The hydrology modeling for this assessment does not project future inflows, but rather relies on the historic record to analyze a range of inflows. As discussed elsewhere in this assessment, the inflow to the Aspinall Unit has historically been highly variable and operations under the proposed alternative are planned to address this variability. The study period used in this analysis includes drought periods and both extremely dry and extremely wet years. Because the action being considered does not involve new construction of storage facilities or outlet features, sizing of facilities in relation to future climate is not a consideration. In addition, neither the baseline nor the proposed action itself are viewed as having any effect on climate.

The proposed alternative also includes an adaptive management process, supported by Recovery Program monitoring, to address new information about the subject endangered fish, their habitat, reservoir operations, and river flows. Reclamation will also continue to support multi-faceted research on climate change (Reclamation 2007). If climate results in effects to the listed species or critical habitats that were not considered in this PBA, then Reclamation would reconsult.

3.4.5 Water Rights

Gunnison River Basin water use began in the 19th century with the establishment of numerous irrigation water rights by individuals, organizations, and government agencies. There are more than 5,000 water rights for direct flow diversions presently in use on the river and its tributaries for irrigation, recreation, and municipal and industrial uses. There are an estimated 264,000 acres of irrigated land in the Basin (Colorado Department of Natural Resources 2006). Significant senior diversion rights established prior to 1910 include the Gunnison Tunnel of the Uncompahgre Project (1,300 cfs) located 2 miles downstream from Crystal Dam and the Redlands Diversion (750 cfs), located on the Lower Gunnison River 3 miles upstream from the Colorado River confluence. The 1933 Federal reserved right for the Black Canyon of the Gunnison National Park, also downstream, is currently being quantified and is predicted to be compatible with the proposed action under this PBA.

In addition to water rights for direct diversions and instream flows, there are significant storage and hydropower rights in place on the Gunnison River. The largest single perfected storage right is the 952,000 acre-foot decree for Blue Mesa Reservoir. There are also numerous small reservoirs and several larger Reclamation project reservoirs on tributaries with storage rights: Taylor Park Reservoir on the Taylor River, Silver Jack Reservoir on Cimarron Creek, Crawford Reservoir on the Smith Fork, Paonia Reservoir on the North Fork, Ridgway Reservoir on the Uncompahgre, and Fruitgrowers Reservoir on Alfalfa Run (see Attachment 1).

4.0 GUNNISON RIVER AQUATIC RESOURCES

Prior to water development in the Gunnison River, the upper river supported Colorado River cutthroat trout along with speckled dace, flannelmouth and bluehead suckers, and less common roundtail chubs and perhaps mottled sculpin (Wiltzius 1978); however, by

1900 native cutthroat had been largely replaced in the river and major tributaries by rainbow, brook, and brown trout due to stocking programs and habitat changes. Early in the twentieth century, the Gunnison already was considered a "world-renowned" trout fishery. The lower Gunnison River supported Colorado pikeminnow, razorback suckers, flannelmouth and bluehead suckers, roundtail chubs, speckled dace, sculpin, and perhaps humpback chub and bonytail. The razorback and perhaps the pikeminnow were common in the lower river as late as the 1950's (Burdick 1995).

The fishery of the Gunnison River and its major tributaries upstream from the Aspinall Unit are generally in good condition at the present time with rainbow, brown, and brook trout populations. Native cutthroat trout now occur only in isolated high elevation tributaries. Taylor Park Reservoir supports a rainbow and brown trout, lake trout, and northern pike fishery. The 1975 Taylor Park Exchange Agreement coordinates Taylor Park and Blue Mesa operations and has benefited fisheries of the Taylor and upper Gunnison rivers along with that of Taylor Park Reservoir itself. Fall migration runs of kokanee salmon from Blue Mesa to the Roaring Judy Hatchery on the East River support increasing recreational use.

Blue Mesa, Morrow Point, and Crystal Reservoirs are managed by the Colorado Division of Wildlife (CDOW) as sport fisheries. Public use and active management are limited at Crystal and Morrow Point due to the difficult access; however, the sport fishery at Blue Mesa is one of the largest and most valuable in Colorado. The present fish populations at Blue Mesa consists primarily of kokanee salmon, rainbow trout, lake trout, brown trout, longnose and white suckers, and longnose dace. Northern pike and more recently yellow perch have entered the fishery.

Downstream Morrow Point and Crystal Reservoirs are steep-sided oligotrophic reservoirs with limited access and fisheries. Survival of fish through the Blue Mesa powerplant provides limited "stocking" for Morrow Point and rainbow trout and kokanee are the most common species. Overall, escapement of non-native fish from the Aspinall Unit to the lower Gunnison River is not considered a significant problem because of mortality associated with the series of the three powerplants, depth of outlet works, and the infrequent spillway use at Blue Mesa and Morrow Point.

The Gunnison River from Crystal Dam to the North Fork Confluence has developed into a productive tailwater fishery due to relatively uniform and cold water releases and has been rated as a Gold Medal and Wild Trout (naturally reproducing) fishery by the CDOW. Bluehead suckers are common in this reach and flannelmouth are also present; and non-native longnose and white suckers and carp are found. Reservoir operations provide a minimum flow of at least 300 cfs through the Gunnison Gorge except in extreme droughts and emergencies and this has been beneficial to the fishery since the mid 1980's. Since the fishery is naturally reproducing, relatively stable daily flows during spawning and fry emergence and early development are critical.

Between the Gunnison River's North Fork Confluence and Austin, the river continues to support a quality trout fishery dominated by brown trout. In this reach roundtail chub, bluehead sucker, flannelmouth sucker, white sucker, and white sucker hybrids become more common. Between Austin and Delta, the trout fishery gradually declines due to warming summer water temperatures and increased turbidity.

Prior to any development, the lower river possibly supported eight fish species, including the bonytail, humpback chub, Colorado pikeminnow, and razorback sucker. By the 1990's, twenty-one species and three hybrids were reported in the lower 75 miles of the Gunnison downstream from the North Fork confluence (Burdick 1995), most with healthy reproducing populations. Seven of these species were native and three were endemic to the Colorado River Basin—the Colorado pikeminnow, humpback chub, and flannelmouth sucker. Other native fish in this reach were the bluehead sucker, speckled dace, roundtail chub, and mottled sculpin. Flannelmouth and bluehead suckers are the most common species.

The river downstream from the Uncompahgre confluence was designated as critical habitat in 1994 for the Colorado pikeminnow and razorback sucker. This reach of the Gunnison retains a healthy reproducing population of native fish and they comprised 79% of a total sample in 1993 surveys (Burdick 1995). This is an unusually high percentage of native fish for a river in the Upper Colorado River Basin and may result in part from the Redlands Diversion (RM 3) which served as a barrier to movement of non-native fish from the Colorado River for most of the 20th century. Numerically the most common fishes sampled were all native fish: bluehead sucker (36%), flannelmouth sucker (29%), and roundtail chub (14%). Kowalski (2008) reported on a more recent 2008 survey that continued to show a healthy population of native fish in the lower Gunnison River.

Floodplain habitat is important to the native fish, and the most extensive floodplain of the Gunnison River is in the 17-mile reach centered near Delta (between River Miles 50 and 67); and this reach has the most complex channel habitats with braided channels, islands, and backwaters (Burdick 1995). Prior to human settlement, the river upstream and downstream from Delta probably supported much more extensive floodplain habitat in this area. Downstream from River Mile 50, the river flows mostly through canyons with the limited floodplain areas developed for orchards, ranches, and gravel pits.

4.1 Discussion of Listed Species

The Service identified 9 endangered, 4 threatened, and 2 candidate species which could be affected by the proposed alternative (Fish and Wildlife Service 2008). Threatened or endangered species are formally listed under Section 7 of the ESA, while candidates are species for which the Service has sufficient information on their status and potential problems to propose them as endangered or threatened, but they have yet to be formally listed. Species of concern are species the Service believes to be vulnerable, but require further study to determine their status.

The species identified by the Service are as follows:

Vegetation		
Clay-loving wild buckwheat	*Eriogonum pelinophilum*	endangered
Uinta Basin hookless cactus	*Sclerocactus glaucus*	threatened
Jones' cycladenia	*Cycladenia humilis var. jonesii*	threatened

Wildlife		
Yellow-billed cuckoo	*Coccyzus americanus*	candidate
Mexican spotted owl	*Strix occidentalis lucida*	threatened
California condor	*Gymnogyps californianus*	endangered
Southwestern willow flycatcher	*Empidonax traillii extimus*	endangered
Black-footed ferret	*Mustela nigripes*	endangered
Canada lynx	*Lynx Canadensis*	threatened
Gunnison's prairie dog	*Cynomys gunnisoni*	candidate
Uncompahgre fritillary butterfly	*Boloria acrocnema*	endangered

Fish		
Colorado pikeminnow	*Ptychocheilus lucius*	endangered
Razorback sucker	*Xyrauchen texanus*	endangered
Humpback chub	*Gila lacypha*	endangered
Bonytail	*Gila elegans*	endangered

Terrestrial wildlife and vegetation species are discussed in Section 5.0.

4.2 Endangered Fish

The Colorado River Basin originally supported a fish fauna with 36 species from 20 genera and 9 families. Of these 36 native species, 64 % were endemic to the basin and only eight were found in both upper and lower portions of the basin. The native fish of the major rivers in the Basin are long-lived and have evolved to live in a system of high spring snowmelt flows, periodic high turbidity, and a wide range of flows.

