

**WILDFIRE IN THE SOUTHWESTERN USA:
EFFECTS ON FISHES**

John N. Rinne*
Rocky Mountain Research Station

1.0 INTRODUCTION

In the southwestern United States, there is little information available on the effects of wildfire on fishes. Propst et al. (1992) first discussed the impacts of fire on a native endangered trout, the Gila trout (*Oncorhynchus gilae*), in headwater streams in southwestern New Mexico affected by the Divide Fire, 1989. Soon after, Rinne (1996) reported on the effects of fire on rainbow (*O. mykiss*) and brook (*Salvelinus fontinalis*) trout in three streams affected by the Dude Fire in central Arizona in 1990. Rinne and Neary (1996) summarized and assessed the probable affects of wildfires on streams in the Southwest.

Study of the effects of wildfire on fishes and their habitats in the Southwest escalated in 2002--one of the worst years for wildfires on record. Rinne and Carter (in press) documented the short-term impacts of three major wildfires on fishes in the Southwest. In summary, they suggested the need to aggressively study and manage southwestern native fishes. The fish fauna of this region is 1) low in diversity, 2) dispersed in isolated reaches of streams (Rinne 1995), 3) rapidly declining due to multiple effects (see also Rinne and Minckley 1991, Rinne in press) and 4) largely comprised of threatened and endangered species of fishes.

In summer 2002, wildfires impacted already drought-stricken streams and their fishes. In Region 3, Arizona-New Mexico, 440,000 Ha (1.1 million A) or about three times the average over the past decade were consumed by wildfire in 2002. Again this year, (2003) wildfire activity was above average. Accordingly, in both years we took opportunity to examine the short-term effects of these fires on aquatic ecosystems. One of the primary purposes of our efforts was to expand our database on fish species other than salmonids. Most of the information that is available on fire effects addresses salmonid species (Propst et al. 1992, Rinne 1996, Rieman et al. 2003, Dunham et al, 2003) Importantly, during 2002-2003, information were obtained on

A dozen salmonid fishes in a half dozen streams affected by wildfire. Several of these streams contained listed species of fishes. We were particularly interested in the post-fire effects on non-salmonid species and native, threatened and endangered species of fishes.

This paper will 1) briefly discuss the effects of wildfire on fishes historically in the Southwest, 2) delineate the extent and potential impact on fishes--especially TES species of fishes, and 3) suggest possible management implications relative to conservation and sustainability of the southwestern native fish fauna. Because the southwestern fish fauna is primarily a cypriniform (minnow and sucker) assemblage (Rinne 2003a) several of these fishes have special status (i.e. threatened, endangered or sensitive) species. Although most of our data are short term, immediate (i.e. < four months) post-fire effects, when combined with historic and more long-term (a decade to 50 years) previous information on both introduced perspective of fire impacts on fishes in and native trout, they have important management implications. Finally, the regional southwestern aquatic ecosystems will be briefly addressed.

**2.0 GENERAL IMPACT OF WILDFIRE ON
SOUTHWESTERN FISHES**

Wildfire is increasingly becoming a major threat to sustainability of southwestern native fishes. It is commonly accepted that dams and introduced fish species have dramatically impacted the fish fauna of the Southwest (Miller 1961, Minckley 1973, Rinne and Minckley 1991, Rinne 2003a, 2003b). However, wildfire may be considered of equal merit as a threat or risk factor (Rinne in press) to native fish fauna sustainability. Brown et al. (2001) suggested wildfire is the most significant risk factor for the sustainability of Gila trout. Further, in headwater streams, over the past 15 years, extensive wildfires on landscapes encompassing the endangered Gila trout corroborate Brown et. al.'s suggestion (Table 1). In summary, on average, a fire has occurred every two that really or potentially affected this rare, listed species.

*Corresponding author address: John N. Rinne,
USDA, Forest Service, 2500 S. Pine Knoll Drive,
Flagstaff, Arizona 86001, email:
jrinne@fs.fed.us

3.0 HISTORIC EFFECTS OF WILDFIRE ON FISHES

3.1 THE MCKNIGHT FIRE, 1950

The McKnight fire occurred in 1950 in the Black Range Primitive Area (current Black Range Wilderness Area) on the headwaters of McKnight Creek, southwestern New Mexico. The fire burned 50,000 acres situated on the steep landscapes of the western flank of the Black Range Mountains. Significantly, in the early 1970's an endangered species, Gila trout (*Oncorhynchus gilae*), was introduced into the stream to meet goals and objectives of the recovery plan for the species. From the late 1970s to mid-1980 a series of floods impacted McKnight Creek (Rinne and Neary 1996). Gila trout in McKnight Creek have fluctuated markedly during that time and declined almost to extinction in 1988. Although cycles of drought and flooding are the norm in the southwestern US (Rinne 2003, in press b), these flood events may, in part, relate to the chronic effects of wildfire a half century Ago.

