in urban fishing lakes, and warm water fish that are generally stocked in urban lakes but have been stocked in various lakes statewide. In all cases, stocking trucks are filled with clean well or spring water before fish are loaded and transferred. Table 1 outlines the procedures followed during stocking operations initiated by AGFD hatcheries and how those procedures influence the persistence of Bd in that operation.

At most AGFD hatcheries, the fish are raised entirely in raised tanks or in raceways that are not available to amphibians that might or might not be infected with Bd. Therefore, fish raised under those conditions do not present a credible threat with respect to transferring Bd through stocking activities.

In the rare event that incentive fish are used for stocking purposes, they are typically netted from “show ponds” or from raceways, and placed directly into stocking trucks with clean water. Show fish numbers are usually in the hundreds, and they are not mixed in trucks with regular stock (truck loads of which typically number in the thousands).

Fish are also purchased from external vendors (primarily from the southeastern U.S.). Those fish are removed from the rearing ponds and placed into truck tanks filled with well water. After loading, the tanks are flushed with well water before transit. Finally, in Texas, all tanks are again flushed with well water. Importantly, vendors are contractually obligated to provide fish that are free of disease or other pathogens as prescribed by AGFD (details depend upon species being purchased), and the loads must be free of non-target organisms (plants or animals). Loads are off-loaded in nets at the receiving point, at which time they are visually inspected for overall health and non-target organisms. Loads that fail to pass this inspection may be rejected.

Bd has been documented in bullfrogs in open hatchery ponds only at BPFH. To date, we have very few data on Bd on amphibians at any other AGFD hatchery, including nearby Page Springs Hatchery, but reports of amphibians in other facilities have been rare. Because bullfrogs can apparently harbor Bd for long periods of time without apparent ill effects (Daszak et al. 2004), the presence of bullfrogs at a hatchery presents a risk for spread of Bd either through spread of infected bullfrogs or tadpoles, or through spread of zoospores shed by infected bullfrogs into water that is then moved from one site to another. Note that fish stocked from AGFD hatcheries, approximately 98% of them are trout from the 5 hatcheries other than BPFH. Those fish from BPFH are primarily warm water native fish and are not stocked for sport fish purposes.

The pathways by which there is transfer of Bd from one environment to another depends on success of a series of events in the life cycle of the fungus: 1) a motile zoospore with a single flagellum disperses by swimming, 2) the zoospore encysts on a suitable host, 3) the resulting zoosporangium produces new zoospores, and 4) new zoospores are released into the water, where the process repeats. Under ideal conditions, the zoospore encysts on amphibian skin.

Thus, the questions that must be addressed are: 1) is there a measureable risk of transporting amphibians that harbor Bd, and 2) is there a measureable risk of transporting viable zoospores or zoosporangia to habitats that support native amphibians, including Chiricahua leopard frogs?

1) Is there a measureable risk of transporting amphibians that harbor Bd?

This pathway of infectivity, transport of infected amphibians (e.g., bullfrogs) along with stocked fish, is the most effective way to transmit Bd. This pathway has serious consequences and if it takes place is very likely to spread the disease from one place to another. Existing AGFD HAACP plans and best management practices incorporated into hatchery operations make this highly unlikely, thus the risk of transporting infected bullfrogs or other amphibians is not significantly different than zero.

2) Is there a measureable risk of transporting viable zoospores or zoosporangia?

Although Bd zoospores can encyst and grow on non-living surfaces and survive for considerable periods of time under controlled conditions in vitro (Longcore et al. 1999, Johnson and Speare 2003, 2005, Piotrowski et al. 2004, Woodhams et al. 2008), we are unaware of any studies that have experimented with the ability or likelihood of zoospores to encyst and grow successfully on non-target surfaces under natural conditions (i.e., in the presence of competitive and predatory organisms). We are also aware of no data to indicate that Bd can encyst on fish skin, where epidermal mucous, bacterial flora, etc. of non-host organisms would probably inhibit attachment. Therefore we think it is highly unlikely that Bd would be carried by an alternate fish host, but acknowledge that the question remains to be tested.
Based on their experimental laboratory studies (again, in a monoculture under controlled conditions), Johnson and Speare (2003) made the following conservative recommendations regarding the movement of water that has come into contact with Bd infected amphibians: 1) water should be regarded as contaminated for at least 7 weeks following last contact with infected amphibians; 2) water storage alone should not be used as a means of disinfecting water; 3) all contaminated water should be disinfected with appropriate chemical disinfectants before being discharged into the natural environment.

However, Piotrowski et al. (2004) suggested that the limited dispersal characteristics of zoospores indicate Bd is most likely spread by close amphibian contact. Although they acknowledge that zoospores could be carried longer distances by water currents, they also point out that passive dispersal like that “would decrease the chances of a zoospore contacting a host, because the spores would be diluted to low concentrations” (Piotrowski et al. 2004, p. 13). Serial dilutions of water that take place in standard hatchery operations would simulate the conditions noted by Piotrowski et al. (2004), i.e., zoospores would be reduced to exceedingly low concentrations. And, infection rates at those lower concentrations might be quite low (e.g., Carey et al. 2006).

Fish purchased from vendors undergo at least 2 dilutions; they are initially netted into a truck with clean water and that water is changed approximately midway during the trip to Arizona. Over the past three years of stocking, approximately 17% of the fish stocked in Arizona were provided by contract vendors. Of those contract vendor fish about 90% were stocked in Urban Fish Program (UFP) lakes that have few or no aquatic connections to sensitive native amphibian sites, and none to Chiricahua leopard frog habitats. During the 10 year period covered in this consultation, risk of transporting viable zoospores or zoosporangia via contract vendor pathway is expected to remain low because: 1) the number of fish purchased is expected to remain similar to current stocking numbers with the exception that there may be some additional locations stocked, including primarily the Fishing in the Neighborhood (FIN) waters that are located in primarily urban areas with limited hydrologic connectivity to sensitive native amphibian sites, and 2) because warm water stockings that would likely require fish purchase in response to a partial or complete loss of a fishery due to catastrophic events could occur during the 10 year period; however these stockings are not anticipated to occur only rarely.

Finally, considering the stocking protocol outlined above, there is a very small chance that some Bd zoospores would be released into waters stocked with fish. Those zoospores would again be diluted by the large volume of water at the stocking site. In order to complete their life cycle, the zoospores would have to encounter an amphibian and encyst on that host. The likelihood of a few zoospores in an exceedingly large volume of water coming in contact with a streamside/lakeside amphibian is, again, extremely low. In addition, depending on the stocking locations, the community of Arizona amphibians that would inhabit those waters would be
limited to a few species. Most native ranids, i.e., those species that would be most likely to become infected with Bd, no longer occur in many of those habitats.

