

Native Montane Fishes of the Middle Rio Grande Ecosystem: Status, Threats, and Conservation

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Abstract—Between 1994 and 1997, research was conducted on three native, montane species of the Middle Rio Grande Ecosystem, in the Carson and Santa Fe national forests. The focus of study was on abiotic and biotic factors that affected status, distribution, biology and habitat of these species. Results of study suggest negative interactions with non-native species and, secondarily, habitat loss as the main factors contributing to the decline of these three native species. An inverse relationship in relative abundance between Rio Grande cutthroat trout and brown trout, extirpation of Rio Grande sucker when in sympatry with white sucker, and predation experiments documenting brown trout as efficient predators of juveniles of all three species, document both the real and potential impact of non-native species.

To sustain the Rio Grande cutthroat trout (*Oncorhynchus clarki virginalis*), and the Rio Grande sucker (*Catostomus plebeius*) and chub (*Gila pandora*) we must 1) protect stocks of native fishes with barriers to migration of non-native fishes, 2) renovate and restock streams with native fish assemblages, and 3) conduct management strategies on a watershed scale to facilitate inter-mixing of populations and subsequent gene flow, and enhance the degree of security of populations in the presence of stochastic natural disasters.

When the first Europeans arrived (ca. 1540) in what is now New Mexico, 27 native fish species were believed to be in existence in the Rio Grande basin. Of these 27 species, 13 have been extirpated in all or portions of this drainage (Sublette and others 1990). For the area known as the Middle Rio Grande Ecosystem (MRGES) Sublette and others (1990) recognize 21 native species present, whereas Rinne and Platania (1995) recognize 17 as native and Smith and Miller (1986) recognize only 16. All of these authors recognize 6 species as endemic. Human influences since this historic period have dramatically changed the palette of our native Rio Grande fish fauna. Presently, there are 43-45 species extant in the Middle Rio Grande Basin (10 native, 28 non-native) and though 10 native species still persist, their range and numbers have been much reduced (Rinne and Platania 1995).

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Although loss of native fish species has been more pronounced in the lower elevation tributaries and the Rio Grande mainstream, decrease in the ranges and abundance of native species also has occurred in upper elevation, montane areas of the MRGES. For example, Rio Grande cutthroat trout (RGCT), *Oncorhynchus clarki virginalis*, now occupies only 9 percent of its historic range in the Rio Grande basin (Stumpff and Cooper 1996). Rio Grande sucker (RGS), *Catostomus plebeius*, is listed as endangered by the state of Colorado and is declining in New Mexico in the northern portion of its range (Calamusso 1992; Langlois and others 1994). Although Rio Grande Chub (RGC), *Gila pandora*, are yet widespread and abundant in the New Mexico portion of its historic range, the species is becoming reduced in range and numbers in the Colorado portion (Zuckerman and Langlois 1990). Numerous factors have been hypothesized as causing the decline of the three native upland, Rio Grande species, the major factors being the introduction of non-native species and habitat loss.

The primary objective of this paper is to present an overview of the status, threats and conservation strategies for three native, montane species based on research funded by the MRGES program and conducted in the Carson (CNF) and Santa Fe (SFNF) national forests located in north-central New Mexico (fig. 1). The first five years of research will not be finalized until autumn 1998. More detailed and specific results of research on abiotic and biotic factors affecting the three native species, that cannot be addressed in this outlet, will be reported in the future. Accordingly, initial results of research are used to document and support recommendations.

