[Colorado Basin]

THESIS

SYSTEMATICS OF NATIVE COLORADO CUTTHROAT TROUT

Submitted by

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ABSTRACT

SYSTEMATICS OF NATIVE COLORADO CUTTHROAT TROUT

Four subspecies of cutthroat trout are presently recognized as indigenous to Colorado's waters: Rio Grande cutthroat trout, Salmo clarki virginalis; yellowfin cutthroat, S. c. macdonaldi, known only from Twin Lakes near Leadville and now extinct; Colorado River cutthroat, S. c. pleuriticus; and the Arkansas and South Platte cutthroat, S. c. stomias.

Introductions of non-native trouts and the mixing of subspecies of cutthroat trout in hatcheries along with alteration and degradation of habitat have led to the decline of the indigenous cutthroat trout of Colorado to the point of virtual extinction as pure populations. Relatively pure populations of the S. c. virginalis exist in the following waters: Trinchera Creek, Costilla County, Colorado; Rio Chiquito, Taos County, New Mexico; Canones Creek, Rio Arriba County, New Mexico; and Indian Creek, Otero County, New Mexico. Cutthroat samples from Douglas Creek, Carbon County, Wyoming; Little West Fork of the Black Fork, Summit County, Utah; North Fork of Beaver Creek and Rock Creek, Sublette County, Wyoming; Cunningham Creek, Pitkin County, Colorado, Northwater Creek, Garfield County, Colorado and the headwaters of the Colorado River, Grand County, Colorado are examples of pure or virtually pure S. c. pleuriticus populations. A pure population of S. c. stomias inhabits Como Creek, Boulder County, Colorado. Populations of predominantly greenback cutthroat trout occur in the Big Thompson River in Forest Canyon of Rocky Mountain National Park, Colorado: Island Lake, Boulder County, Colorado; headwaters of Little South Poudre, Larimer County, Colorado; and the very headwaters of South Huerfano Creek, Huerfano County, Colorado.

Management goals necessary to save and expand the remnant populations of indigenous trout in Colorado should include transplanting fish from pure populations into barren waters, attempts to locate other pure populations and the development of sport fisheries with special regulations to allow a unique angling experience based on pure populations of these rare and beautiful fish.

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Introduction

Four subspecies of cutthroat trout are commonly recognized as indigenous to Colorado's waters. The Rio Grande trout, Salmo clarki virginalis, has nearly vanished in its pure form from the Rio Grande basin of Colorado and New Mexico. The enigmatic yellowfin cutthroat, S. c. macdonaldi, was known only from Twin Lakes. The population of "macdonaldi," whether native or an introduced Colorado River cutthroat became extinct shortly after the turn of the century. The Colorado River cutthroat, S. c. pleuriticus, is known to exist as small, remnant populations in Wyoming, Colorado and Utah. The greenback trout, S. c. stomias, indigenous to the Arkansas and South Platte River systems, is virtually extinct as pure populations.

The taxonomic validity and diagnostic characters of these subspecies have never been established. The original descriptions of the taxa of the trouts of the Rocky Mountains are vague, without valid diagnostic characters and often lacking in authenticated type localities. Original descriptions mentioned only such variable characters as external appearance, body shape, color, and spotting patterns.

The classification of cutthroat trouts was greatly influenced by David Starr Jordan. Prior to 1879, cutthroat trout from each drainage basin was accepted as distinct species (Salmo pleuriticus, S. virginalis, S. stomias, S. spilurus, and S. lewisi). Jordan (1879) suggested all of the cutthroat were varieties of a single species, S. clarki. Jordan and Gilbert (1880) began listing the various described cutthroat trout as subspecies of "S. purpuratus"--a species described from Kamchatka in 1811 by Pallas and erroneously assumed to be a cutthroat trout by Jordan. The name, S. mykiss Walbaum, was applied to the Kamachatkan trout in 1792

giving S. mykiss priority over S. purpuratus. When this fact was recognized by Jordan, he classified the cutthroat trout as a subspecies of S. mykiss as was done in the great work on North American fishes by Jordan and Evermann (1896). Jordan and Evermann (1898) concluded that cutthroat trout did not extend to Kamchatka and the name S. mykiss was not applicable to North American trout. The name S. clarki Richardson was then resurrected for the cutthroat species. Behnke (1966) reviewed the taxonomy and nomenclature of S. mykiss pointing out that the affinities of S. mykiss are with the rainbow trout, S. gairdneri and not S. clarki. Later in his career, Jordan changed his opinion and treated all the described forms of cutthroat trout as full species (Jordan, 1920b). In the checklist of Jordan, Evermann and Clark (1930) 17 species are listed that are more properly considered as subspecies or synonyms of the polytypic species, S. clarki.

The original distribution of the subspecies under discussion is uncertain. Early collecting expeditions often confused records of their collection sites. Subsequent publications have not contributed much new information. Environmental changes and the introduction of non-native species, including the rainbow trout, and the mixing of subspecies of cutthroat trout have made the task difficult.

The genetic diversity of a polytypic species such as Salmo clarki is important to document because many subspecies of this species are rapidly disappearing and it is not only prudent to try to save the remaining diversity of this species for esthetic and scientific purposes but there may be some practical aspects of unique genotypes for application in fisheries management (Behnke, 1972).

Knowledge of the diagnostic characters and location of remnant populations of indigenous trout in Colorado is basic to any plan to save them and increase their numbers.