This PBA addresses the habitat and populations of endangered fish in the Gunnison River and to a lesser extent addresses these fish in the Colorado River downstream from the Gunnison confluence. Recovery Program activities for the Gunnison and Colorado rivers are also discussed. This assessment assumes that improvement in flow regimes in the Gunnison can have positive cumulative impacts on habitat in the Colorado River downstream from the Gunnison confluence. Recovery Program activities for the Gunnison River are discussed; however, it should be noted that there are also many activities under the Recovery Program involving the Colorado mainstem and other tributaries including activities to improve flow conditions, address non-native species, and conduct monitoring and research.

Historical information on the Gunnison River's fish populations is limited and was summarized by Burdick (1995):

> Jordan (1891) collected both Colorado squawfish and razorback sucker from the Gunnison and Uncompahgre Rivers near Delta. He also reported collecting one "bonytail"; however this specimen may have been confused with the more numerous roundtail chub, since they were considered

subspecies until 1970 (Holden and Stalnaker 1975). Chamberlain (1946) reported razorback sucker as common in the Gunnison River downstream from Delta, and also reported Colorado squawfish from the lower Gunnison River. Kidd (1977) reported that a commercial fisherman frequently collected both Colorado squawfish and razorback sucker from 1930 until 1950 near Delta. Some razorback sucker were collected by CDOW during the 1950's, and one was collected near Delta in 1975 (Wiltzius 1978). Anecdotal accounts also suggest razorback sucker may have been abundant in the Delta area. Quartarone (1993) cites local Delta residents reporting both Colorado squawfish and razorback sucker as common in the Delta area and that razorback sucker used to enter the Hartland Diversion Ditch where they became stranded. Kenneth and Wendell Johnson (Personal communication 1993), long-time residents of Delta, indicated that they commonly caught razorback sucker in homemade traps in a flooded oxbow that was connected to the Gunnison River during spring runoff. They also added that they noticed that razorback sucker numbers declined rapidly in the late 1950's. Wiltzius (1978) believed that the Redlands Diversion reduced Colorado squawfish numbers in the Gunnison River by preventing upstream movement from the Colorado River.

4.2.1 Colorado pikeminnow (*Ptychocheilus lucius*)

4.2.1.1 General

The Colorado pikeminnow is the largest member of the minnow family in North America and historically was the top predator fish species in the Colorado River system. This long-lived fish was found throughout warm water reaches of the entire Colorado River Basin downstream to the Gulf of California. Loss of approximately 75 % of its historic range, unknown status in the Upper Basin and threats of further habitat loss prompted listing of Colorado pikeminnow as an endangered species in 1967. Critical habitat was designated on March 21, 1994 (59 FR 13374) as six reaches (1,848 km) of the Upper Colorado River Basin or about 29% of historic habitat, including portions of the Upper Colorado, Green, Yampa, White and San Juan rivers.

Today, Colorado pikeminnow occur in the Green River from Lodore Canyon to the confluence of the Colorado River (Tyus 1991; Bestgen and Crist 2000); the Yampa River downstream of Craig, Colorado (Tyus and Haines 1991); the Little Snake River from its confluence with the Yampa River upstream into Wyoming (Marsh et al. 1991; Wick et al. 1991); the White River downstream of Taylor Draw Dam and Kenney Reservoir (Tyus and Haines 1991); the lower 143 km of the Price River (Cavalli 1999); the lower Duchesne River; the upper Colorado River from Palisade, Colorado, to Lake Powell (Valdez et al. 1982b; Osmundson et al. 1997, 1998); the lower 54 km of the Gunnison River (Valdez et al. 1982a; Burdick 1995); and the lower 2 km of the Dolores River (Valdez et al. 1982a). The Green River and its major tributaries support the largest population of Colorado pikeminnow (2,142 adult fish; Bestgen et al. 2007). The upper

Colorado River adult population increased from 372 in 1991-1994 to 534 fish during 1998-2000 (Recovery Program 2006b).

4.2.1.2 Distribution and Abundance in the action area

While data is scarce, it does appear that the Gunnison historically supported a population of pikeminnow that at some point in time declined markedly. Wiltzius (1978) summarized written and anecdotal reports on this species; information on the relative abundance of the species was not consistent within these reports. Surveys since 1980 revealed only a very small remnant population in the Gunnison River (Valdez et al. 1982a; and Wick et al. 1985).

More recently, Burdick (1995) captured 5 adult pikeminnow during the 1992-1994 period. All fish reported by Burdick (1995) and Valdez et al. (1982a) were captured between RM 17 and 48, with most occurring near RM 33. During 2006 sampling, 2 wild adult pikeminnow were captured (McAda and Burdick 2006), although none were collected during 2007 (McAda and Burdick 2007). Figure 3 presents recent distribution information.

Larval Colorado pikeminnow were collected in very small numbers downstream from the Redlands Diversion in 1992, 1995, and 1996 and larval fish were collected near RM 29 and RM 5.5 in the mid-1990s (Osmundson and Kaeding 1989; Anderson 1994; Burdick 1995; and Anderson 1999). A possible spawning area was located between RM 32 and 33 based on congregation of radio-tagged fish and collection of larvae downstream. In 2006, a pikeminnow originally tagged in 1993, was captured at RM 32.3 in July.

Although pikeminnow use the entire Colorado River above Lake Powell, there are distinct differences in distribution among age classes. In general, most adults are found in the upper reaches of the Colorado River and most sub-adults, juveniles, and young-of-year (YOY) are found in the lower reaches (McAda 2003; Valdez et al. 1982b; Archer et al. 1985; McAda and Kaeding 1991; Osmundson et al. 1997). This difference in distribution may relate to increased abundance of appropriate-sized prey in upstream reaches (Osmundson 1999). Studies involving catch-rates indicate that the Gunnison River has a relatively high population of fish that could serve as potential prey for pikeminnow (Osmundson 1999).

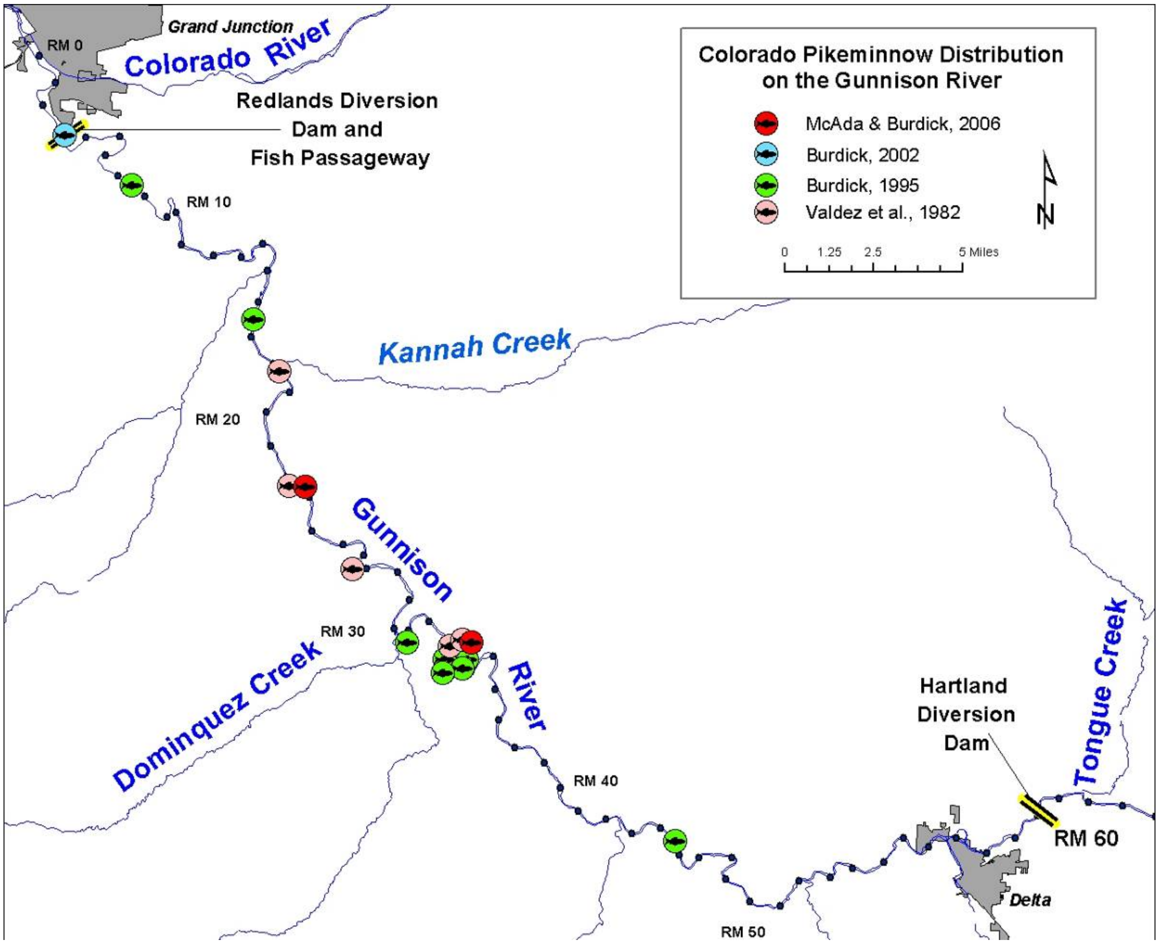


Figure 3. Recent distribution, Colorado pikeminnow, Gunnison River.