Status

Rio Grande Cutthroat Trout

The Rio Grande cutthroat trout is one of two salmonids native to New Mexico and one of four salmonids native to Colorado (Sublette and others 1990; Alves 1998). It is a member of the inland cutthroat trouts (Behnke 1991), and is the southern most occurring of the group. While the historic range of the RGCT is not definitely known, it is likely that the species occupied all waters capable of supporting trout in the Rio Grande drainage and the headwaters of the Canadian and Pecos River drainages of New Mexico and south-central Colorado (Sublette and others 1990). Stumpff and Cooper (1996) speculate that this distribution may have covered approximately 40 hydrologic sub-basins in Colorado and New Mexico and may have extended as far

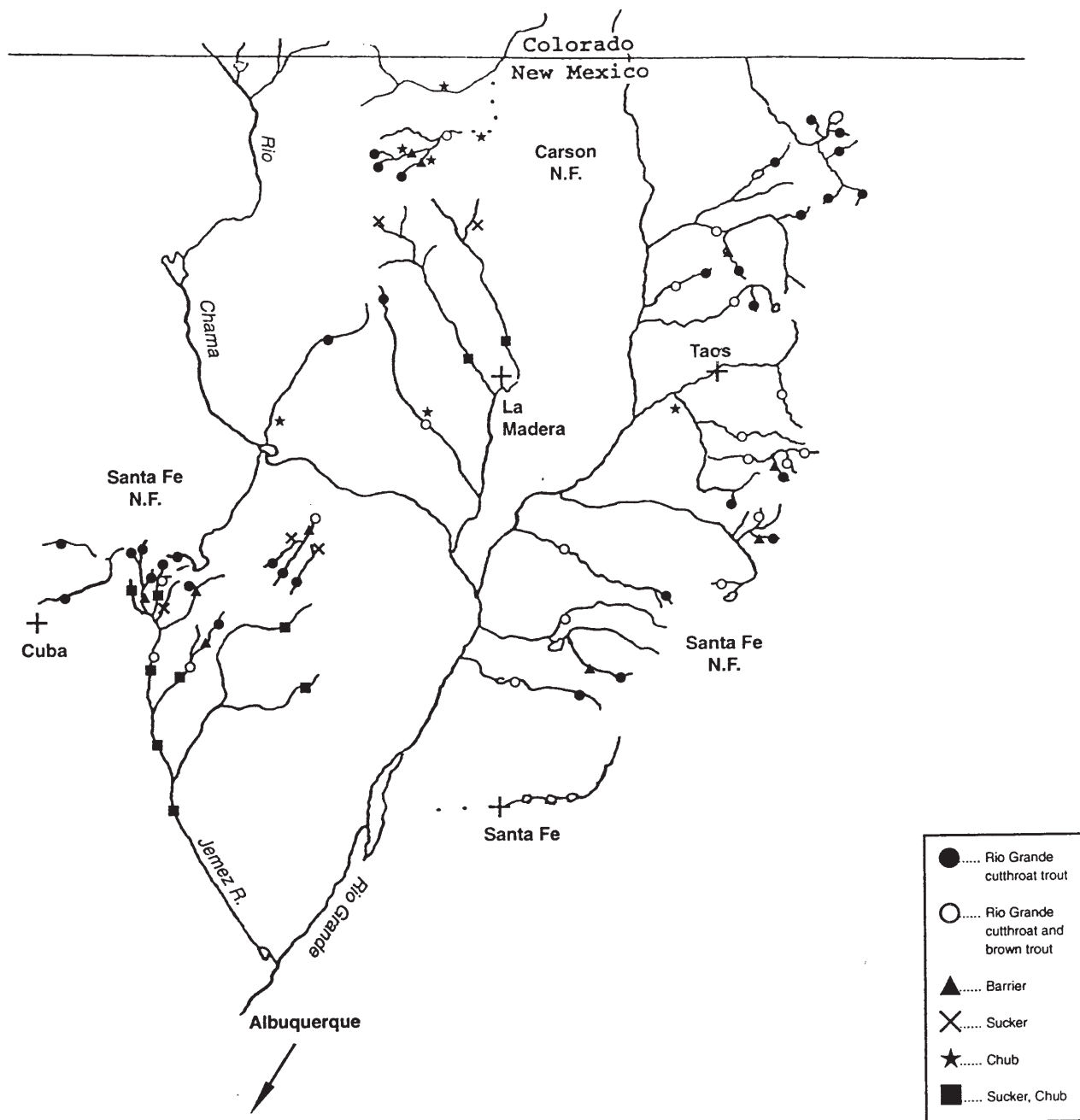


Figure 1—Study area including the current distribution of Rio Grande cutthroat trout relative to brown trout and the distribution of Rio Grande sucker and chub in the Rio Grande drainage of the Carson and Santa Fe National Forests, New Mexico as of January 20, 1998.