Conclusions
Chytridiomycosis is an extremely serious amphibian disease, and there is no doubt that it has caused significant losses among Arizona’s native fauna. Many aspects of the natural history and ecology of Bd remain to be answered, and mechanisms of dispersal beyond the actual movement of infected amphibians (e.g., Vredenburg et al. 2010) are woefully understudied. Thus, it is important to approach questions of potential spread of Bd with caution, and to take steps to prevent that spread. AGFD staff working with aquatic organisms (including mollusks, fishes, amphibians and reptiles) practice strict disinfectant protocols (as outlined in the Chiricahua leopard frog recovery plan [USFWS 2007]) to prevent the spread of Bd (and other pathogens) among populations of aquatic wildlife.

However, there are specific concerns that the AGFD hatchery stocking program might spread Bd. This risk has been assessed and found to be very low considering the life cycle of Bd (Berger et al. 2005), behavior of the zoospores (Piotrowski et al. 2004), the procedures followed in normal hatchery operations, and the precautions taken in the AGFD HACCP plan and best management practices within the hatcheries. The particular case of spreading Bd is one that relies on a long series of unlikely events taking place that would lead to amphibians being infected by Bd in areas where the disease does not already exist. Specifically: 1) a hatchery would have to be infected with Bd; 2) water from an infected hatchery would need to have enough Bd zoospores so that some individual spores would survive treatments during fish transfer and those called for in the HAACP plan; 3) zoospores would have to survive freshwater dilution in raceway raising, sorting or tagging procedures; 4) remaining zoospores would have to survive the trip in the hatchery truck to the stocking site; 5) zoospores would have to survive in the stocking area long enough to encounter an amphibian host; and 6) the amphibian host would have to develop chytridiomycosis then spread the disease to others.

Finally, Error! Reference source not found. outlines the steps in stocking hatchery fish and how these steps relate to the prevention of the spread of chytridiomycosis.

Table 4. Operations and procedures followed by AGFD hatcheries to collect, sort, transport, and stock native and nonnative fish.

<table>
<thead>
<tr>
<th>Step</th>
<th>Notes on hatchery procedures</th>
<th>Notes relevant to the persistence of Bd</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. fill sanitized stocking truck with spring or well water (proceed to step 2a)</td>
<td>if truck had been previously exposed to Bd zoospores, they will be killed during sanitization</td>
<td></td>
</tr>
<tr>
<td>Step</td>
<td>Notes on hatchery procedures</td>
<td>Notes relevant to the persistence of Bd</td>
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<tr>
<td>or 2b)</td>
<td></td>
<td>truck is filled with water that has low or no likelihood of having exposure to fish, bullfrogs, or Bd</td>
</tr>
<tr>
<td>2a. if fish are collected from raceways, they are usually individually netted or in some cases harvested using automated equipment (contained, drained, and moved) and placed in transport truck (proceed to step 5)</td>
<td>raceways are inspected during feeding [daily] and cleaning [1-3 times per week] for non-target organisms</td>
<td>this step should get rid of Bd infected amphibians</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bd zoospores will be in the residual water on the skin of fish and collecting gear or runoff from the collecting process</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bd zoosporangia in shed amphibian skin could hatch and become free swimming</td>
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<tr>
<td></td>
<td></td>
<td>Bd zoospores could remain free-swimming or encyst on the skin of a fish or on the inside of the transport truck at any step</td>
</tr>
<tr>
<td>2b. if fish are collected from ponds: fish and possibly frogs and tadpoles are netted or seined and moved to transport truck (proceed to step 3)</td>
<td>these are generally native fish, but also include incentive fish, e.g. trout fish from raceways and ponds have residual water during collection and movement</td>
<td>this step should get rid of Bd-infected amphibians</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bd zoosporangia in shed amphibian skin could be discharged and become free swimming</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bd zoospores will be in the residual water on the skin of fish and collecting gear or runoff from the collecting process</td>
</tr>
<tr>
<td>3. fish are placed in raceways fed by spring or well water and sorted, then placed in the stocking truck (proceed to step 4)</td>
<td>non target organisms (frogs and tadpoles) are removed during sorting</td>
<td>in raceways, Bd zoospores might remain on the skin of fish, but will not grow, or be placed back in “solution” and diluted or “swept away” by the flowing water of the raceway</td>
</tr>
<tr>
<td>4. refill unsanitized truck with spring or well water and put fish in stocking</td>
<td>truck has been drained, but not disinfected after the</td>
<td>truck is filled with water that has low or no likelihood of having exposure to fish, bullfrogs, or Bd</td>
</tr>
</tbody>
</table>
### Step 3

**Notes on hatchery procedures**

- truck (proceed to step 5) previous step. It may be left “empty” for some duration
- 5. one to three hour drive to stocking site (proceed to step 6)
- 6. acclimate water in truck to local water quality parameters (proceed to step 7)
- 7. release fish by dumping entire load or individually netting fish

**Notes relevant to the persistence of Bd**

- Bd zoospores have been diluted by the volume of water in the transport truck
- once at the stocking site, free-swimming zoospores would have to find a suitable amphibian host, encyst, and form many zoosporangia and reinfect host

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### Chiricahua and Northern Leopard Frog

#### Introduction

The Arizona Game and Fish Riparian Herpetofauna Database contains observational data for native ranid frogs that were collected from 1884 to present. Historical ranid frog distributions were determined from museum registers, published and gray literature reports and observations of credible individuals (for a complete list of citations, see Sredl 1997). In addition to these sources, this dataset includes data from AGFD surveys targeting native ranid frogs: *Rana blairi*, *Rana chiricahuensis*, *Rana pipiens*, *Rana subaquavocalis*, *Rana tarahumarae*, and *Rana yavapaiensis* and includes positive and negative site visits for these taxa. For complete survey methodology, see Sredl (1997).

#### Historical and recent frog observations

To evaluate the status of frog populations at a stocking site or in the vicinity of that site, we considered the best available positive and negative frog survey data, habitat suitability, and survey effort (Table 18), using data from the following sources: AGFD Riparian Herpetofauna Database, HDMS, and RAPI_from_MacVean, Tonto National Forest (Tonto NF 1979-2008), Apache-Sitgreaves National Forest (Black Mesa (Negative) 2003-2007), and Coconino National Forest (Coconino NF 2005-2008). Positive frog observations from these sources were divided in four categories:

**Observations made prior to 1980:** By 1980, all currently recognized species of Arizona leopard frogs had been described or recognized (note: although the lowland leopard frog was not
described until after 1980 (Platz 1984), the term “lowland form” to reference this taxon was commonly used in the literature prior to 1980). This timeframe captures what has often been used by researchers to establish baselines for status and distribution studies (e.g. Clarkson and Rorabaugh 1989, Sredl et al. 1997).