4.2.1.3 Life history

Colorado pikeminnow in the upper Colorado River sub basin live to at least 12 years (Hawkins 1992). Larvae at hatching are 6.0–7.5 mm long and grow under laboratory conditions at about 13 mm/month (Hamman 1981). Mean annual growth rate of fish from the upper Colorado River aged 3–6 years ranged from 32.2 (age 6) to 82.0 (age 3) mm/year and declined to 19.8 mm/year for fish 500–549 mm total length (TL) (Osmundson et al. 1997); fish 550 mm and larger grew an average of 9.5 mm/year. Average-sized Colorado pikeminnow in the upper basin are 450–550 mm TL and weigh 1–2 kg.

The Colorado pikeminnow is an obligate warm-water species that requires relatively warm temperatures for spawning, egg incubation, and survival of young. Hatchery-reared males became sexually mature at 4 years of age and females at 5 years. Spawning activity begins after the peak of spring runoff during June-August at water temperatures typically 16°C or higher (Vanicek and Kramer 1969; Hamman 1981; McAda 2003; Muth et al. 2000). Spawning in the Gunnison River, based on limited larvae collection, ranged from early June to mid-July. Colorado pikeminnow are broadcast spawners that scatter adhesive eggs over cobble substrate which incubate in interstitial spaces. Hatching success is greatest at 20–24°C with incubation time of 90–121 hours (Hamman 1981; Marsh 1985).

Survival and recruitment of Colorado pikeminnow is pulsed, as a strong year class appears and is reflected in the size composition of the population over time. This "storage effect" (Gilpin 1993) enables long-lived populations to maintain themselves despite several years of failed or low reproductive success. Greatest cohort strength in the upper Colorado River (i.e., 1986, 1996) occurred 1–2 years after high river flows, indicating that high velocities are needed to flush excessive sediments and organics from interstices of spawning cobbles, which otherwise suffocate eggs and reduce survival of larvae. McAda and Ryel (1999) noted that especially strong cohort strength in the Colorado River was related to high spring peak flows (ca. 50,000 cfs) during the previous year and moderately high spring peaks (30,000 to 40,000 cfs) during the year in which the fish were produced. Successful cohorts during high flows may be precluded by delayed warming of the river which causes delayed spawning, poor age-0 survival, and/or displacement of larvae beyond optimal rearing habitat (Thompson et al. 1991; Converse et al. 1998), but these high peaks may be necessary to provide optimal spawning conditions during the following year.

Studies of overwinter survival show a significant relationship between densities of age-0 fish in fall and spring, suggesting that high spawning success and egg and larval survival by fall (i.e., 3–4 months of age) largely determine cohort strength (Valdez et al. 1999; McAda and Ryel 1999). Overwinter survival also influences cohort strength, but the linkage to environmental correlates (e.g., flow variability, river temperature and ice formation, average backwater depth, and non-native fish density) is unclear. Overwinter survival was related to backwater depth with higher survival (85%) in backwaters deeper than 120 cm and lowest survival (18%) in backwaters less than 30 cm deep (Valdez et al. 1999). In the upper Colorado River, overwinter survival ranges from 7–77% (mean, 49%; McAda and Ryel 1999). Survival rates of adults >550 mm TL from the upper Colorado River is about 85% (Osmundson et al. 1997).

Backwaters and other low-velocity shoreline habitats in alluvial reaches of the upper Colorado, Green, and San Juan rivers are important nursery areas for larval and juvenile Colorado pikeminnow (Tyus 1991; Holden 2000; McAda 2003; Muth et al. 2000), and researchers believe that non-native fish species in those habitats limit the success of Colorado pikeminnow recruitment (e.g., Muth and Nesler 1993; Bestgen et al. 1997; McAda and Ryel 1999; Valdez et al. 1999). Non-native fish assemblages in these habitats are dominated by fathead minnow, sand shiner and red shiner. McAda and Ryel (1999) demonstrated that abundance of these non-native species during both summer (larvae) and autumn (juvenile and adults) was inversely correlated with magnitude of the previous spring peak flows, whereas relationship of young-of-year native fish to spring peak flows was either positive or statistically not significant.

Young Colorado pikeminnow remain near nursery areas for the first 2–4 years of life, and then move upstream to recruit to adult populations and establish home ranges

(Osmundson et al. 1998). Adult Colorado pikeminnow remain in home ranges during fall, winter, and spring and may move considerable (up to 950 km) distances to and from spawning areas in summer (Irving and Modde 2000) . Individuals move to spawning areas shortly after runoff in early summer, and return to home ranges in August and September (Tyus 1990; Irving and Modde 2000). Long range movement of Colorado pikeminnow among the Green and Colorado rivers suggests that the upper basin population is panmictic with evidence of source/sink dynamics (Gilpin 1993).

4.2.1.4 Colorado Pikeminnow Habitat

Colorado pikeminnow live in warm-water reaches of the Colorado River mainstem and larger tributaries, and require uninterrupted stream passage for spawning migrations and dispersal of young. Throughout most of the year, juvenile, subadult, and adult Colorado pikeminnow utilize relatively deep, low-velocity eddies, pools, and runs that occur in nearshore areas of main river channels (Tyus and McAda 1984; Valdez and Masslich 1989; Tyus 1990, 1991; Osmundson et al. 1995). In spring, however, Colorado pikeminnow adults utilize floodplain habitats, flooded tributary mouths, flooded side canyons, and eddies that are available only during high flows (Tyus 1990, 1991; Osmundson et al. 1995). Such environments may be particularly beneficial for Colorado pikeminnow because other riverine fishes gather in floodplain habitats to exploit food and temperature resources, and may serve as prey. Such low-velocity environments also may serve as resting areas for Colorado pikeminnow. River reaches of high habitat complexity appear to be preferred.

During most of the year, distribution patterns of adults are stable (Tyus 1990, 1991; Irving and Modde 2000), but distribution of adults changes in late spring and early summer, when most mature fish migrate to spawning areas (Tyus and McAda 1984; Tyus 1985, 1990, 1991; Irving and Modde 2000). High spring flows provide an important cue to prepare adults for migration and also ensure that conditions at spawning areas are suitable for reproduction once adults arrive. Specifically, bankfull or much larger floods mobilize coarse sediment to build or reshape cobble bars, and they create side channels that Colorado pikeminnow sometimes use for spawning (Harvey et al. 1993). Spawning occurs in gravel-cobble substrates in riffles and runs, and adjacent pools or backwaters can be used for resting or staging. Spawning habitat in the action area is located in meandering, alluvial reaches susceptible to considerable change during years of high flows (McAda 2003). Thus, while spawning doesn’t necessarily occur in the same area from one year to the next, six sites in the action area have been identified as potentially important areas for spawning activity:

1) The Colorado River reach immediately above the Gunnison River confluence
2) Two Colorado River reaches below the Gunnison river and above Westwater Canyon
3) The Colorado River downstream from Westwater Canyon near Fish Ford
4) The Gunnison River immediately below Redlands Diversion
5) The Gunnison River near RM 32

Cobble-gravel bar complexes that typify these sites are found at many locations in the upper Colorado River basin, however, and spawning activity can vary spatially from one year to the next.

Eggs are broadcast on cobble substrates in riffles and runs and incubate in the interstitial spaces for 4-7 days before hatching. The new larvae remain in the gravel/cobbles for about one week and then emerge and enter the river current. After emerging, Colorado pikeminnow larvae drift downstream to backwaters in sandy, alluvial regions, where they remain through most of their first year of life (Holden 1977; Tyus and Haines 1991; Muth and Snyder 1995). Backwaters and the physical factors that create them are vital to successful recruitment of early life stages of Colorado pikeminnow, and age-0 Colorado pikeminnow in backwaters have received much research attention (e.g., Tyus and Karp 1989; Haines and Tyus 1990; Tyus 1991; Tyus and Haines 1991; Bestgen et al. 1997). It is important to note that these backwaters are formed after cessation of spring runoff within the active channel and are not floodplain features. Colorado pikeminnow larvae occupy these in-channel backwaters soon after hatching. They tend to occur in backwaters that are large, warm, deep (average, about 0.3 m in the Green River), and turbid (Tyus and Haines 1991). Recent research (Day et al. 1999, 2000; Trammell and Chart 1999a, 1999b) has confirmed these preferences and suggested that a particular type of backwater is preferred by Colorado pikeminnow larvae and juveniles. Such backwaters are created when a secondary channel is cut off at the upper end, but remains connected to the river at the downstream end. These chute channels are deep and may persist even when discharge levels change dramatically. An optimal river-reach environment for growth and survival of early life stages of Colorado pikeminnow has warm, relatively stable backwaters, warm river channels, and abundant food (Muth et al. 2000).

Summer water temperatures at Whitewater only infrequently exceed optimal ranges for Colorado pikeminnow growth, and upstream reaches appear to be too cool for pikeminnow reproduction (see Table 10 and Attachment 6). Due to cool releases from the Aspinall Unit, Gunnison River summer temperatures in critical habitat were about 3 degrees °C cooler than river reaches in other parts of the Colorado River Basin that have relatively large populations of endangered fish. Osmundson (1999) considered the potential for extending the range of endangered fish in the Gunnison River, and determined that distribution of Colorado pikeminnow was temperature-limited and extended only to about 33 miles upstream of the Colorado River confluence (Dominguez Creek – Peeples Orchard). Cooler water upstream does not preclude fish from using upper reaches but the cooler temperatures can interfere with life processes such as reproduction and can lower growth rates. Osmundson (1999) reported good prey and habitat conditions upstream, but only sporadic use by Colorado pikeminnow and hypothesized that water temperature may reduce the upstream use.