south as Mexico (Behnke 1992). Ninety-two populations of genetically pure RGCT exist today, 53 in New Mexico and 39 in Colorado. Most of these populations are found within United States Forest Service (USFS) lands. In New Mexico, the RGCT occupies only 9 percent of its former range (Stumpff and Cooper 1996). Most streams inhabited by RGCT are small, low productivity headwater streams where space and resources are limited. Gene flow among these disjunct and isolated populations is almost non-existent.

Currently, only 47 populations of pure RGCT remain in the Upper Rio Grande Ecosystem (URGES) and MGRES of

New Mexico (fig. 1). All are listed as “at risk/stable” by the New Mexico Department of Game and Fish (NMDGF). Nine additional populations pure and putative RGCT, representing a 19 percent increase in known populations, were identified by our surveys from 1994-1997 (table 1).

In response to the decline in RGCT stocks, the subspecies has been classified by the Colorado Division of Wildlife (CDOW) as a “species of special concern”, and by the NMDGF as diminishing— “A species that is absent from significant portions of its historic range, yet self-sustaining populations exist.” The USFS classifies the subspecies as a sensitive

Table 1—New distributions for Rio Grande cutthroat trout, CNF and SFNF, 1994-1998.

Stream	UTM	Elevation (m)
American Creek	338460E,3984710N	2,500
Canada de Osha	446050E,4002240N	2,400
Comales Creek	447750E,4001190N	2,583
Agua Piedras	452640E,3998770N	2,583
Rio de las Trampas	429450E,4001150N	2,209
Rio San Leonardo	439360E,3988900N	2,720
Rito de las Palomas	338260E, 3984350N	2,488
Italianos Creek	455620E, 4048670N	2,652
Yerba Creek	453430E,4046970N	2,497

species (Rinne and Medina 1996)—“A species that is in jeopardy of becoming threatened with extinction.” In 1989, the RGCT was listed in a federal “notice of review” as a “category C” subspecies—“taxa that are now considered to be more abundant and/or widespread than previously thought.” (Williams and others 1989). It currently is under consideration for listing as a threatened species.

Rio Grande Sucker

The Rio Grande sucker, an obligate riverine fish, was once common in the Rio Grande and its tributaries from southern Colorado to southern New Mexico (Cope and Yarrow 1875; Ellis 1914; Minckley 1980; Koster 1957, Zuckerman and Langlois 1990; Sublette and others 1990). At present, RGS are extant in the Rio Grande, primarily north of the 36th parallel and its tributaries primarily north of the 33rd parallel (Sublette and others 1990; Calamusso, unpublished data). Populations of this small mountain sucker have declined throughout the MRGES (Calamusso 1992; Calamusso and Rinne 1996) and are listed by the CDOW as endangered in the URGES of Colorado (Langlois and others 1994). After sampling over 250 streams in the early 1990's, Zuckerman and Langlois (1990) reported only two locations for RGS in the URGES. Since that time one of these populations has been extirpated and one persists (Hot Creek). Recently, the CDOW has restored two streams for RGS (Kelly 1997). The decline in RGS stocks have been attributed to the introduction and expansion of non-native white sucker, *Catostomus commersoni*, however, empirical data which identifies the competitive advantages of white sucker are needed to support this hypothesis.