Observations made between 1980 and 1999: This timeframe includes the period when the modern taxonomy for Arizona leopard frogs became widely used in inventory, status and distribution studies. This period includes survey work by Clarkson and Rorabaugh (1989), which was the seminal paper that brought declines of Arizona ranid frogs to the attention of the research and conservation communities, and the work of Sredl et al. (1997), who conducted the first comprehensive analysis of inventory, status and distribution of Arizona ranid frogs. The work of Sredl et al. (1997) and subsequent surveys are cited as Arizona Game and Fish Riparian Herpetofauna Database in our analyses.

Observations made between 2000 and 2005: After 1999, field surveys targeting Arizona ranids began to transition from wide-ranging inventories and status and distribution studies to monitoring extant populations, evaluating sites for recovery opportunities or reconnaissance of new leopard frog populations. In addition to many records included in Arizona Game and Fish Riparian Herpetofauna Database, other datasets used in our analyses that primarily fall within this timeframe are: MacVean (RAPI_from_MacVean), Tonto National Forest (Tonto NF 1979-2008), Apache-Sitgreaves National Forest (Black Mesa (Negative) 2003-2007), and Coconino National Forest (Coconino NF 2005-2008).

Observations between 2005 and the present: In many cases, observations made after 2005 represent our best assessment of leopard frog populations that are extant, and are located in all data sets used in our analyses.

Habitat suitability
Throughout the discussion of leopard frog habitat and dispersal corridors, we use the term “less suitable,” which requires some discussion/definition. There is no definitive set of criteria that dictate whether or not leopard frogs will or can occur in a particular area. The ability of leopard frogs to occupy a site and subsequently thrive there depends on a number of habitat characteristics, including, but not limited to water availability, cover, prey, predators, etc.. Stocking sites or stream reaches would be considered “less suitable” for leopard frogs when there are known reasons in conditions that generally reduce or prevent successful recruitment, and thus population persistence. For example, the presence of bullfrogs, crayfish, or predatory fishes could make the site less suitable for leopard frogs because they exert predatory or competitive pressures on the frogs.
**Frog occupancy**

It is difficult to determine if frogs are absent from a site or area. In order to make that determination, we used a “preponderance of evidence approach” to build a case that frogs are present or absent. We acknowledge that these criteria are imperfect, but they utilize the best available data in a consistent manner.

1. Frog sites / stocking complexes will be considered **occupied** if they contain
   
   a. extant populations of frogs, defined as sites that have positive observations for Chiricahua or northern leopard frogs made from 2006 to the present, or
   
   b. locations where frogs were observed one or more times from 2000 through 2005 and habitat is in good condition and therefore could contribute to “recovery” (e.g. those sites in a Chiricahua Leopard Frog Management Area [MA])

2. Frog sites / stocking complexes **may be occupied**
   
   a. if they are located in the historical range (i.e. within the approximate boundaries of a Chiricahua Leopard Frog Recovery Unit [RU]) and contain positive observations from 1980 through 1999 but there have been no subsequent surveys or
   
   b. if they are located in the historical range and contain leopard frog records that were made prior to 1980 and the area has been poorly surveyed

3. Frog sites / stocking complexes will be considered **unoccupied** if they are
   
   a. outside the historical range (i.e. RUs) or
   
   b. within the historical range and contain no positive observation made through 1999 and
      
      i. areas that have been well-surveyed and all survey results are negative at both historical and non-historical localities or
      
      ii. there has been a no post-1999 positive reports from areas that are frequently visited by knowledgeable biologists or
      
      iii. presence of degraded habitats (e.g. those that are dewatered or contain many nonnatives) and all surveys subsequent to 1999 are negative
Table 5. Criteria used and data considered to characterize the likelihood that Chiricahua or northern leopard frogs occupy a site or area.

<table>
<thead>
<tr>
<th>Status</th>
<th>Occurrence data</th>
<th>Habitat suitability</th>
<th>Survey effort</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupied</td>
<td>extant frog population (= positive observations from 2006 to present) or frogs observed from 2000 through 2005</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>…and habitat is in a condition such that it could contribute to &quot;recovery&quot; (i.e. area is in CLF MA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May be occupied</td>
<td>frogs observed from 1980 through 1999 or frogs observed prior to 1980</td>
<td>…and in historical range (~RU)</td>
<td>but there have been no subsequent surveys</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>and area has been poorly surveyed</td>
</tr>
<tr>
<td>Unoccupied</td>
<td>frogs observed through 1999</td>
<td>…and in historical range (~RU)</td>
<td>and well-surveyed area and results include only negative surveys at both historical and non- historical localities or lack of positive reports from areas that are frequently visited by knowledgeable biologists</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and all surveys subsequent to 1999 are negative</td>
<td></td>
</tr>
</tbody>
</table>
Developing Buffered Stocking Complexes

**Local Analysis**

To evaluate both the likelihood that a site or local area is occupied by Chiricahua and northern leopard frogs, and the level of exposure of stocked fish to these leopard frogs, we developed a buffered stocking complex approach by creating a minimum convex polygon (MCP) around all stocking sites within a stocking complex, and buffering this MCP by 5 miles.

In most cases we used the buffered MCP approach to circumscribe the entire stocking complex, but in three stocking situations we had to depart from this approach and create sub-complexes. These situations arose when stocking sites in complexes consisted of: 1) fewer than 3 sites, 2) sites that were isolated and distant from other stocking sites, or 3) only stream reaches. In these cases, a 5 mile buffer was made around individual stocking sites or around the entire stocking reach. A buffered MCP or a 5 mile buffer was applied only to those sites or complexes that lie within the known historical range of Chiricahua and northern leopard frogs. Some stocking complexes were so large or heterogeneous (e.g. Middle Verde River stocking complex), we divided the complex into smaller, more manageable sub-complexes comprising one or more of the three situations outlined above.

We analyzed potential impacts of stocking at two levels, the local and broad scales. For the local analyses, we used each buffered stocking complex to limit our query of historical and visual encounter survey data. We then used these data to consider at the local level the likelihood of occupancy and exposure to stocked fish. Water distribution and connectivity within each stocking complex was reviewed thoroughly to fully understand the ability and likelihood of fish and frog movement within the buffered stocking complexes, reaches or sites.