3.2 THE DUDE FIRE, 1990

The Dude fire occurred as a result of a lightning strike on the watershed of Dude Creek, on June 25, 1990. The fire quickly spread and affected the watersheds of Dude, Bonita, and Ellison Creeks. Ultimately, the fire burned 30,000 acres, destroyed 55 homes, cost 6 million to extinguish, and very unfortunately, 6 lives were (Rinne 1996). The post-fire ash and flood flows were fatal to all brook (Bonita Creek) and rainbow (Dude and Ellison Creek) trout except one brook trout captured in the extreme headwaters of Dude Creek. In September 2001, Bonita and Ellison creeks were sampled along with three additional contiguous Mogollon Rim streams that both contained previous density and biomass estimates (Rinne and Medina 1988) and were not affected by the Dude Fire. These data (Fig. 1) suggest that the trout populations in these two streams have not recovered.

4.0 SPECIFIC EFFECTS OF WILDFIRE ON FISHES, 2002

Three fires sampled in summer 2002 that affected watersheds encompassing streams with surface water and fishes extant were the Borrego, Ponil Complex, and Cub Mountain fires, all in New Mexico. All were lightning-caused fires ignited during the building of the monsoon season characteristic of the Southwest. The Ponil Fire was contained at over 90,000 acres; the Borrego and Cub Mountain fires were smaller, both burning about 13,000 acres.

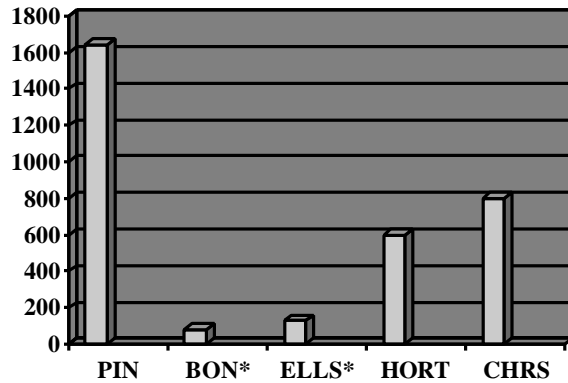


Figure 1. Density (A) (n/km) of trout in streams in Bonita and Ellison creeks 11 years after the Dude Fire compared to three contiguous, non-impacted streams (Pine, Horton, and Christopher).

4.1 STREAMS IMPACTED

Middle Ponil Creek was the primary stream impacted by the Ponil Complex Fire. The reaches sampled and studied were all second and third order stream channels. Rio Medio, affected by the Borrego Fire, is a second order stream, and the West Fork of the Gila River (Cub Mountain) is a third order stream in the reaches sampled. Except for Ponil Creek, all had surface water at time of immediate post-fire sampling. Ponil Creek was intermittent and in extreme drought condition during late June post-fire sampling. Sample locations in Ponil Creek were determined by presence of surface water during initial sampling efforts. Rio Medio had the greatest base flow (17-25 m³/min; 10-15 cfs), with the West Fork of the Gila being much reduced in flow (< 5 m³/min; 5 cfs).

4.2 THE FISHES

In 2002, A dozen new species of fishes were sampled in the streams affected by the wildfires in the Region three of the U. S. Forest Service. In Ponil Creek, information was obtained on densities and biomasses of three cypriniform species: creek chub, *Semotilus atromaculatus*, white sucker, *Catostomus commersoni*, and blacknose dace, *Rhinichthys cataractae*. These three species comprised the major portion (98%) of the fish assemblage (see Table 1). Rainbow trout (*Oncorhynchus mykiss*) also were present in low numbers.

Only brown trout, *Salmo trutta*, was present in Rio Medio, however, this represented a new species of trout for which fire effects was determined. In the West Fork of the Gila River, data were collected on a half a dozen native species of the Gila River basin: longfin dace,

Agosia chrysogaster; speckled dace, *Rhinichthys osculus*; Sonora, *Catostomus insignis*, and desert (*C. clarki*) sucker; roundtail chub, *Gila robusta*; and the threatened spikedace, *Meda fulgida*. This reach of river also contains the threatened loach minnow, *Rhinichthys cobitis*, however, this species has only been collected a kilometer downstream Rinne et al. in press). These downstream reaches were intermittent during regular, annual sampling exercises in May and therefore were not usable in delimiting the effects of wildfire. Spikedace also have been collected at an established, long-term monitoring site (Rinne et al. in press) positioned between sample sites 1 and 2. In summary, in summer 2002, a dozen new species were collected in reaches of three streams that potentially could be affected by post wildfire impacts.