Stream surveys conducted by the CNF and USFS Rocky Mountain Research Station (RMRS) (1992-1997) identified a total of 14 populations of RGS in the study area. Three streams on the CNF and eleven streams on the SFNF contain the native sucker (fig. 1). Surveys of streams which were determined to have suitable RGS habitat on the SFNF (Jemez Drainage) revealed robust populations of RGS. Streams on the SFNF draining into the Chama River were found to have populations of pure RGS or RGS in sympatry with white sucker. Only three populations of RGS were found on CNF where 5 populations once were known to exist. Many Rio Grande tributaries draining the CNF and adjacent lands exhibited habitat characteristics suitable for RGS but did not contain the species. These tributaries now are inhabited by the white sucker. In contrast to the CNF,

streams in the Jemez drainage of the SFNF do not contain white sucker due to the barrier to migrating non-native fishes from the Rio Grande mainstem created by the Jemez Canyon dam. Similar to RGCT, populations of RGS are often fragmented which limits genetic exchange among populations. Based upon the endangered status of RGS in Colorado and its decline on the CNF we consider the RGS as “imperiled” in the northern portion of its range.

Rio Grande Chub

Inhabiting both riverine and lacustrine habitats, the endemic Rio Grande chub is widely distributed throughout the MRGES and URGES. It is found in the Rio Grande and its tributaries primarily north of the 33rd parallel (Sublette and others 1990; Calamusso, unpublished data). Declines for this species have been greater in the URGES than the MRGES (Zuckerman and Langlois 1990).

RGC were found in 17 streams in the study area; 9 on the CNF and 8 on the SFNF and were found at all historic locations. Elevations in these streams ranged from 1,717 to 2,810 meters. RGC were commonly sampled in streams exhibiting habitat characteristics that are preferred by the native chub (fig. 1). In contrast to both the RGS and RGCT, gene flow among chub populations is fluid. The status of the RGC is listed as stable and reproducing for New Mexico (Sublette and others 1990; Calamusso and Rinne 1996).

Co-occurrence of Native Fishes

Co-occurrence of two or more of the native species was documented in only 10 streams within the study area (table 2). Streams exhibiting co-occurrence for all three native species was greatest in the Jemez drainage of the SFNF and lowest on the CNF. RGC and RGS were found in sympatry at lower elevations, whereas RGCT and RGS were found in sympatry at higher elevations. When RGCT were found occurring with the native cypriniforms their numbers were very low due to an abundance of non-native salmonids present in the lower elevation reaches. The low number of streams (n=3) exhibiting co-occurrence of all three of the formerly sympatric species reflects the degree of fragmentation to which the natives have been subjected.

Table 2—Co-occurrence of Rio Grande cutthroat trout, sucker and/or chub, Carson and Santa Fe National Forests, 1994.

Stream	Rio Grande cutthroat trout	Rio Grande sucker	Rio Grande chub
Carson NF			
Rio Tusas	X	X	
Canjilon Creek	X		X
El Rito	X		X
Rio San Antonio	X		X
Rio Nutrias	X		X
Santa Fe NF			
Rio de las Vacas	X	X	X
Rito de las Palomas	X	X	X
American Creek	X	X	X
Canones Creek	X	X	

Threats

Habitat degradation, dewatering and grazing have all been cited as factors contributing to the decline of many native species (Rinne and Minckley 1991). We can assume that RGCT populations are limited due to declining habitat conditions. Grazing studies, however, are limited for the Southwest and none have shown a direct link to the decline in native fishes, especially cypriniform fishes (Rinne 1988; Rinne 1998; Rinne in press). For example, in our habitat studies of RGS, two streams, the Rio Tusas and Rio de las Vacas exhibited severely grazed riparian stream reaches with a high width to depth ratio, but had the greatest relative abundance of all streams surveyed that contained RGS. Thriving populations of RGS and RGC have been reported in a reach of the Rio San Jose which receives sewage discharge from Grants, New Mexico (AquaScience 1982). Dewatering of montane streams for irrigation and acequia systems has and will continue to occur. We view these as contributing-secondary factors in the reduction in range and numbers of montane Rio Grande native fishes. Our research indicates that the principal threat to these native fishes is the expansion in range and numbers and continued introduction of non-native fishes.