**Broad Scale Analysis**

The likelihood of occupancy of Chiricahua and northern leopard frogs and exposure to stocked fish were evaluated on a broader scale by assessing potential movement of fish and frogs upstream and downstream beyond the buffered stocking complex, reach, or individual site. The water distribution and connectivity portion of each stocking complex was reviewed thoroughly to fully understand the ability and likelihood of fish and frog movement outside of the buffered stocking complexes, reaches or sites.

**Determining exposure: Dispersal of fish and frogs**

To evaluate the likelihood that dispersing Chiricahua or northern leopard frogs could be exposed to stocked fish, we used data on flow, distance, and other attributes of corridor suitability for fish and frogs to make this determination (see Table 19 for criteria examined). By circumscribing a distance of 5 miles around all stocking sites within a stocking complex, we considered all possible distances that Chiricahua and northern leopard frogs are reasonably likely to disperse (1 mile overland, 3 miles along intermittent drainages, and 5 miles along permanent drainages, see
USDA Forest Service Southwestern Region 2004, Chiricahua Leopard Frog Recovery Plan 2007 and references therein). For details on buffering stocking complexes, see section below.

**Table 6. Criteria used to characterize the likelihood of exposure of dispersing Chiricahua or northern leopard frogs to stocked fish.**

Flow was categorized by the predominant flow type (perennial or intermittent, or none), while considering additional information on water distribution and potential for frogs and fish to disperse through that corridor. Distance between occupied frog sites and stocking sites was measured in ArcGIS. Known reasons that alter the “suitability of dispersal corridor” include natural and manmade barriers to dispersal of stocked fish and presence of nonnative aquatic species (crayfish, fish, and bullfrogs).

<table>
<thead>
<tr>
<th>Likelihood of Exposure</th>
<th>Flow</th>
<th>Distance (miles)</th>
<th>Suitability of dispersal corridor</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Perennial</td>
<td>&lt; 5</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>&lt; 3</td>
<td>NA</td>
</tr>
<tr>
<td>Moderate</td>
<td>Perennial</td>
<td>&gt; 5</td>
<td>There are known reasons that decrease the likelihood of dispersing frogs being exposed to stocked fish</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>&gt; 3</td>
<td>There are known reasons that decrease the likelihood of dispersing frogs being exposed to stocked fish</td>
</tr>
<tr>
<td>Low</td>
<td>Perennial</td>
<td>&gt;&gt; 5</td>
<td>There are many known reasons that decrease the likelihood of dispersing frogs being exposed to stocked fish</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>&gt;&gt; 3</td>
<td>There are many known reasons that decrease the likelihood of dispersing frogs being exposed to stocked fish</td>
</tr>
</tbody>
</table>

In order to evaluate the likelihood that Chiricahua or northern leopard frogs could be exposed to dispersing stocked fish, we used data on flow and other attributes of corridor suitability found in the watershed chapters to make this determination (see Table 20 for criteria examined).
Table 7. Criteria used to characterize the likelihood of exposure of Chiricahua or northern leopard frogs to dispersing stocked fish. Flow and known reasons that alter the “suitability of dispersal corridor” determined as in Table 19.

<table>
<thead>
<tr>
<th>Likelihood of Exposure</th>
<th>Flow</th>
<th>Suitability of dispersal corridor</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Perennial</td>
<td>NA</td>
</tr>
<tr>
<td>Moderate</td>
<td>Perennial</td>
<td>There are known reasons that decrease the likelihood of frogs being exposed to dispersing stocked fish</td>
</tr>
<tr>
<td></td>
<td>Intermittent (may contain substantial pools)</td>
<td>There are known reasons that decrease the likelihood of frogs being exposed to dispersing stocked fish</td>
</tr>
<tr>
<td>Low</td>
<td>Perennial</td>
<td>There are many known reasons that decrease the likelihood of frogs being exposed to dispersing stocked fish</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>There are many known reasons that decrease the likelihood of frogs being exposed to dispersing stocked fish</td>
</tr>
</tbody>
</table>

**Northern Mexican Gartersnake**

*Range wide discussion*

Northern Mexican gartersnakes are closely associated with riparian areas and typically inhabit cienegas, perennial streams, rivers, earthen stock tanks, and ponds with thick bank vegetation (Holycross et al. 2006; Rosen and Schwalbe 1988). Their historical range wide distribution extends from central Arizona and west-central New Mexico south along the Sierra Madre Occidental to west-central Veracruz and also includes isolated populations in central Oaxaca and central Nuevo Leon, Mexico (Holycross et al 2006). In Arizona, northern Mexican gartersnakes were historically found between 500-2050 m (1640-6725 ft) elevation and have been previously documented from Tonto Creek, upper Verde River, Agua Fria River, Salt/Black River, Little Colorado River, San Bernardino Ranch, San Pedro River, Altar Wash, and Santa Cruz River watersheds (Holycross et al. 2006). While they were once considered common, northern Mexican gartersnakes are believed to have declined substantially throughout their range and are now candidates for Federal listing under the Endangered Species Act.

Using the best available data, the USFWS determined in their 12-month finding (USFWS 2008a) that northern Mexican gartersnakes are likely extant at the following locations: Santa Cruz River/Lower San Rafael Valley, Verde River from the confluence with Fossil Creek upstream to
Clarkdale, Oak Creek at Page Springs, Tonto Creek from the mouth of Houston Creek downstream to Roosevelt Lake, Cienega Creek from the headwaters downstream to the “Narrows” just downstream of Apache Canyon, Pantano Wash (Cienega Creek) from Pantano downstream to Vail, Appleton-Whittell Research Ranch and vicinity near Elgin, and Red Rock Canyon east of Patagonia. They determined that it is unknown whether the species is still extant at the following locations: downstream portion of the Black River drainage from the Paddy Creek confluence, downstream portion of the White River drainage from the confluence of East and North forks, Big Bonito Creek, Lake O’Woods near Lakeside, Spring Creek above the confluence with Oak Creek, Bog Hole Wildlife Area, Upper 13 Reservoir, Patagonia Mountain bajada, Babocomari River, Upper Scotia Canyon in the Huachuca Mountains, Arivaca Cienega, Gila River at Highway 180. The species is considered likely extirpated from the following locations: the Gila River, Lower Colorado River from Davis Dam to the International Border, the San Pedro River, Santa Cruz River downstream from the International Border at Nogales, Salt River, Rio San Bernardino from International Border to headwaters at Astin Spring (San Bernardino National Wildlife Refuge), Agua Fria River, Verde River upstream of Clarkdale, Verde River from the confluence with Fossil Creek downstream to its confluence with the Salt River, Tanque Verde Creek in Tucson, Rillito Creek in Tucson, Agua Caliente Spring in Tucson, Potrero Canyon/Springs, Babocomari Cienega, Barchas Ranch, Huachuca Mountain bajada, Parker Canyon Lake and tributaries in the Canelo Hills, and Oak Creek at Midgley Bridge (USFWS 2008a).