4.2.1.5 Flow and habitat maintenance

The relationship between flow regimes and habitat maintenance was summarized in McAda (2003):

Spring
- Increasing flows cue fish to prepare for migration and spawning
- High flows inundate floodplain habitats to provide warm food-rich environments for growth and gonadal maturation
- High flows scour vegetation on banks and side channels to maintain habitat complexity
- High flows scour sediment from the cobbles and gravels to provide suitable location for eggs and larvae
- High flows mobilize the bed in runs and riffles; fines are flushed from the substrate and interstitial spaces
- High flows transport sediment and build in channel bars for backwater habitat
- High flows reduce non-native predators and competitors

Late Spring/Early Summer
- Declining flows and increasing water temperatures initiate migration and spawning
- Flows are sufficient to provide migration routes
- Flows are sufficient to prevent sedimentation of eggs and larvae

Summer
- Base flows maximize preferred habitat and sufficient depth for movement
- Base flows maximize backwater habitats available to young fish

Winter
- Base flows maximize preferred habitat and sufficient depth for movement and resting
- Base flows maximize backwater habitats available to young fish

4.2.2 Razorback sucker (*Xyrauchen texanus*)

4.2.2.1 General

The razorback sucker is a large catostomid and is endemic to the Colorado River. It is a long-lived fish and historically was found throughout warm water reaches of the entire Colorado River Basin downstream to the Gulf of California. By the 1990's, the largest riverine population was found in the middle Green River. The razorback sucker was listed as endangered under the ESA on October 23, 1991 (56 FR 54957). Critical habitat was designated on March 21, 1994 (59 FR 13374) as 15 reaches (2,776 km) of the Colorado River System or about 49% of historic habitat, including portions of the Colorado, Green, Yampa, Duchesne, White, Gunnison, and San Juan rivers in the upper basin, and portions of the Colorado, Gila, Salt, and Verde rivers in the lower basin. A recovery plan was approved in 1998 and amended and supplemented with recovery goals in 2002 (U.S. Fish and Wildlife Service 2002d).

4.2.2.2 Distribution and abundance in the action area

It appears that razorback sucker was once abundant in the Gunnison River, yet significantly declined in the second-half of the 20th century, perhaps becoming totally expatriated from the river by the 1990's. Historical information on the Gunnison River's fish populations is limited and was summarized by Burdick (1995) (Section 4.2).

Prior to Recovery Program activities, the last wild adults were captured near Delta in 1981 (Holden et al. 1981). Extensive sampling after that failed to capture any more individuals of the species in the Gunnison (McAda 2003). Since 1994, over 50,000 razorback sucker (ranging from 100 to 300 mm in length) have been stocked in the Upper Colorado River Basin (Burdick 2003). Most stocking occurs in the Colorado River, although approximately 3,000 razorback suckers per year are currently stocked in the Gunnison River (Tom Czapla, personal communication; Burdick 2003). Fish stocked at a minimum of 200 mm total length are recaptured most frequently. Stocked razorbacks are surviving in the Gunnison River and are reproducing based on captures of larval fish; and razorback sucker larvae are surviving through the first years (Recovery Program, 2008). The May 2008 Recovery Program Assessment indicated "Larvae of stocked razorback are potentially surviving through the first year in the Gunnison River. Juveniles captured at Redlands were either produced in the wild or were stocked into Butch Craig."

Figure 4 presents the current distribution of razorback sucker in the action area. Recent surveys of stocked razorback sucker in the Gunnison River indicate stocked fish have been at large for 5-11 years (McAda and Burdick 2006, 2007). Repeat observations of razorback sucker in backwater habitats were made near RM 51.4 during 2006 and 2007, although one fish was caught upstream of the Delta highway bridge and one near the mouth of Roubideau Creek. Overall there is little evidence of successful recruitment of this species in the Upper Colorado River Basin, although recent surveys indicate that stocked razorback sucker are spawning successfully in the Gunnison and Colorado rivers (Osmundson and McAda 2006, 2007).

In the Colorado River, most razorback suckers have been captured in the Grand Valley reach of the Colorado River (Loma to Palisade) near the confluence of the Gunnison and Colorado rivers (McAda 2003). In the late 1970's, razorback sucker were frequently captured from gravel pit ponds connected to the mainchannel Colorado River (Kidd 1977; McAda and Wydoski 1980). Their abundance in those areas has decreased considerably since that time. Only 11 wild razorback sucker were captured from the

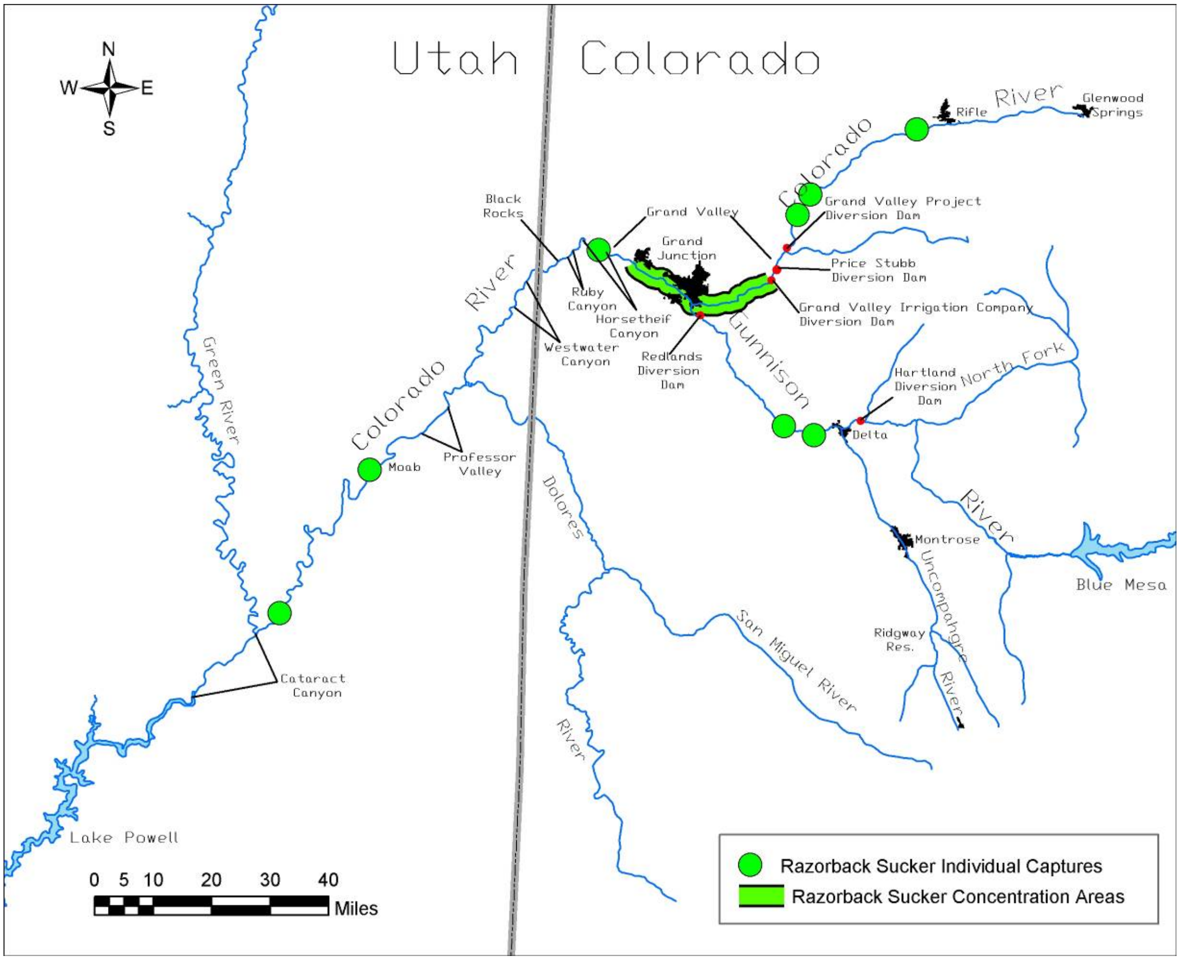


Figure 4. Razorback sucker distribution information, Colorado and Gunnison rivers.

Colorado River since 1990 (Osmundson and Kaeding 1991), all of which were brought into captive propagation programs.

Razorback sucker were also captured in considerable numbers near DeBeque in 1974-1975 by Kidd (1977). No razorback sucker captures have been made in that area since, although Burdick (1992) documented low numbers of fish in gravel pit ponds upstream and downstream of DeBeque. Few razorback sucker occur below Loma.

4.2.2.3 Life history

Adult razorback sucker attain a maximum size of about 1 m TL (5–6 kg; (Minckley 1973) and can exceed 40 years in age (McCarthy and Minckley 1987), although most individuals are less than 650 mm. Growth of razorback sucker is variable, depending on environmental conditions. Razorback sucker reared in hatchery aquaria were 150 mm TL in their first year of life (Valdez et al. 1982b), but fish reared in outdoor ponds near Vernal, Utah, grew to 127–156 mm TL in 4 months (Bestgen 1990). Fish reared in riverside ponds near Grand Junction, Colorado, grew from an average of 54.8 mm TL to 307 mm TL in 6 months (Osmundson and Kaeding 1989).