Rio Grande Cutthroat Trout

Except for the westslope cutthroat trout, native to the Salmon and Clearwater drainages in Idaho and to the John Day River drainage in Oregon, interior cutthroat trout evolved apart from rainbow, *Oncorhynchus mykiss*, and redband trout, *Oncorhynchus mykiss gairdneri*. They lack innate isolating mechanisms that would allow them to coexist with those forms and with non-native trout species (Behnke 1992). Of the 86 populations of RGCT (Grade A - F) recognized in the study area 24 (28 percent) are considered to be introgressed with rainbow trout genes or some form of non-native cutthroat trout (NMDGF, Unpublished Data). Snake River cutthroat trout, *Oncorhynchus clarki* subsp. were stocked in New Mexico until the late 1980's, whereas rainbow trout continue to be stocked within the native range of RGCT. In an evaluation of historic RGCT streams in Colorado that were experiencing declines in populations, 72 percent were declining due to non-native trout, 14 percent to failed barriers (hence invasion from non-native fishes), whereas only 14 percent of the RGCT populations experiencing declines were attributed to poor habitat conditions (Alves 1998). The threat of introgression by non-native *Oncorhynchus* remains ever constant.

No less of a threat to the sustainability of RGCT are non-native brown, *Salmo trutta*, and brook trout, *Salvelinus fontinalis*. Preliminary information suggest this impact may be great. In American Creek, Rito Cafe, and the Rio de las Vacas there appears to be an inverse trend of density and/or biomass between the native cutthroat and the introduced brown trout (table 3). Of the 41 streams in the study area draining into the Rio Grande containing pure populations of RGCT only 13 (32 percent) are occupied solely by the cutthroat native, whereas 28 (68 percent) have brown trout co-occurring (usually in lower reaches) with RGCT. Of these 26 streams only 15 (54 percent) have pure populations of RGCT which are protected by barriers to non-native trout.

Table 3—Relative density (D) (n/hectare) and biomass (B) (kilogram/hectare) of Rio Grande Cutthroat trout (RGCT) and brown trout (BT) in study reaches in American Creek and Rito Cafe, Rio de las Vacas, Santa Fe National Forest, 1995.

Study section	RGCT		BT	
	D	B	D	B
American Creek				
1	324	9	279	22
2	702	32	0	0
3	90	6	90	13
4	488	13	195	9
5	300	9	486	12
6	89	5	714	58
7	56	5	617	46
Rito Cafe: Below Barrier				
1	676	14	2801	241
2	400	15	2300	182
3	0	0	3200	144
4	0	0	3875	96
Rito Cafe: Above Barrier				
5	2545	30	91	30
6	2608	36	0	0
7	1080	22	83	5
Rio de las Vacas: Below Barrier				
1	0	0	318	18
2	117	2.7	233	10
3	0	0	595	60
4	156	2.4	739	43.3
5	0	0	1468	83.7
6	61	.55	1908	118.9
Rio de las Vacas: Above Barrier				
1	3905	133.3	0	0
2	2827	153.7	0	0
3	3386	121.4	0	0
4	2548	121.0	0	0

Rio Grande Sucker

Little information exists on interactions of RGS with non-native species. Zuckerman and Langlois (1990) speculated that declines in RGS abundance in Colorado were due to genetic swamping by white sucker. They reported capturing hybrids of RGS and white sucker in two streams in southern Colorado. Recent genetic studies, however, found no evidence of hybridization of RGS with white sucker (Sue Swift, USFS, Pers. Com.) and while the mechanism of decline in RGS populations is unknown, RGS populations have been observed to decline across their range when in sympatry with the non-native white sucker.