5.0 THE FIRES

5.1 PONIL FIRE

The effects of post-fire runoff on this drought-stricken stream were dramatic (Table 1). At seven sites where over 2,000 fish were collected in early July 2002, no fishes were collected in early August 2002. Water quality of ash flows sampled contained hundreds of thousands of mg/l of suspended sediments, oxygen was reduced to 10-20% saturation from 70-80%, and turbidity exceeded 1,000 Jackson Turbidity Units. By contrast, fish populations at site one remained unchanged from July to October (Table 2). Sampling in summer 2003 revealed numbers of fishes at site one were also reduced and only two white suckers were collected at site 2. Monitoring of channel morphology, substrates, macro-invertebrates and water quality is ongoing.

Table 1. Total fish numbers at sample points in Ponil Creek, June 29-July 1, 2002. Fish species are: 1-longnose dace, 2-white sucker, 3-creek chub, and 4-rainbow trout. Site one was above fire influence zone, site four was affected by a small ash flow, and site six was affected by an ash/flood event at time of late June sampling.

Site	Fish species			
	1	2	3	4
1	15	8	6	18
2	71	10	30	5
3	42	45	291	0

3a ¹	58	142	208	0
4	78	42	164	13
5	159	46	135	0
6	0	0	0	0
7 ²	91	95	138	0
Totals	514	388	972	36

1. Elliot Barker Wildlife Unit site
2. A group of pools below site 4

Table 2. Comparison of fish species abundance and total fish numbers in Ponil Creek, site one, at initial (June) and final autumn (October) sampling, 2002.

Species	June	October
Rainbow trout	18	13
White sucker	8	5
Creek chub	6	2
Longnose dace	15	29
Totals-Site 1	47	49
SITES 2-7	1,910	0

5.2 BORREGO FIRE

Brown trout populations were reduced about 70% from initial sampling in late June to October 2002 (Table 3). Re-sampling in June 2003 revealed that populations of this introduced trout were even further reduced.

Table 3. Pre- and post-fire comparison of brown trout densities per 50-meter reaches of stream, Rio Medio, Santa Fe National Forest. Percent reductions between June and October are in parentheses. Sites two and three were not sampled in August.

Site	Jun	August	October
1	74	331	21 (72)
2	77	--	19 (75)
3	97	--	18 (86)

5.3 CUB MOUNTAIN FIRE

The Cub Mountain Fire provided opportunity to obtain information on the largest native fish assemblage to date, seven species. Two threatened species, spikedace and loach minnow, inhabit the West Fork of the Gila River downstream of the fire, and Gila trout are present in the headwaters. Total numbers of fishes were not reduced following several ash flows in July. However, after a flood event (1,500 cfs) in early September, estimated numbers of fishes in October decreased by about 70% (Table 4). Similar to the brown trout populations in Rio Medio, re-sampling of the West Fork Gila River below the Cub Mountain Fire in June 2003

Table 4. Total numbers of fishes in 50-meter reaches of stream in the West Fork of the Gila River, July and October 2002.

Date	Site 1	Site 2
Early July	168	560
Late July	278	481
October	50	118

revealed that total fish population was yet reduced.

6.0 MANAGEMENT IMPLICATIONS

Data collected on the short-term effects of fire on over a dozen species of fishes in a half dozen streams corroborate previous long-term findings by Propst et al. (1992) and hypotheses of Rinne and Neary (1996). Because the majority of southwestern native fishes are threatened, endangered or Forest Service sensitive and state-listed species, managers must be vigilant of opportunities to remove fishes from streams whose watersheds are affected by wildfire. Efforts such as those conducted for Gila Trout following the Divide Fire (Propst et al. 1992) and for Gila chub following the Aspen Fire that occurred in summer 2003 may be considered a fundamental management approach to address native fish sustainability in the Southwest following wildfires. Because most populations of rare, southwestern fishes are isolated and unique genetically they are evolutionary significant units. As such, they cannot be replaced once lost. Further, the climate and landscapes of the Southwest dictate fragmentation of aquatic habitats (Rinne 1995). Such fragmentation precludes natural repatriation that occurs more readily and frequently with primarily salmonid

species in the more mesic, northern Rockies and Pacific Northwest (Rieman et al. 2003, Dunham et al. 2003).