Most observations of razorback sucker reproduction in the Upper Colorado River Basin have been made in the Green River near Jensen, Utah. These fish spawn in May–June at temperatures of 6–19°C in velocities <1.0 m/s and depths of <1.0 m, near the upstream end of large gravel-cobble riffles (McAda and Wydoski 1980; Tyus and Karp 1990; Snyder and Muth 1990). Spawning sites occur in broad alluvial, flat-water regions with large cobble riffles and large riverside bottomlands as nursery areas immediately downstream (Bestgen 1990; Tyus and Karp 1989, 1990). Adults congregate in deep pools and runs near large cobble bars and spawn in April–May with rising water levels and increasing temperatures. Due to high reproductive potential and great longevity (McCarthy and Minckley 1987), razorback sucker may not spawn every year.

Newly hatched larvae (7-10 mm) drift into warm and highly productive flooded bottomlands, where they remain until the river recedes. The association of spawning during the ascending limb of the spring hydrograph and subsequent transport of newly hatched larvae into flooded bottomlands appears to be a critical relationship to the survival of this species that has been disrupted with regulation of high spring flows. Survival of newly hatched larvae appears to be the limiting factor for razorback suckers in the Upper Colorado River Basin (Tyus 1998). Absence of flooding that historically created flooded bottomlands in the Green, Yampa, and Colorado Rivers has limited nursery areas for newly hatched larvae (Bestgen 1990; Tyus and Karp 1990; Tyus 1998). Modde et al. (1996) correlated successful razorback recruitment in the Green River with high spring flows which reconnect floodplain habitats to the mainchannel.

Razorback suckers can migrate extensively to and from spawning sites in spring, but tend to move very little at other times of the year. As recently as the early 1980s, large numbers of adults were seen congregated at tributary mouths on the Green River (Tyus et al. 1982) and in gravel pits and large flooded bottomlands in the Colorado River (Valdez et al. 1982b). Except for spawning migrations, razorback suckers are relatively sedentary, moving only a few km over several months (Tyus 1987; Tyus and Karp 1990). Razorback sucker in the upper basin live sympatrically with about 20 species of warmwater, non-native fishes (Tyus et al. 1982; Lentsch et al. 1996) that are potential predators, competitors, and vectors for parasites and diseases. Hawkins and Nesler (1991) identified red shiner, common carp, fathead minnow, channel catfish, northern pike, and green sunfish as the non-natives considered by Upper Colorado River Basin researchers to be of greatest concern because of their suspected or documented negative interactions with native fishes. Sand shiner, white sucker, black bullhead, smallmouth bass, and largemouth bass were identified by Hawkins and Nesler (1991) as non-natives of increasing concern because of their increasing abundance, habitat preferences, and/or piscivorous habits. Lentsch et al. (1996) identified existing threats to native fishes in the upper basin from six species of non-native fishes including red shiner, common carp, sand shiner, fathead minnow, channel catfish, and green sunfish.

4.2.2.4 Razorback sucker habitat

Razorback suckers use different habitats with season and age (Valdez et al. 1987; Bestgen 1990; Tyus and Karp 1990). Habitat of (post-larval) juveniles has not been well documented because of small numbers of individuals captured in the wild. Juveniles (59–124 mm TL) have been captured in backwaters, tributary mouths, and flooded bottomlands (Taba et al. 1965). Adults over-wintered in deep runs and pools (0.6–1.4 m deep, 0.03–0.33 m/s) in alluvial and canyon regions of the Green River (Valdez and Masslich 1989), but often move into riverside gravel pits (Valdez et al. 1982b) and large flooded bottomlands during spring runoff for feeding and shelter from high mainstem flows (Tyus and Karp 1990). Adults in spring used deep, near-shore runs (0.6–3.4 m deep, 0.3–0.4 m/s), moved to large cobble islands (0.63 m deep, 0.74 m/s) for spawning, and shifted to shallow, slack water near mid-channel sandbars in summer (<2 m deep, 0.5 m/s) (Tyus 1987).

Temperature is an important aspect of habitat for razorback suckers. Thermal preference for adults was 22.9–24.8°C, based on electronic shuttle box studies, and lower avoidance temperature was 8.0–14.7°C and upper avoidance temperature was 27.4–31.6°C (Bulkley and Pimentel 1983). It was concluded from this study that alterations in year-round water temperature outside the range of 12.0–29.0°C should not be allowed if preservation of habitat for razorback suckers is a consideration.

Based on recent larval fish survey, spawning activity of stocked fish is taking place in the Gunnison River between the Redlands Diversion and Delta (Osmundson and McAda 2007). Larvae have been collected during most years since 2002, indicating successful reproduction. Locations of specific spawning sites have not been identified to date. Consequently, while the Recovery Program has identified and prioritized floodplain wetlands, their active restoration and management depends on proximity to these yet unknown spawning locations (Valdez and Nelson 2006). High priority floodplain habitats in the action area are identified in Section 2.1.1.

The relationship between flow regimes and habitat maintenance was summarized in McAda (2003):

Spring

- Increasing flows cue fish to migrate to spawning areas and trigger reproduction
- High flows inundate floodplain habitats to provide warm food-rich environments critical for larval fish and to provide river-floodplain connections
- High flows scour vegetation on banks and side channels to maintain habitat complexity
- High flows scour sediment from the cobbles and gravels to provide suitable location for eggs and larvae
- High flows mobilize the bed in runs and riffles; fines are flushed from the substrate and interstitial spaces
- High flows transport sediment and build in channel bars for backwater habitat
- High flows reduce non-native predators and competitors

Late Spring/Early Summer

- Declining flows allow increasing water temperatures
- Flows are sufficient to provide migration routes for adults and larvae

Summer
- Base flows maximize preferred habitat and sufficient depth for movement
- Base flows maximize backwater habitats available to young fish

Winter
- Base flows maximize preferred habitat and sufficient depth for movement and resting
- Base flows maximize backwater habitats available to young fish

4.2.3 Humpback chub (*Gila cypha*)

4.2.3.1 General

The humpback chub is a mid-sized cyprinid endemic to the Colorado River basin, generally found in deep-water canyon-bound reaches of the river system. Humpback chub were first listed as federally endangered on March 11, 1967 (32 FR 4001) and is protected under the Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1531 *et seq.*). Critical habitat was designated on March 21, 1994 (59 FR 13374) as seven reaches (610 km) of the Colorado River System or about 28% of historic habitat

4.2.3.2 Historical distribution and abundance in the action area

Within the action area, humpback chub are most numerous in the Westwater Canyon and Black Rocks area of the Colorado River (McAda 2003). Westwater Canyon is an 18 mile reach comprised of rapids, deep pools and strong eddies; Black Rocks is a 1 mile reach just upstream of the Colorado-Utah state line. The two populations are generally considered isolated, although some limited movement between the two has been documented (Valdez and Clemmer 1982; Kaeding et al. 1990; Chart and Lentsch 1999a; McAda 2002b). The Westwater Canyon population has declined from 6,985 adults during 1993-1996 (Chart and Lentsch 1999) to about 2,413 fish in 2003 (Hudson and Jackson 2003; Recovery Program 2006b). Similarly, the Black Rocks population has declined from 764 fish in 1998 to 478 fish in 2003 (McAda 2007). In 2008, the Recovery Program estimated a population of about 3,000 adults in the Black Rocks and Westwater Canyon core populations (Recovery Program, 2008).

The Gunnison River has never been considered habitat for the humpback chub. Burdick (1995) captured one specimen in a canyon bound reach at RM 22. The Gunnison Gorge contains some habitat similar to other river reaches in the basin that support humpback chub, but only roundtail chub were documented during pre-impoundment surveys (Wiltzius 1978).

4.2.3.3 Humpback chub habitat

Canyon-bound reaches of deep water such as at Black Rocks and Westwater canyons are preferred habitat of humpback chub adults (McAda 2003). They appear to prefer low-velocity habitats adjacent to the main channel, primarily eddies. Humpback chubs spawn in late spring or early summer at, or shortly after the spring peak, generally mid-June to late July. Little is know about spawning but limited data indicates that spawning occurs in gravel and cobble substrates. Larval drift does not appear to be as significant as with the pikeminnow and razorback.

4.2.4 Bonytail (*Gila elegans*)

4.2.4.1 General

The bonytail is a large cyprinid fish endemic to the Colorado River and is the rarest of the four big river endangered fishes in the Colorado River Basin; wild populations are considered nearly extinct.

4.2.4.2 Historical distribution and abundance

The Gunnison River has never been confirmed as habitat for this species; however, early sampling and anecdotal information suggests the species was common in the Green and Colorado Rivers in the early 20th century (McAda 2003). The Fish and Wildlife Service (2002) cited one capture in the Gunnison River near Delta by Jordan (1891), although identification of this specimen has been questioned and 5 captures in the mainstem Colorado River in the 1980's. Therefore it is possible that the species once utilized the Gunnison River. In recent years the species has been stocked in backwaters adjacent to the river near Whitewater and Kowalski (2008) reported collecting 2 bonytail from the river near the backwater in the summer of 2008.

4.2.4.3 Bonytail habitat

Because the bonytail is so rare in the wild, little is known about habitat preferences (McAda. 2003). Limited captures have occurred in canyon sections such as Cataract Canyon and Black Rocks on the Colorado and canyon sections of the Green River. Because the bonytail evolved in the same system as the pikeminnow and razorback, it is assumed that similar flow regimes would be beneficial to all species.

4.3 Historical Habitat Changes

The baseline habitat of the four listed species has changed significantly over the last 125 years. Sections of this report document the significant changes in the hydrology, geomorphology, and water quality, including water temperature, of the Gunnison River and further information is found in McAda (2003). It is not entirely clear when populations of endangered fish declined in the Gunnison River and this makes the direct cause of the decline difficult to identify. Habitat changes related to flow changes, non-native fish, migration blockage, water quality, and river channelization all may play a part in the decline of the species.