In the 1980's five streams in the CNF were listed as containing RGS. Our surveys found only two streams inhabited solely by RGS (Rio Tusas, Little Tusas), one stream had white sucker in co-occurrence with the native (Rio Vallecitos), and in two streams the native sucker had been completely replaced by the white sucker (Rio Costilla, Rio Grande del Rancho). Presently, a beaver dam protects the Tusas system from intrusion by white sucker and while the Rio Tusas and Little Tusas appear free of white sucker, the Rio Vallecitos has white sucker established in the lower and middle reaches (up to Canon Plaza). The absence of white sucker in the

upper reaches of the Rio Vallecitos near Hopewell Lake may only be temporary as white sucker were found further upstream in 1995 than in 1992. Without a physical barrier to migration between Canon Plaza and the upper reaches, intrusion by white sucker would seem imminent. At present, all streams draining into the Rio Grande and Rio Chama from the CNF have been or are susceptible to colonization by white sucker.

Streams within the Jemez drainage (SFNF) are safe from intrusion by the white sucker due to the migrational barrier created by Jemez Canyon Dam. The potential for unintentional introduction of white sucker into this system could occur from its use by fisherman as bait. White suckers have been found in the Rio Chama and in its southern tributaries (for example Canones Creek) originating on the SFNF. These streams are currently vulnerable to invasion by white sucker.

Rio Grande Chub

Probably least studied of the three native species is the Rio Grande chub. While the RGC is considered to be common and is abundant throughout the study area a general decline in this native cyprinid has been observed in the URGES (Zuckerman and Langlois 1990). RGC are capable of exploiting both lentic and lotic habitats, this may allow the RGC to maintain its general abundance in the MRGES. Factors such as dewatering and grazing in riparian areas may have a negative effect on RGC populations since the species is commonly associated with aquatic vegetation, instream woody debris, and overhanging riparian vegetation.

Interactions of Brown Trout with Cypriniformes

As with RGCT, brown trout have been suspected in contributing to the decline in RGS and RGC populations, although no published data existed prior to this study. To test this predation hypothesis we used instream experimental cages in which brown trout, RGS, and RGC were placed together. Results from this experiment were dramatic yet perhaps inconclusive. In the instream cages, predation on the natives by brown trout was severe. Yet in light of these results if one examines electrofishing data from the Rio de las Vacas an inverse relationship between brown trout abundance and cyprinid abundance is not evident (fig. 2). It may be that brown trout do not extirpate these cyprinids, but do depress the natural abundance that would occur in the absence of the non-native predator. What the abundance of these cyprinids would be in the presence of the native cutthroat can only be speculated since there are so few instances where healthy populations of RGCT, RGS, and RGC co-occur.

In summary, our data indicates that non-native fishes are the main vector of demise for the three native species in our study area. Non-native salmonids can be directly linked to the decline of RGCT stocks in the study area and throughout its historic range. The impact of white sucker through potential genetic swamping, aggression, or greater fecundity along with predation by brown trout may act in concert

to extirpate stocks of RGS. Habitat degradation and overall environmental decline may play a role in the demise of native fishes in the montane reaches of the MRGES. Declining habitat conditions may make the natives less fit to compete with non-natives, however data is not available to support this hypothesis. At present our ability to measure and identify these mechanisms may be lacking.

Conservation and Management: Current Management

Rio Grande Cutthroat Trout

Management directed toward the sustainability of the RGCT has been ongoing since the 1970's when extensive distributional surveys were conducted by the CDOW, NMDGF and the USFS. The search for unknown populations of pure RGCT continues. Both the CDOW and the NMDGF have developed and are implementing RGCT management plans (Stumpff and Cooper 1996; Alves 1998). To insure the persistence of existing stocks of RGCT, agencies continue to build and identify sites for migrational barriers to non-native salmonids. In an effort to increase the number of RGCT populations, renovation of streams for the reintroduction of RGCT into its historic range is one of the major management practices presently being used by both states. Two brood stocks are maintained in Colorado, one in Haypress Lake and the other at the Fish Research Hatchery in Fort Collins. The NMDGF is in the process of developing a RGCT brood stock at the Seven Springs Hatchery. The RMRS continues to conduct research aimed at identifying habitat variables that influence RGCT productivity, spawning success, and recruitment and is beginning to evaluate population characteristics to develop population viability analyses that will help predict the sustainability of specific RGCT populations. Progress toward the goal of sustaining RGCT stocks, however, is slow and may be losing ground. Funding of restoration and protection programs is still a limiting factor.