Home range

Home range information is lacking for northern Mexican gartersnakes, however, a study in British Columbia found that for adult terrestrial gartersnakes (Thamnophis elegans), a species similar to northern Mexican gartersnakes, home-range varied from 10 to 100,000 m² (108 to 1,076,391 ft²) and that they often migrated nearly 3 km (1.86 mi) in a season (Graves and Fuvall 1990, Farr 1988, cited in Rossman et al. 1996). Additionally, common gartersnakes, T. sirtalis, from Manitoba made long distance movements between hibernation sites and feeding areas which ranged from 4.3 to 17.7 km (2.67 to 11 mi) (Gregory and Steward 1975, cited in Rossman et al. 1996). In a Kansas study, the mean activity area for T. sirtalis ranged from 92,000 m² (990,280 ft²) for females to 142,000 m² (1,528,475 ft²) for males (Fitch 1965, cited in Rossman et al. 1996), and in Michigan, their range was recorded at 8000 m² (86,111 ft²) (Carpenter 1952, cited in Rossman et al. 1996). In yet another study, researchers found that recaptured gartersnakes were rarely found more than 160 m (525 ft) from their original capture locations (Freedman and Catlin 1979, cited in Rossman et al. 1996).

While northern Mexican gartersnakes are likely capable of large-scale overland movements similar to those described above for other gartersnake species, the frequency at which they occur is unclear. Though they are rarely found more than 15 m (52 ft) from permanent water, observations of this species from the San Rafael Valley, Arizona, indicate that northern Mexican
gartersnakes can wander overland and be found several kilometers from riparian areas (e.g., cienegas and rivers) (Rosen and Schwalbe 1988). For example, northern Mexican gartersnakes have been found at overland distances of 3 km (1.86 mi) (FS799 tank) and 6.2 km (3.85 mi) (Upper 13 Reservoir) from the Santa Cruz River despite a lack of aquatic connectivity (T. Jones pers. comm.). While it is unclear whether the observations were of dispersing individuals or resident snakes, these data support the suggestion that this species, similar to other gartersnakes, is capable of moving across the landscape and can persist at sites beyond riparian corridors. The large-scale movements described for similar species listed above likely reflect their need to move between limited suitable hibernation locations and feeding areas during the active season. The average distance northern Mexican gartersnakes travel between hibernation sites and active season feeding areas is currently unknown.

Snakes are cryptic by nature and their detectability is generally low, even among common species. Currently, no standard survey protocol exists for detecting northern Mexican gartersnakes, however, researchers employ similar field techniques which include trapping with mesh minnow traps, visual searching, dip-netting, and turning cover objects (boards, rocks, logs, etc.). The area covered and duration of trapping and visual searching periods often vary by site and over time. It is difficult to quantify the degree to which populations of northern Mexican gartersnakes have declined over time because long-term demographic data are generally lacking. There are few comparisons of relative abundance between/among sites and those are typically quantified through catch per unit effort (e.g., person-search hours and trap-hours), however, this measure does not account for habitat variables or other covariates that might influence detectability. Often, and as is the case for gartersnakes, these indices of relative abundance constitute the best available information from which management decisions must be made for a species. While the assumption is often made that snakes will be detected if present at a site, it is necessary to use caution when interpreting relative abundance or presence/absence data and extrapolating across sites.

To demonstrate how detectability varies with survey design and effort, we offer two examples from a similar area along the Santa Cruz River in the San Rafael Valley, Arizona. In 2000, Rosen et al. (2001) reported results from trapping and surveying efforts along the main-stem of the Santa Cruz River (~11 hrs dip-netting and general searching; 1 trapping array for 24 hr), Heron Spring (10 min general searching; 1 gartersnake fyke trap for 48 hr), and Sharp Spring (45 min general searching; 1 trapping array for 48 hr). Across six survey days, only five northern Mexican gartersnakes were observed and none trapped. The number of traps deployed within each array was not reported, thus it is not possible to quantify trap effort accurately. Based on their results, Rosen et al. (2001) concluded that the population was persisting and may not be declining rapidly, though there were no means of comparison from previous years. Conversely, AGFD staff implemented two intensive 8-day trapping sessions (~100 traps spaced 25 m [82 ft]
apart during each session) along a 2.7 mile (4.5 km) stretch of the Santa Cruz River extending north from the U.S./Mexico border within the San Rafael State Natural Area. During 15.4 days (1553.6 trap days), 52 northern Mexican gartersnakes were captured and individually marked. An additional three gartersnakes were observed but not captured. It might appear that this population increased in size based on raw numbers of captures in 2008 vs. those including the same area in 2000; however, the difference in capture numbers likely results from differences in survey design and trapping efforts. All but two of the snakes captured in 2008 were large adults, which suggests low recruitment rates within the population (M. Ingraldi, R. Mixan pers. comm.). Both studies indicate that northern Mexican gartersnakes persist along the upper Santa Cruz River in the San Rafael Valley, but it is not possible to evaluate the viability of the population without further study. As these two examples demonstrate, detectability varies with survey design and effort, thus it is necessary to use caution when interpreting relative abundance or presence/absence data and extrapolating across sites.

**Criteria Developed:**
We evaluate the potential for exposure of northern Mexican gartersnakes to stocked sport fish for each watershed in which the USFWS determined that populations are extant or of unknown status (USFWS 2008a). For those watersheds in which gartersnake populations existed historically but are currently believed extirpated, we determined that northern Mexican gartersnakes are unlikely to occupy the stocking complex and that there was no likelihood of exposure to stocked sport fish. The likelihood of exposure to stocked sport fish was not evaluated for watersheds that lie outside the known historical range of the species. As described above, similar gartersnake species are capable of long-distance movements exceeding several kilometers during their active seasons. While home range and movement data are lacking for northern Mexican gartersnakes, we assume they too are capable of such large movements both overland and along drainages. The frequency at which these movements occur is unclear but likely correlates with prey availability in a system, reproductive activity, postpartum dispersal, etc.