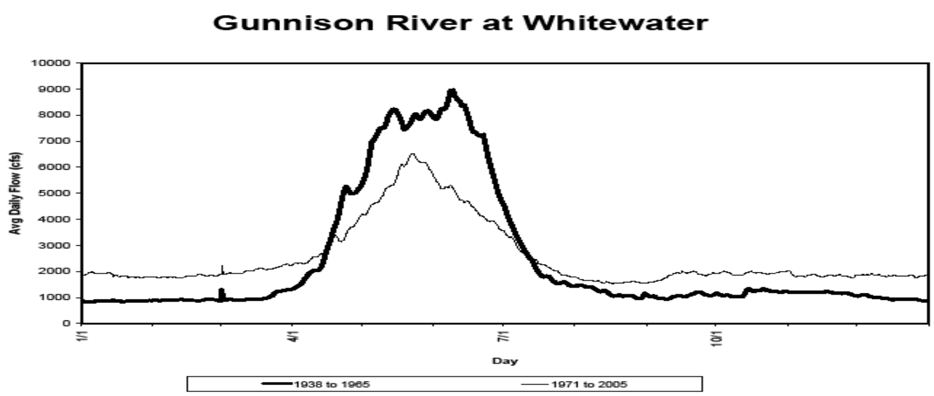
River flows

Pitlick et al. (1999) reported that since 1950, annual peaks of the Colorado River near Cameo have decreased by 29 % and annual peaks of the Gunnison near Grand Junction decreased by 38 %. Mean annual flows of the Gunnison have not changed significantly since 1950, while annual flows of the Colorado River have decreased significantly due to transmountain diversions. As an indication of increased summer and winter flows following construction of the Aspinall Unit, the percentage of months flows exceed 300 cfs downstream from the Redlands Diversion have increased from 43 to 65 % for August; 32 to 85% in September; 49 to 88% in October; 64 to 83% in December; 12 to 79% in January; 20 to 80% in February; 43 to 82% in March; and 85 to 90% in April.

Figure 5 provides a generalized picture of monthly flow changes in the Gunnison River over various time periods at Whitewater and in the Black Canyon. Long-term changes in climatic conditions, along with increased diversions for irrigation explain some of the differences in annual runoff at the Gunnison Tunnel. For example, the average annual natural flow of the Gunnison River at the Gunnison Tunnel between 1938 and 1965 was 185,940 af less than the period between 1911 and 1937. Overall, the 1992-2003 period was drier than the other periods. In addition, average Gunnison tunnel irrigation diversions increased by about 83,000 af per year in the same 1938-1965 period. However, changes in the seasonal distribution pattern of flows depicted by the hydrographs are due mostly to reservoir storage patterns.

Changes in flow regimes affected backwater habitats, channel maintenance, sediment movement, and other habitat factors. McAda (2003) summarized investigations into the influence of water development on channel morphology and river habitat:

> Pitlick et al. (1999) documented large-scale morphological changes that have occurred in parts of the Gunnison (lower 60 mi) and Colorado rivers (15-mi reach, 18-mi reach, and Ruby-Horsethief Canyon) by comparing aerial photographs taken in 1937, 1954, 1968, 1993, and 1995. The largest changes were in the 15- and 18-mi reaches where the Colorado River is largely unconstrained and still free to move about the floodplain (Pitlick et al. 1999). Although main channel and side channel area increased in some river segments, the overall trend was a decrease in surface area with main channel area decreasing by 15%, backwater area decreasing by 9% and side channel area decreasing by 26% (Pitlick et al. 1999). The reduction in side channel habitat may be especially important because side channels increase habitat diversity even though they comprise a small percentage of the river. Complex river reaches (i.e. multi-thread reaches) provide a variety of habitats in a small area and are preferred over single-thread reaches by adult Colorado pikeminnow. The 15- and 18-mi reaches provide most side-channel habitat in the Colorado River (Pitlick and Cress 2000) and contain a much higher number of adult Colorado pikeminnow than other, much longer reaches of the river.



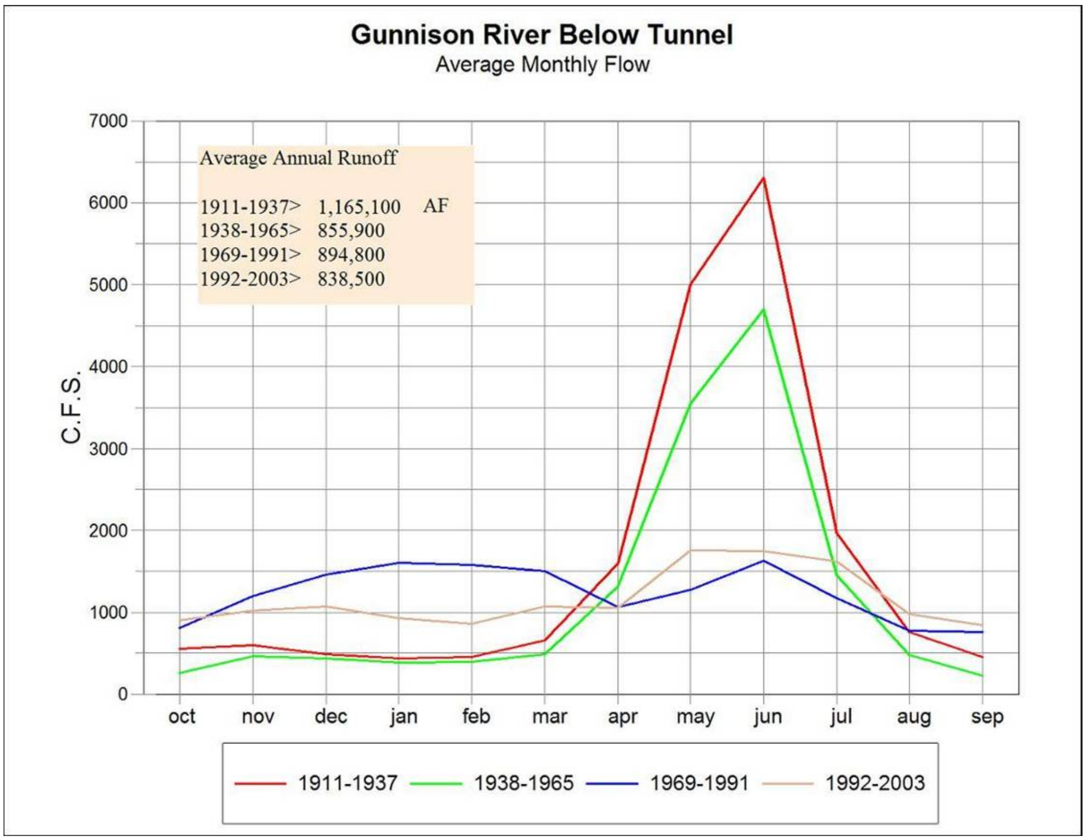


Figure 5. Generalized presentation of average monthly flow changes, Gunnison River at Whitewater and in Black Canyon.

Change in the channel area of the Gunnison River was less than observed for the Colorado River, but results were probably underestimated because of large differences in river flow when the two sets of aerial photographs were taken (Pitlick et al. 1999). Also the Gunnison River is more incised than the Colorado River and less change would be expected. Pitlick et al.

(1999) documented little change in main channel and side channel area, but showed a 15% decrease in island area between 1937 and 1995.

Geomorphology

While spring peak flows have decreased in the rivers, sediment inflow to the rivers apparently has not (Pitlick et al. 1999, Pitlick and Cress 2000). These two interacting factors reduce channel complexity as side channels gradually fill with sediment. Overall the rivers can become narrower and more simplified. This tendency is magnified by construction of dikes and other channel control structures. According to Pitlick et al. (1999), the period from the late 1950's through the 1970's had lower peak flows and similar annual sediment loads than occurred before or after that period, and this may have resulted in substantial sediment deposition in fish habitat, thus affecting spawning areas and backwaters. Very high flows, such as occurred in 1983 and 1984 tend to reverse the process temporarily.

Sediment deposition may also adversely affect the carrying capacity of rivers for the endangered fishes by reducing periphyton and macroinvertebrates that are important parts of the riverine food web (Osmundson et al. 2002) and Lamarra (1999).

Migration

Prior to water development in the basin, it is assumed that fish freely moved between the Gunnison and Colorado rivers; however, early water projects cut off these movements. The Redlands Diversion, located 3 miles upstream from the Colorado River confluence, was a barrier to upstream fish migration to the Gunnison River for nearly 100 years; and, during base flow periods, diverted a significant portion of the river and also presumably larval and adult fish. The Hartland Diversion, upstream from Delta, to a lesser extent, was also a barrier to migration. On the mainstem Colorado River migration was precluded by Boulder Dam in 1935 and by subsequent dams including Glen Canyon. Diversion Dams on the Colorado River upstream from the Gunnison confluence in Mesa County Colorado also blocked migration. In the last decade, fish passage has been provided around the Redlands Diversion and through the diversions on the Colorado River upstream from the Gunnison confluence. In addition fish screens have been constructed at major canals to reduce losses of fish to canals.