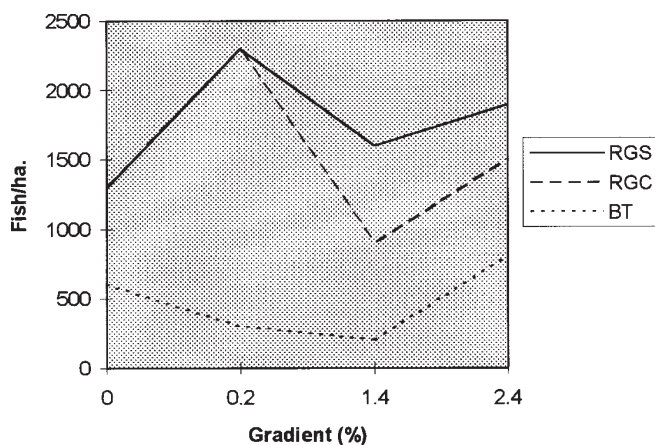


Figure 2—Relative abundance of RGS, RGC and brown trout in the Rio de Las Vacas.

Rio Grande Sucker

In response to the decline of the RGS in the URGES the CDOW initiated a Rio Grande Sucker Recovery Plan partially funded by Great Outdoors Colorado Lottery monies (Kelly 1997). Population and habitat surveys were conducted in Hot Creek, the one remaining stream that contained RGS along with examining streams in New Mexico where RGS are abundant. In 1996 the CDOW captured 200 RGS from the Rio Tusas (CNF) and released them in Medano Creek, which flows into a closed basin where access by non-native fishes is impossible. Prior to RGS being released in this drainage, the CDOW had restored this stream for RGCT. If the transplant of RGS is successful, RGC will be transplanted into this drainage to complete the native fish assemblage. In an effort to create a third population, 54 RGS were transplanted from Hot Creek to San Francisco Creek, a nearby drainage. Identification of suitable reintroduction sites in Colorado is ongoing.

Although the RGS is in general decline in the MRGES of New Mexico it is still considered common and is not afforded any special protection or status by the NMDGF. We speculate, however, that there will be a further decline in RGS in the CNF, tributaries of the Chama River (CNF, SFNF) and in any remaining unprotected drainages emptying into the Rio Grande drainage. Because of the threat of decline, the RMRS continues its efforts to identify remaining populations of RGS in the MRGES and in Rio Grande tributaries of southern New Mexico. The RMRS also has plans to develop population viability models for RGS populations in New Mexico.

Rio Grande Chub

Currently, RGC are not actively managed or afforded protection in New Mexico, however, efforts are being made in the URGES by the CDOW to restock the chub in historic waters. The CDOW continues to search for streams where the native fish assemblage (RGCT, RGS, RGC) can be reintroduced. The RMRS will continue to conduct distributional and habitat surveys to further define the role of RGC in the aquatic ecosystems of the MRGES.