Throughout the discussion of gartersnakes, AGFD uses the term “less suitable,” which requires some discussion/definition. There is no definitive set of criteria that dictate whether or not gartersnakes will or can occur in a particular area. The ability of gartersnakes to occupy a site and subsequently thrive there depends on a number of habitat characteristics, including, but not limited to cover, prey, predators, etc.. While some sites might be capable of supporting large adult snakes, those same sites might not allow for successful recruitment. Stocking sites or stream reaches would be considered “less suitable” for gartersnakes when local conditions generally reduce or prevent successful recruitment, and thus population persistence. For example, the presence of bullfrogs, crayfish, or predatory fishes could make the site less suitable for gartersnakes because they exert predatory or competitive pressures on the snakes. However, gartersnakes might continue to persist in “less suitable” sites in the presence of nonnative species if those sites have greater habitat complexity and provide escape cover or feeding sites for
neonates or juvenile snakes. An example of this would be Mexican gartersnakes on the middle Verde River, where although we have few data on population status, snakes appear to persist in exceedingly complex riparian habitat in some areas (e.g., Dead Horse Ranch State Park) despite the presence of bullfrogs, crayfish and predatory fishes.

In addition, there are sites within the elevational range of gartersnakes where distributional data suggest gartersnakes do not occur, but other structural habitat features seem to be appropriate. Although lack of data does not necessarily equate with absence, if there are additional habitat characteristics (predators, lack of cover, etc.) that would preclude gartersnakes from occupying those sites or thriving, we also refer to those sites as “less suitable” which contributes to a conclusion that snakes probably do not occur there.

**Stocking complex analysis:**
Following methods similar to those described for Chiricahua and northern leopard frogs, we used ArcGIS to map and identify sport fish stocking complexes from which positive observations of northern Mexican gartersnakes exist and that lie within the historical range of the species (Rosen and Schwalbe 1988, Holycross et al. 2006, HDMS, Arizona Game and Fish Riparian Herpetofauna Database). We then developed a similar buffered stocking complex approach by creating a minimum convex polygon (MCP) around all stocking sites within a stocking complex, and then buffering the MCP by 20 km (12.43 mi). This buffer was developed after evaluating the best available home range and movement data for similar gartersnake species and northern Mexican gartersnake observations described above, and it represents a conservative estimate of distances that northern Mexican gartersnakes might make along ephemeral or perennial drainages. Overland movements will likely be <20 km, however, over ecological time, gartersnakes within a population could move long distances in search of food or suitable habitat. Within some stocking complexes, stocking sites were widely separated from one another and were therefore considered separately, in which case a circular buffer with a 20 km (12.43 mi) radius was created around each stocking site (e.g., Santa Cruz stocking complex). Within each of these buffered stocking complexes, we evaluated the potential for northern Mexican gartersnakes to be exposed to stocked sport fish by considering the criteria described below and detailed in Table 21.

It is difficult to determine whether gartersnakes occupy a site/area because their detectability is low and recent systematic surveys have generally not been conducted in most areas.

Therefore, to make our determination, we built a case using positive observations reported from HDMS, the Arizona Game and Fish Riparian Herpetofauna Database, and the USFWS (2008a) 12-month finding to determine whether or not northern Mexican gartersnakes are likely to occupy each buffered stocking complex. Rosen and Schwalbe (1988) began the first large-scale surveys for gartersnakes in 1985, which contributed to our understanding of their recent
distributions in Arizona. Therefore, occupancy was described according to whether observations were made prior to or after 1985. Then based on the occupancy determinations, we evaluated whether there is a likelihood of exposure to stocked sport fish, as described below and detailed in Table 21. We did not make a qualitative assessment for the likelihood of exposure (e.g., high, medium, low) because sufficient surveys have not been conducted in most areas and the status of most populations is unknown.

1. Occupancy—stocking complexes will be considered:
   a. Occupied—if there are positive gartersnake observations within the complex since 1985 (Rosen and Schwalbe 1988, Rosen and Schwalbe 2001, Holycross et al. 2006, HDMS, Arizona Game and Fish Riparian Herpetofauna Database) or the USFWS determined that the species is likely extant (USFWS 2008a).
   b. May be occupied—if gartersnake records exists prior to 1985, but since then either surveys have been conducted and no snakes have been found, no systematic surveys have been conducted and habitat condition has diminished (e.g., bullfrogs or crayfish are present), or the USFWS has determined that its status is unknown.
   c. Unoccupied—if a single historical record exists (prior to 1985) but no observations have been made since, the USFWS (2008a) has determined that the species is likely extirpated, or the area lies outside the historical range of the species (Rosen and Schwalbe 1988, Rosen and Schwalbe 2001, Holycross et al. 2006, HDMS).

2. Likelihood of exposure:
   a. Exists—if there is a known population of northern Mexican gartersnakes occupying the complex or snakes are likely to move into the stocking complex because they persist nearby, then there is a likelihood that snakes could encounter stocked sport fish.
   b. Low—if the status of northern Mexican gartersnake populations is unknown in the complex, or the habitat is less suitable because there are other invasive species already present, such as bullfrogs and crayfish, then there is a low likelihood that snakes could encounter stocked sport fish.
   c. Does not exist—if northern Mexican gartersnakes are likely extirpated from a stocking complex or the area lies outside the historical range of the species, then it is unlikely that snakes will encounter stocked sport fish.
Table 8. Criteria for determining whether northern Mexican gartersnakes occupy a site/stocking complex and the likelihood of exposure to stocked sport fish.

<table>
<thead>
<tr>
<th>Status</th>
<th>Available data/habitat condition</th>
<th>Likelihood of exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupied</td>
<td>Records &gt;1985; USFWS (2008a) determined status as likely extant.</td>
<td>Exists (positive)—species known to occupy area.</td>
</tr>
<tr>
<td>May be occupied</td>
<td>Records exist &lt;1985, but no systematic surveys have been conducted; or, surveys have been conducted but no snakes were observed; or, habitat condition is diminished (e.g., invasive bullfrogs or crayfish present); or, USFWS (2008a) determined status as unknown.</td>
<td>Low—species may occupy area or habitat suitability is low.</td>
</tr>
<tr>
<td>Unoccupied</td>
<td>Single historical record exists (&lt;1985), but no observations since then; or, USFWS (2008a) determined status as likely extirpated; or, area lies outside historical range.</td>
<td>Does not exist (negative)—species is unlikely to occur.</td>
</tr>
</tbody>
</table>

**Downstream analysis:**
There is potential for northern Mexican gartersnakes to occur downstream of stocking sites, stocking stream reaches and outside buffered stocking complexes. Therefore, after carefully examining water connectivity and potential fish movement as described within each stocking complex chapter, we analyzed the likelihood that gartersnakes could be exposed to dispersing sport fish or that gartersnakes will move into the stocking complexes based on the occupancy criteria presented in Table 21, above.