Water quality

While records are sparse, it is likely that water quality conditions in the early mining/timbering/grazing days were extreme and may have significantly affected fisheries. Mining in the headwaters and uncontrolled grazing in early settlement years affected water quality and streamflows, while large-scale irrigation in valleys underlain by Mancos shale resulted in return flows with increased salinity and selenium levels. Hamilton (1999) cited very high levels of selenium in the Colorado River basin early in the 20th Century. According to Hamilton, "In the 1930's selenium concentrations in various drains, tributaries and major rivers in the upper and lower Colorado River basins were in the 100s and 1000s of (ppb)." Levels of 80 ppb were reported from the mouth of the Gunnison River (NIWQP display based on Hamilton 1999).

The historical effect and the effect of present levels of selenium related to the recovery of endangered fish in the Green, Colorado, and Gunnison rivers has been a debated topic. Hamilton et al. (2000) suggested that survival and recruitment of razorback larvae in the Green River was limited due to selenium concentrations. Hamilton (1999) also hypothesized on the possible role of selenium in the decline of endangered fish species in the Colorado River Basin:

> In retrospect, the extremely elevated selenium concentrations in the Colorado, Gunnison, Uncompahgre, and San Juan rivers and their tributaries from the mid-1930's, which presumably started in the 1890s when irrigation activities began, would be expected to have had a devastating effect on native fish, based on adverse effects demonstrated in recent studies with endangered fish and numerous other species. This adverse effect was recognized indirectly as the disappearance around the 1910 to 1920 period of large-river fish such as Colorado pikeminnow and razorback sucker before large dams were constructed in the upper Colorado River basin. In the lower basin these fish were found until 1911 in abundance in irrigation ditches, but by 1925 to 1930 were considered scarce. The statement of Minckley et al. (1991) about the striking historical absence of young razorback sucker in collections suggests reproductive failure probably was occurring, i.e., no recruitment of young fish to the population, which is one of the well documented effects of selenium exposure. There is little doubt that the construction of mainstem reservoirs and introduction of exotic species have contributed to the decline of endangered fish in the Colorado River. There is now evidence that selenium, historically and currently, may be contributing to the endangerment of fish in the Colorado River basin.

In contrast to this study however, the Recovery Program also sponsored evaluations of selenium contamination on endangered fish during the mid- to late 1990's. Beyers and Sodergren (1999) conducted laboratory experiments on effects of direct exposure to dissolved and dietary selenium on survival and growth of razorback sucker larvae. They observed no changes in survival or growth or larvae due to exposure to selenium in any form or concentration, although dietary concentrations were likely insufficient to elicit a response. Predictions from this study were later validated by exposing razorback sucker larvae to water collected from three locations in the Colorado River near Grand Junction and food organisms cultured in that water, including higher levels of dietary selenium than used in the laboratory study (Beyers and Sodergren 2001a, b). As with the laboratory study, significant negative biological effects of selenium were not detected in razorback larvae. However, while the authors noted that selenium could be harmful if effects of maternal selenium transfer were considered, they recommended that the Recovery Program consider all threats to razorback sucker recruitment and survival (i.e., loss of physical habitat, altered thermal and hydrologic regimes and interactions with non-native fish) in their formulation of management actions.

Other studies concluded that most of the evidence implicating selenium is circumstantial and that “neither the historical record nor the technical literature consistently supports the emphasis given selenium toxicity (Korte 2000).

Much like other deep-release dams, Blue Mesa Dam has decreased the summer temperatures of the Gunnison River and increased winter temperatures. Summer temperatures below the North Fork have declined by as much as 10 degrees C in the summer (Stanford 1994), but due to rapid warming rates below that point temperatures near Delta are only 2 degrees C below pre-dam levels (McAda and Kaeding 1991). Temperatures reach pre-dam levels where the Gunnison enters the Colorado River, and the latter is not thermally affected by the Aspinall Unit (McAda 2003).

Backwaters

Development of towns such as Delta, the railroad that parallels the river downstream from Delta, and individual orchards and farms along the river led to the construction of dikes and bank protection measures all along the Gunnison River and to filling in or cutting off backwater areas. Irving and Burdick (1995) estimated that bottomland habitat availability was much more common prior to dike construction and flow regulation. The loss of backwaters may be of particular importance to the razorback sucker. The razorback spawns in the spring as flows increase and eggs hatch 1-2 weeks after spawning. Larvae are thought to drift into backwaters and floodplains that provide early critical habitat for the young fish. Backwaters were once extensive in the Delta area and have been reduced; this habitat has also been reduced downstream from the Roubideau confluence area but was probably never common. Flows above 10,000 cfs increase backwaters and flooded habitat. The frequency of years having flows greater than 10,000 cfs decreased from 57 % to 33 % following construction of the Aspinall Unit based on the period between 1937 and 1997. Similar channel modification developments occurred along the Colorado River, particularly in valley reaches.

Non-native species

Non-native fish have been introduced to the Gunnison and other basin rivers and now species such as the white sucker, common carp, red shiner, sand shiner, fathead minnow, and green sunfish are common in endangered fish habitat. Fifty-two fish species occur in the Upper Basin, but only 13 of those are native species (Fish and Wildlife Service 2000). Competition with and predation from the non-natives affect the endangered fish species. Tyus and Saunders (2001) discussed how competition and predation by introduced fishes has emerged as a major biotic factor limiting the survival and recovery of endangered fish populations. Overall, however, the Gunnison River appears to have a higher percentage of native fish (such as roundtail chubs and bluehead and flannelmouth suckers) than other upper basin rivers. The CDOW surveyed the Gunnison River in 2008 and reported a high percentage of native fish with bluehead, roundtail, and flannelmouth common (Kowalski, 2008).

There is some belief that the Redlands Diversion may have impeded the spread of non-natives such as channel catfish and largemouth bass upstream into the Gunnison. Brown trout and to a lesser extent rainbow trout are common in the Gunnison River upstream from Austin and occasionally occur in critical habitat downstream from Delta. McAda (2003) reported that there is some evidence that high spring flows may reduce the abundance of some non-native fish. Burdick (2005) found that young of native fish composed a much higher percentage of the fish population in Gunnison River backwaters in the high water year of 1993 than in the low water year of 1992. The introduced species may be less able to survive the high flows than native fish. Even if this reduction is temporary, it may increase the survival of young native fish.

Non-native vegetation may also affect the fish. The non-native shrub tamarisk has become established along most of the Gunnison and Colorado rivers, facilitating stabilization of river banks.

4.4 Critical Habitat and Recovery Goals

Critical habitat for the Colorado pikeminnow and razorback sucker was designated in 1994. Overall 1,980 miles of rivers were designated. “Critical habitat," as defined in section 3(5)(A) of the ESA, means: ``(i) the specific areas within the geographical area occupied by the species at the time it is listed, on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and (III) specific areas outside the geographical area occupied by a species at the time it is listed, upon a determination by the Secretary that such areas are essential for the conservation of the species."

Designated critical habitat for the razorback sucker makes up about 49 % of the species’ original range and occurs in both the Upper and Lower Colorado River Basins. Critical habitat for the Colorado pikeminnow makes up about 29 % of the species’ original range and occurs exclusively in the Upper Colorado River Basin (FR 59 13374-13400). Critical habitat for both species includes the Gunnison River and its 100-year floodplain from the Uncompahgre River confluence to the Colorado River confluence (Figure 6). In Colorado and Utah critical habitat includes the Colorado River from the town of Rifle to Lake Powell; the Gunnison River from Delta to the Colorado River confluence; the Yampa River from Craig to the Green River; the White River from Rio Blanco Dam to the Green River; and the Green River from Dinosaur National Monument to the Colorado River confluence.

Critical habitat was also designated for all four endangered fish species within portions of the Colorado River in Colorado and Utah. Critical habitat for Colorado pikeminnow in Colorado extends from the town of Rifle to Lake Powell. Razorback sucker critical habitat extends from Rifle, Colorado to Westwater Canyon. Humpback chub and bonytail

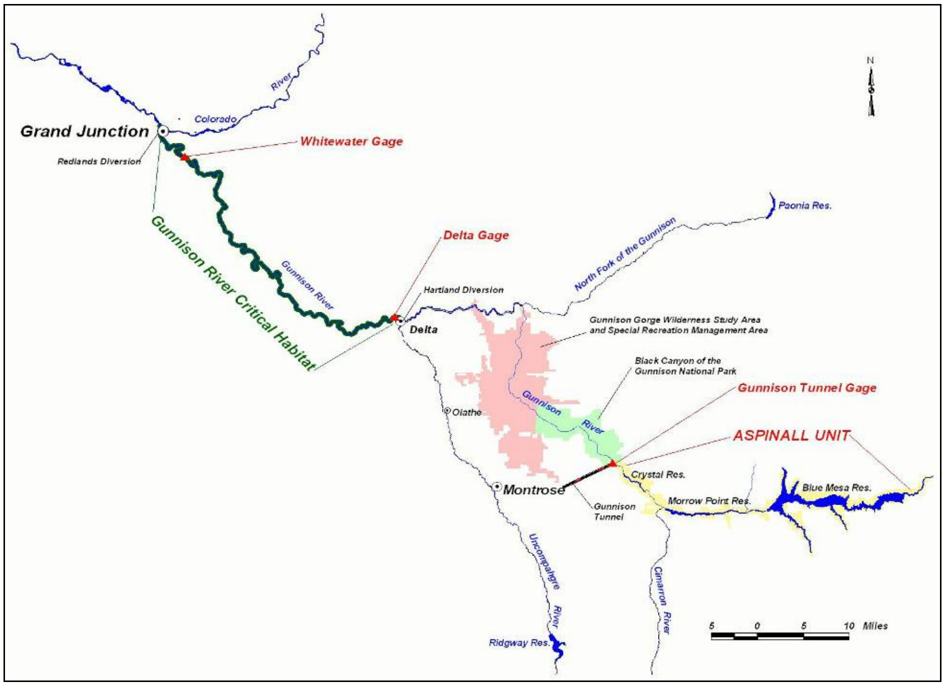


Figure 6. Critical habitat, Gunnison River.

critical habitat includes the Colorado River from Black Rocks to Fish Ford and Cataract Canyon in Utah.