Finally, 2002 was a year characterized again by extensive and extreme fire activity in Region 3 (Arizona and New Mexico) of the U. S. Forest Service. The Southwest is currently in a period of prolonged drought. Continued drought combined with the massive outbreak of bark beetles across forested landscapes has resulted in thousands of acres of dead and dying trees in the national forests of the southwestern region. The potential is high for even greater wildfire activity in the future. In parallel, the probability likewise increases that additional streams containing rare and endangered fishes will be impacted by the aftermath of these fires. Recent (2002-2003) data combined with long-term data on the McKnight and Dude fires suggest a call to action to address the issue of wildfire effects on rare, TES fishes in the Region. Land and fishery resources managers must be prepared to take strategic, coordinated, and timely responses to these events as they potentially affect the invaluable, often locally irreplaceable resource, native southwestern fishes.

7.0 ACKNOWLEDGEMENTS

Special recognition and thanks are given to Cody Carter of Northern Arizona University, Dennis Miller and students at Western New Mexico University, Gary Snider and Kara Hilwig of Northern Arizona University, Will Diemien of Chino Valley High, Mark Anderson of Philmont Scout Ranch, Bob Calamusso and Terry Tolbert of the Tonto National Forest who either provided logistics for and/or participated in sampling during 2002-2003.

8.0 REFERENCES

- Brown, D. K., A. A. Echelle, D. L. Propst, J. E. Brooks, and W. L. Fisher. 2001. Catastrophic wildfire and number of populations as factors influencing risk of extinction for Gila trout (*Oncorhynchus gilae*). *Western North American Naturalist* 61(2): 139-148.
- Dunham, J. B., M. K. Young, R. Gresswell, and B. E. Rieman. 2003. Effects of fire on fish populations: landscape perspectives on persistence of native and non-native fish invasions. *Forest Ecology and Management* 178: 183-196.
- Minckley, W.L. 1973. *Fishes of Arizona*. Arizona Game and Fish Department, Phoenix, AZ. 293 pp.

- Miller, R.R. 1961. Man and the changing fish fauna of the American Southwest, Pap. Michigan Acad. Sci. Arts, Letts., 46:365-404.
- Propst, D. L., J. A. Stefferud, and P. R. Turner. 1992. Conservation and status of Gila trout, *Oncorhynchus gilae*. The Southwestern Naturalist 37(2): 117-125.
- Rieman, B. E., D. C. Lee, R. Gresswell, M. Young, D. Burns, R. Stowell, J. Rinne, and P. Howell. 2003. Current status and conservation of native fishes and issues for integration with fire and fuels management. Forest Ecology and Management 178: 197-212.
- Rinne J. N. 1995. Sky Island Aquatic Resources: Habitats and Refugia For Native Fishes. USDA Forest Service General Technical Report RM-264: 251-260.
- Rinne J. N. 1996. Short-term effects of wildfire on fishes and aquatic macroinvertebrates: Southwestern United States. North American Journal of Fisheries Management 16: 653-658.
- Rinne, J. N. 2003a. Southwestern riparian stream areas and fish habitats: Conservation and management implications, pp 193-213. In, P. F. Ffoliott . M. B. Baker, L. F. DeBano, and D. G. Neary. (eds). Ecology and management of riparian areas in the southwestern United States. Lewis Press, Boca Raton, FL.
- Rinne, J. N. 2003b. Native fishes: their status, threats and conservation, 277-297. In, Ffolliott, P, M. B. Baker, L. F. DeBano, and D. G. Neary (eds). Hydrology, ecology and management of riparian areas in the southwestern United States. Lewis Press, Boca Raton, FL.
- Rinne, J. N. In press. Flows, fishes, foreigners, and fires: Relative impacts on southwestern native fishes. Hydrology and Water Resources in the Southwest 33.
- Rinne J. N. and A. L. Medina. 1988. Factors influencing salmonid populations in six headwater streams, central Arizona, USA. Polish Archives Hydrobiology. 35(3-4): 15- 532.
- Rinne, J. N. and W. L. Minckley. 1991. Fishes in Arid Lands: Dwindling Resources of the Desert Southwest, USDA Forest Service Gen. Tech. Rep. RM-206, Rocky Mountain For. Range. Exp. Stn., Fort Collins, CO. 1-45.
- Rinne J. N. and D. G. Neary. 1996. Effects of fire on aquatic habitats and biota in Madrean-type ecosystems – Southwestern USA. USDA Forest Service General Technical Report RM-289: 135-145.
- Rinne, J. N. and C. Carter. In press. Short-Term Effects of Wildfires on Fishes in the Southwestern United States, 2002: Management Implications. Proc. Sympos. on Effects of Fire on Wildlife, San Diego, CA. Dec 2002.