**Narrow-headed Gartersnake**

*Range wide discussion*

Narrow-headed gartersnakes are one of the most aquatic gartersnake species, only leaving the water to bask, rest, or gestate (Rosen and Schwalbe 1988; Rossman et al. 1996). The species is confined to primarily large, perennial streams within montane and Great Basin conifer woodlands, chaparral, and upland desert scrub. Important microhabitats include the submerged rock-boulder complexes near riffles and pools, and thick backside vegetation used for basking and escaping from predators (Rosen and Schwalbe 1988, Degenhardt et al. 1996). Narrow-headed gartersnakes also appear to be strongly tied to boulders, rock piles, and other cover structures that lie within the floodplain of creeks (Nowak 2006).
The historical range wide distribution for narrow-headed gartersnakes includes permanent drainages of the Mogollon Rim and White Mountains of Arizona and New Mexico, and the Sierra Madre Occidental in Mexico. They are primarily found at elevations of 1200-1900 m (3937-6234 ft), but have been observed at elevations of 700-2430 m (2297-7972 ft) (Holycross et al. 2006). In Arizona, narrow-headed gartersnakes are found in headwater streams of the Gila River watershed.

Narrow-headed gartersnakes forage for prey along stream banks, in shallow riffles, and between boulders within the stream (Rossman et al. 1996, Pierce 2007). Small soft-rayed fishes make up their primary diet (Nowak and Santana-Bendix 2002), which includes suckers, rainbow trout, red shiner, speckled dace. They have also been reported to prey on larval and adult anurans and larval tiger salamanders (Degenhardt et al. 1996). Narrow-headed gartersnakes will, to a lesser extent, take spiny-rayed fish such as sunfish and catfish (Degenhardt et al. 1996, Pierce 2007). Nonnative spiny-rayed fishes are thought to be unsuitable prey because narrow-headed gartersnakes cannot safely ingest the fish without them becoming lodged in their throats or causing other physical damage to the digestive tract (Nowak and Santana-Bendix 2002).

Narrow-headed gartersnakes have experienced significant population declines throughout their range in Arizona and New Mexico (Holycross et al. 2006, Pierce 2007). Holycross et al. (2006) surveyed for gartersnakes during 2004 and 2005 and only found narrow-headed gartersnakes at 5 of 16 known historical Arizona localities. Based on those surveys, Holycross et al. (2006) concluded that the species was likely extirpated from 5 of the surveyed sites. Furthermore, narrow-headed gartersnakes have experienced significant declines at one of the largest known populations in Arizona in Oak Creek Canyon. As a result of recent (2002, 2004, and 2005) surveys, Nowak and Santana-Bendix (2002) and Nowak (2006) determined that narrow-headed gartersnakes may be extirpated from sites downstream of Oak Creek Canyon. Also, they suggested that while snakes in the upper reaches of the canyon appear to be persisting, there is a declining trend in numbers of snakes detected in the lower reaches of the canyon.

As with other gartersnake species in Arizona, multiple stressors are likely contributing to this species’ decline (Nowak 2006). Nonnative predators such as fish, crayfish, and bullfrogs are believed to be the main cause of decline for the species throughout its range, however, other major threats include habitat destruction and degradation associated with aquatic recreation, urbanization, and overgrazing (Rosen and Schwalbe 1988, Rossman et al. 1996, Nowak and Santana-Bendix 2002).

Home Range Size:
All home range information for this species is based on one radio-telemetry study (n = 4 males, 5 females) at Oak Creek Canyon (Nowak 2006). Narrow-headed gartersnakes appear to have intermediate home range sizes compared to published home ranges for other gartersnake species,
with males, on average, having a larger home range than females. Home ranges of males at Oak Creek Canyon were up to 2.2 ha (5.44 acres) in size, while female home range was up to 1.1 ha (2.72 acres) in size. Home ranges, especially those of males, were very linear, as would be expected for a snake that does not venture far from stream habitats during their active season (March through October/November). During their active season, narrow-headed gartersnakes used upland areas up to 100 m (328 ft) from the creek, but were strongly associated with boulders within the floodplain. Hibernacula consisted of rock piles, hillsides with small rocks, boulders, and rock overhangs located 20-200 m (66-656 ft) from the creek. There are no data available describing long distance movements in narrow-headed gartersnakes. However, Harter’s watersnake (*Nerodia harteri*) is a snake of similar size, habits and ecological characteristics, has been well studied in rivers in Texas, and provides an ecological analogue with which to predict movements in narrow-headed gartersnakes (Hibbits and Fitzgerald 2005). Harter’s watersnakes also typically move relatively short distances during a season, e.g., approximately 150-460 m (493-1509 ft), but over several years, one male moved 19 km (11.8 mi) (Greene 1993, cited in Gibbons and Dorcas 2004, Whiting and Dixon 1997). Therefore, similar long-distance dispersal might be expected in narrow-headed gartersnakes. Although the downstream movement potential during high water events is unknown, narrow-headed gartersnakes are probably unlikely to make large overland movements, since the species is highly dependent on water for foraging.

**Criteria Developed:**

As described above, narrow-headed gartersnakes are riparian obligates and they forage almost exclusively on fishes. While home range and movement data are limited for narrow-headed gartersnakes, we assumed the frequency at which narrow-headed gartersnakes will make large overland movements is extremely low (i.e., rarely found >200 m [219 ft] from stream edge) and that they will travel linearly along narrow perennial riparian corridors. By examining the inter-connectivity of the perennial waterways and fish movements as described within the stocking complex chapters, we evaluated the potential for exposure of narrow-headed gartersnakes to stocked sport fish for each watershed in which there are positive records for the species. For those watersheds in which gartersnake populations existed historically but are currently believed extirpated or of unknown status (Holycross et al. 2006), we determined that narrow-headed gartersnakes are unlikely to occupy the stocking complex and that there was no likelihood of exposure to stocked sport fish. The likelihood of exposure to stocked sport fish was not evaluated for watersheds that lie outside the known historical range of the species or for which there is a single historical record prior to 1985 and no additional observations.