Recovery goals, that define when species may be downlisted or delisted, were established for the species in 2002; these goals essentially call for establishing self sustaining populations. Goals are defined as population numbers, recruitment, and trends in the Green and Upper Colorado River. There are no specific goals for the Gunnison River, and Gunnison River populations would be included in the Upper Colorado River numbers. Recovery goal details are included in Attachment 7. At the present time, goals are being updated.

Recovery Goals for razorback sucker and Colorado pikeminnow recommend continued operation of the Redlands Fish Ladder and feasibility studies on increasing Gunnison River water temperature as site-specific management actions to address listing factors, and assessment of effects of selenium contamination are also identified for the entire Colorado River basin. The Recovery Program continues to fund and operate the Redlands Fish Ladder on an annual basis as part of its regular operation and maintenance budget. The Program also funded completion of two feasibility studies on potential modification of Aspinall Unit operations or infrastructure to increase water temperatures in the Gunnison River and expand endangered fish range, but have made no decision to date on the necessity of such actions for recovery.

4.5 Activities to benefit the species

The Recovery Program has overseen research activities on the endangered fish of the Gunnison River, with field studies being initiated in 1992. One end product of these investigations was publication of flow recommendations (McAda 2003) for the Gunnison and Colorado (downstream from the Gunnison confluence) rivers to benefit the endangered species.

The Aspinall Unit provided research flows during 1992-1998 for the Recovery Program studies, during which time release of excess water was reconfigured to provide a maximum release at Crystal Reservoir of 4,000 cfs. Duration and magnitude of releases varied greatly with inflow volumes. Since that time, Reclamation has implemented similar management of “risk of spill” water to benefit the endangered fish. The extended drought of the early 2000’s has limited magnitude and duration of spring peaks, however. Studies completed during the research period included surveys of distribution and abundance of endangered fish in the Gunnison River (Burdick 1995); assessment of Gunnison River flows on Colorado pikeminnow larvae and nursery habitat in the Colorado (Anderson 1999; Trammell and Chart 1999a, b); changes in the geomorphology of the Colorado and Gunnison river channels (Pitlick et al. 1999); effects of research flows on young-of-year Colorado pikeminnow (McAda and Ryel 1999); response of endangered fish habitat to research flows (McAda and Fenton 1998); effects on humpback chub in Westwater Canyon (Chart and Lentsch 1999); and impacts of research flows on geomorphology and food web dynamics in the Colorado River (Lamarra 1999; Osmundson 1999; Pitlick and Cress 2000).

Results from the research period and other studies were utilized through a weight-of-evidence approach to develop the flow recommendations for the Colorado and Gunnison rivers (McAda 2003). Specific relationships between biological response and river flow were used to quantify the underlying causes for biological responses, with considerable emphasis on flow response of riverine habitats critical to endangered fish. Partial restoration of natural functions through mimicry of a natural hydrograph was hypothesized to benefit endangered fish and physical and biological resources they rely on (Stanford 1994; Stanford et al. 1996; Poff et al. 1997).

Control of non-native fish in the Colorado and Gunnison rivers began in 1995-1996, during which time small numbers of northern pike were removed from the Gunnison River with electrofishing, fyke nets and trammel nets (McAda 1997). The effort proved successful at suppressing northern pike range expansion in the Gunnison River due to low or nonexistent in-stream recruitment. More recently, increased numbers of smallmouth and largemouth bass in the Colorado River has prompted the Recovery Program to begin aggressive mechanical removal programs in the Grand Valley reach. While numbers of smallmouth bass have apparently declined following these efforts, numbers of largemouth bass have increased (Burdick and McAda 2007).

The Recovery Program has established hatchery and grow-out facilities, and stocking of Colorado pikeminnow and razorback sucker began in the Gunnison and Colorado Rivers in the 1990’s in an effort to establish reproducing populations. A total of 49,954 razorback sucker (ranging from 100 to 300 mm in length) were stocked in the Upper Colorado (31,531) and Gunnison (18,423) rivers from April 1994 through October 2001 (Burdick 2003). Fish stocked at a minimum of 200 mm total length were recaptured most frequently. Larval fish monitoring indicates that these stocked razorback sucker are reproducing successfully.

Since 2001, 5,483-12,906 razorback sucker were stocked annually in the Colorado River and 549-3,805 were stocked in the Gunnison River (Tom Czapla, UWFWS, personal communication). The current stocking target for the Colorado and Gunnison rivers combined is 9,930, with the Colorado receiving about two-thirds of the fish. During that same period, stocked bonytail varied from 3,985 to 37,968 fish/year and the current target is 5,330 fish/year. Due to relative abundance of wild Colorado pikeminnow, stocking rates of this species are much lower (1,125 fish/year each in the Colorado and Gunnison rivers) and stocking occurred only in 2003 and 2004. To date, the Recovery Program has not determined the future of the Colorado pikeminnow stocking program.

Habitat improvements have been completed on the Gunnison River. A fish ladder was constructed around the Redlands Diversion and has been operated successfully since 1996; between 1996 and 2008 the ladder was used by 102 pikeminnow, 24 razorback suckers, 1 bonytail, and almost 86,000 other native fish (Recovery Program 2008). Recaptures have shown that there is some movement both upstream and downstream past the Redlands Diversion. A fish screen has been installed on the Redlands Canal to reduce losses of native and endangered species in the canal. Bottomland/floodplain habitat has been improved near Whitewater and Delta to increase nursery habitat for young fish. Fish passage, backwater protection, habitat improvement, and improved flows have also been implemented on the Colorado River mainstem. Growout ponds for razorback suckers have been constructed along the Gunnison River and are operated by the Service using water diverted from Gunnison River.

The Recovery Program has investigated the feasibility of warming releases from the Aspinall Unit (Hydrosphere 2002; Boyer and Cutler 2004). The two feasibility studies concluded that it was possible to meet downstream temperature targets for Colorado pikeminnow and razorback sucker (ca. 1-2 °C warmer than current conditions) through construction of a selective withdrawal structure on Blue Mesa Dam. However, uncertainties associated with model error, the status of the Gunnison River fish community and blockage of upstream migration routes at Hartland Diversion Dam prompted the Recovery Program to table discussions on construction of such a withdrawal structure until uncertainties are resolved.

A Coordinated Reservoir Operations Program (CRO; Recovery Program 2006a) was established through the Recovery Program to identify operational flexibility in existing water storage reservoirs that could collectively be used to enhance peak flows in the 15-Mile Reach of the Colorado River to benefit endangered fish species and their habitats without reducing project yields, increasing costs or affecting a project's water rights. CRO participants requested official Recovery Program concurrence with the CRO concept and process, and the latter were approved by the Recovery Program Management Committee in 2006. Implementation of the CRO process has proven to be possible during most years since 1997. In 1998 and 1999, a total of 65,000 af was released to support spring flows, which on average increased spring peaks by 2,000 cfs. Apparently these contributions were sufficient to mobilize small proportions of the bed in the 15- and 18-mile (Gunnison confluence to Loma) reaches, and overall CRO can assist in providing flows to achieve sediment mass balance and avoid channel narrowing (Pitlick 2007).

Recovery Program activities in the Gunnison River are primary directed toward the Colorado pikeminnow and razorback sucker and no specific activities are designed for the humpback chub or bonytail. However, the two species are included in the flow recommendations (McAda 2003) which the Recovery Program has approved. These recommendations acknowledge the role of Gunnison River flows in the maintenance and improvement of habitat conditions in the Colorado River, where humpback chub and possibly bonytail are present. It is also possible that operation of the Redlands Fish Ladder may allow humpback chub or bonytail to occupy new habitat, and as noted previously bonytail have been stocked in Gunnison River backwaters.

5.0 OTHER SPECIES

5.1 Vegetation

5.1.1 Clay-loving wild buckwheat (*Eriogonum pelinophilum*)

The clay-loving wild buckwheat is a small shrub that is found in semi-desert shrub communities of adobe hills. It is normally located in specific microhabitats and can be associated with shadscale and mat saltbush. Its range is restricted to small acreages in Delta and Montrose Counties and primary threats include fragmentation or clearing of habitat for urban development and off-road vehicle use. In the early 20th century, habitat was probably more extensive and was probably cleared for agricultural lands. Soils supporting the species are derived from Mancos shale (Lyon and Williams 1998).

The species is not associated with riparian lands along the Gunnison River and would not be affected by the proposed operation changes. The buckwheat does occur in the vicinity of laterals and canals on the eastern side of the Uncompahgre Valley. This is the same area where selenium/salinity control improvements are a priority. Consequently, Reclamation will survey all selected work areas in order to identify and avoid disturbing populations of this species.

5.1.2 Uinta Basin hookless cactus (*Sclerocactus glaucus*)

The Uinta Basin Hookless Cactus is a small cactus normally found on gravelly alluvial soils or in clay between 4,500 and 6,000 feet and can be associated with shadscale, sagebrush, greasewood, saltbush, and other desert vegetation. In Colorado it is reported