Management Recommendations and Future Conservation Goals

To sustain the native montane fishes of the MRGES we believe management and research should proceed by evaluating the specific requirements of each species and their requirements in the context of the aquatic community. To that end we suggest the following for each species and the aquatic ichthyofaunal community:

Rio Grande Cutthroat Trout

To conserve the Rio Grande cutthroat trout resource, managers of all agencies must have the latest information on this cutthroat subspecies's distribution and status. Distributional and population data for this rare southwestern trout are dynamic. The addition of 7 new populations of

RGCT during the 1994 field season and the confirmation of the Rito de las Palomas and American Creek as pure in 1998 suggests that despite almost two decades of effort toward sustaining this Southwestern cutthroat subspecies, much is yet unknown about its distribution and status. Continued effort toward defining the distribution of this subspecies in New Mexico and Colorado is warranted. Of primary importance is the protection of existing pure stocks of RGCT. Placement and the maintenance of barriers to upstream migration from non-native salmonids, though reducing gene flow among populations, appears to be the only viable method in light of the wide distribution of non-native salmonids in the Southwest. Accordingly, there is an urgent and continuing need to define the extent and degree of impact of introduced salmonids, especially brown, on RGCT. Restoration of streams will be necessary to increase the number of pure populations in the subspecies' former range. Hatchery facilities need to be dedicated to the maintenance of a variety of high quality RGCT genetic strains which can be combined to replicate gene flow that is now not viable in nature due to the lack of connectivity among cutthroat populations. Stocking of non-native trout in watersheds that contain pure populations of RGCT must cease. All too often unknowing fisherman inadvertently stock non-native fishes above barriers not realizing the consequence of their actions. Research to define population dynamics (fecundity, recruitment, age class structure, longevity) is needed to begin to develop population viability analyses to determine the potential long term persistence of pure populations of RGCT.

Rio Grande Sucker

Surveys to identify unknown populations of RGS need to continue. Similar to RGCT, known populations of RGS warrant protection from invasion by the white sucker and non-native salmonids. Instream barriers need to be constructed for tributaries draining to the Rio Grande and Chama River.

While streams within the Jemez drainage are currently safe from intrusion by the white sucker due to Jemez Canyon Dam white sucker may eventually be introduced into this system via bait bucket. Regulations may be warranted to limit any use of non-native bait or to prohibit the use of bait in the Jemez system above the Jemez Canyon Dam. White sucker have been found in the Rio Chama and in its southern tributaries (for example Canones Creek). Here, the only way to prevent white sucker from expanding its range into streams containing RGS would be the placement of barriers. Due to the precarious status of northern populations of RGS protection of populations of RGS in isolated Rio Grande tributaries in southern New Mexico should be considered. Restoration efforts should identify those waters having modest gradients (<2.5 percent) with well developed glide/pool habitat within a mosaic of various habitat types.

Rio Grande Chub

Continued delineation of the distribution of the RGC throughout the MRGES and its entire range is warranted. Monitoring of RGC populations is also necessary to ensure long-term sustainability.

Further, the recommendations suggested for the individual species should be incorporated on a watershed scale. Management or stream renovation of isolated reaches will not be enough to sustain the native fishes of the MRGES. Managing on a watershed scale incorporates a greater diversity of aquatic habitats, thereby increasing ichthyofaunal diversity. Gene flow among various stocks of native fishes is enhanced and the effects of stochastic events is dampened. The Rio de las Vacas (SFNF) of the Jemez River drainage is a watershed that has the potential to be managed on this large landscape approach. Currently, all three native species, along with the native longnose dace, *Rhinichthys cataractae*, occur and are abundant in this drainage. At the lower reaches of the Jemez River the system is protected from intrusion from non-native fishes from the Rio Grande by Jemez Canyon dam. A migrational barrier would have to be constructed at the lower reaches of the Rio de las Vacas and subsequent stream renovations would be needed to remove non-native fishes, primarily brown and rainbow trout. The monetary and logistical costs of this project would be substantial, however the benefits to the sustainability of native fishes would be great.

Conclusions

To sustain native fishes of the MRGES protection of its aquatic habitats and the resultant aquatic community should be the primary goal of any management plan. Future management must address the threats from non-native species identified by this research. Restoring native species to their former range and managing aquatic communities on a watershed scale will address the losses realized over decades of misguided fish introductions and habitat degradation. With additional funding and management plans incorporating these two approaches future persistence of native fishes may be assured.

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