Throughout the discussion of gartersnakes, AGFD uses the term “less suitable,” which requires some discussion/definition. There is no definitive set of criteria that dictate whether or not gartersnakes will or can occur in a particular area. The ability of gartersnakes to occupy a site and subsequently thrive there depends on a number of habitat characteristics, including, but not limited to cover, prey, predators, etc.. While some sites might be capable of supporting large
adult snakes, those same sites might not allow for successful recruitment. Stocking sites or stream reaches would be considered “less suitable” for gartersnakes when local conditions generally reduce or prevent successful recruitment, and thus population persistence. For example, the presence of bullfrogs, crayfish, or predatory fishes could make the site less suitable for gartersnakes because they exert predatory or competitive pressures on the snakes. However, gartersnakes might continue to persist in “less suitable” sites in the presence of nonnative species if those sites have greater habitat complexity and provide escape cover or feeding sites for neonates or juvenile snakes. An example of this would be Mexican gartersnakes on the middle Verde River, where although we have few data on population status, snakes appear to persist in exceedingly complex riparian habitat in some areas (e.g., Dead Horse Ranch State Park) despite the presence of bullfrogs, crayfish and predatory fishes.

In addition, there are sites within the elevational range of gartersnakes where distributional data suggest gartersnakes do not occur, but other structural habitat features seem to be appropriate. Although lack of data does not necessarily equate with absence, if there are additional habitat characteristics (predators, lack of cover, etc.) that would preclude gartersnakes from occupying those sites or thriving, we also refer to those sites as “less suitable” which contributes to a conclusion that snakes probably do not occur there.

**Stocking complex analysis:**
We used ArcGIS to map and identify sport fish stocking complexes for which positive observations of narrow-headed gartersnakes exist and that lie within the historical range of the species (Nowak and Santana-Bendix 2002, Nowak 2006, Holycross et al. 2006, HDMS, Arizona Game and Fish Riparian Herpetofauna Database). Because narrow-headed gartersnakes are unlikely to make long distance overland movements, we did not analyze the potential for exposure to stocked sport fish at sites in which it would be necessary for gartersnakes to travel >0.25 mile (>0.4 km) overland to reach those sites. For stocking sites with aquatic connectivity, we took a conservative approach and assumed that narrow-headed gartersnakes can move upstream and downstream throughout the stocking complex, similar to fish movements. To analyze the likelihood of exposure to stocked sport fish, we first determined whether narrow-headed gartersnakes occupy the area according to the criteria listed below and described in Table 22, and then examined the degree of aquatic connectivity that would permit gartersnakes to move through the stocking complex. Similar to our analysis for northern Mexican gartersnakes, we did not make a qualitative assessment for the likelihood of exposure (e.g., high, medium, low) because sufficient surveys have not been conducted in most areas and the status of most populations is unknown.

As discussed above for northern Mexican gartersnakes, it is difficult to determine whether gartersnakes occupy a site/area because their detectability is low and systematic surveys have generally not been conducted in most areas. Therefore, to make our determination, we built a
case using positive observations reported from HDMS, the Arizona Game and Fish Riparian Herpetofauna Database, and (Heritage) reports to AGFD to determine whether or not narrow-headed gartersnakes are likely to occupy each stocking complex. Rosen and Schwalbe (1988) began the first large-scale surveys for gartersnakes in 1985, which contributed to our understanding of their recent distributions in Arizona. Therefore, occupancy was described according to whether observations were made prior to or after 1985. Then, based on the occupancy determinations, we evaluated whether there is a likelihood of exposure to stocked sport fish, as described further below and detailed in Table 22. We did not make a qualitative assessment for the likelihood of exposure (e.g., high, medium, low) because sufficient surveys have not been conducted in most areas and the status of most populations is unknown.

1. Occupancy—stocking complexes will be considered:
   a. Occupied—if there are positive gartersnake observations within the complex since 1985 (Rosen and Schwalbe 1988, Nowak and Santana-Bendix 2002, Holycross et al. 2006, HDMS, Arizona Game and Fish Riparian Herpetofauna Database) and suitable habitat exists.
   b. May be occupied—if gartersnake records exist prior to 1985, but since then either surveys have been conducted and no snakes have been found or no systematic surveys have been conducted and habitat condition has diminished (e.g., bullfrogs or crayfish are present).
   c. Unoccupied—if a single historical record exists (prior to 1985) but no observations have been made since, habitat is unsuitable for the species (e.g., closed basin lakes), or the area lies outside the historical range of the species as identified by Holycross et al. (2006).

2. Likelihood of exposure—level of exposure:
   a. Exists—if there is a known population of narrow-headed gartersnakes occupying the complex or snakes are likely to move into the stocking complex because they persist nearby, then there is a likelihood that snakes could encounter stocked sport fish.
   b. Exists but is low—if the status of narrow-headed gartersnakes is unknown in the complex, the habitat is less suitable because there are other invasive species already present, such as bullfrogs and crayfish, or the species would need to make large overland movements in order to reach the stocking complex, then there is a low likelihood that snakes could encounter stocked sport fish.
c. Does not exist—if narrow-headed gartersnakes are unlikely to occupy the area because it is not suitable habitat or the complex lies outside the historical range of the species, then it is unlikely that snakes will encounter stocked sport fish.

Table 9. Criteria for determining whether narrow-headed gartersnakes occupy a site/stocking complex and the likelihood of exposure to stocked sport fish

<table>
<thead>
<tr>
<th>Status</th>
<th>Available data/habitat condition</th>
<th>Likelihood of exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupied</td>
<td>Records &gt;1985 ; and suitable habitat exists.</td>
<td>Exists (positive)—species known to occupy area.</td>
</tr>
<tr>
<td>May be</td>
<td>Records exist &lt;1985, but no systematic surveys have been conducted; or, surveys have been conducted but no snakes were observed; or, habitat condition is diminished (e.g., invasive bullfrogs or crayfish present).</td>
<td>Low—species may occupy area; or, habitat suitability is low; or, large overland movement necessary for species to reach stocking complex.</td>
</tr>
<tr>
<td>Unoccupied</td>
<td>Single historical record exists (&lt;1985), but no observations since then; or, habitat is unsuitable for the species (e.g., lakes); or, area lies outside historical range.</td>
<td>Does not exist (negative)—species is unlikely to occur.</td>
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Downstream analysis:
There is potential for narrow-headed gartersnakes to occur downstream of stocking sites, stocking stream reaches and outside buffered stocking complexes. Therefore, after carefully examining water connectivity and potential fish movement as described within each stocking complex chapter, we analyzed the likelihood that gartersnakes will be exposed to dispersing sport fish or that gartersnakes will move into the stocking complexes based on the occupancy criteria presented in the table below.