Methods

Collections were made of suspected pure populations from the Colorado-Green River drainage of Colorado, Wyoming and Utah; the Rio Grande drainage of Colorado and New Mexico; and the Arkansas and South Platte basins of Colorado. Many samples were collected by biologists with state and federal agencies interested in determination of possible pure populations of native trout in their regions. Museum material representing older collections, mainly pre-1900 were examined in order to help clarify original descriptions and to establish diagnostic characters of subspecies prior to the effects of introductions. Selection of collecting sites with the potential of having pure populations was influenced by such factors as size of stream, remoteness, barriers against upstream migration and streams not connected to lakes.

The Colorado Division of Wildlife and its predecessor organizations and federal agencies have stocked cutthroat trout representing all of the native subspecies in addition to non-native subspecies into most of the waters of the state at one time or another during a period of almost 100 years. Samples of cutthroat trout stocks currently propagated in Colorado were obtained and their taxonomic characters analyzed. Also data on a large series of Yellowstone Lake cutthroat were recorded. The Yellowstone cutthroat was widely stocked in the state from 1900 to the 1950's. The range of variability of the typical hatchery rainbow trout was determined. These three sources: cutthroat trout propagated by the Colorado Division of Wildlife, Yellowstone Lake cutthroat (mainly from federal hatcheries) and hatchery rainbow trout are the cause of hybridization which has affected virtually all of Colorado's indigenous trout populations.

Cutthroat specimens were captured mainly by angling. Some were obtained through electro-fishing, gill netting and seining. The fish were immediately placed in a 10% formalin solution. Ionol, a color preservative, and borax, used as a buffing agent, were added to the formalin solution in concentrations of .4% and 1 tsp. per gallon respectively to help maintain the specimens.

Several morphological measurements were recorded and evaluated for their usefulness in distinguishing between subspecies. Hubbs and Lagler (1947) described the procedure for measuring morphological characters. The morphometric characters measured (total length, standard length, head length, upper jaw length, dorsal fin origin to snout tip, dorsal fin depressed length, adipose fin depressed length, caudal peduncle depth and length) did not indicate any significant differences between the subspecies. This data may be useful for comparative purposes in certain aspects of Salmo taxonomy, but for the present study the characters exhibit great natural variation and are susceptible to non-gentic variation and allometry (sex, age, growth rate), and are not included in the presentation of the data. Notes and color photographs were taken of most fresh specimens.

Prior published accounts pertaining to the indigenous trout in Colorado are of little value for recognizing subspecies or serving as a basis for separating one subspecies from another. It was necessary to select from the meristic characters examined in this study and other studies those which have some diagnostic power. The meristic characters counted and compared from the different samples included: pyloric caeca, gill rakers, vertebrae, basibranchial teeth, lateral series scales, scales above the lateral line, pelvic fin rays and right and left branchiostegal rays.

Pyloric caeca counts were made by pulling every complete tip loose from the anterior region of the intestine. Gill rakers were stained with alizarin to expose all rudiments. Counts were obtained from the upper and lower rami of the first gill arch. Vertebrae were counted from X-ray negatives. Each centra was counted including the three centra that function to support the caudal skeleton ("urostyle"). Alizarin strain was used on the basibranchial teeth to facilitate their counting. All teeth located on the basibranchial plate were counted. Two different scale counts were made on the left side of the body. The epidermal covering was removed and malachite green was applied to the scales to facilitate counting. The lateral series count was made by counting the scales two rows above the lateral line from the first scale in contact with the pectoral girdle to the end of the vertebral column (determined by flexing the tail). Scale number above the lateral line was made by counting the scales in an oblique row downward and backward from the anterior base of the dorsal fin to, but not including, the scale in the lateral line. The number of rays in the pelvic fin was taken from the left pelvic fin. Every ray was counted including rays which were unbranched but had completely developed. Branchiostegal ray counts were made from both the right and left sides and included rudimentary rays. A binocular microscope was used to make meristic counts.

Taxonomic evaluation of the specimens was made in the systematics laboratory of the Colorado Cooperative Fishery Unit. Except for the designated museum specimens, all specimens used for analysis are maintained in the Cooperative Fishery Unit collection.

Character Evaluation

In order to determine the magnitude of differences between subspecies of cutthroat trout, distinguishing characters must be established which allows separation of the subspecies. McDowall (1972) reviewed the problems encountered in establishing taxonomic validity and differentiating characters between groups of a morphologically and ecologically plastic, polytypic species. Mayr, (1969) defined a taxonomic character as: "any attribute of a member of a taxon by which it differs or may differ from a member of a different taxon." Within a species or a population of a species variation is normally expected as a manifestation of genetic heterozygosity. For taxonomic purposes, it is important that character variation is largely under genetic influence; that is, differences between two groups are an actual reflection of genetic differentiation. It has been well documented that variation can be induced by environmental conditions, age, and sex. An interaction of genetic and environmental factors control the meristic characters in fish via influence of developmental rates during segmentation of the embryo. The number of segments is determined during a "sensitive period" of embryonic development (Hubbs, 1927). Several environmental factors, such as temperature, light, and dissolved gases and ions can affect the "sensitive period." Environmental (non-genetic) influence on meristic characters has been the subject of many papers such as research conducted by Gabriel (1944), Hubbs (1926), Vladykov (1934) and Taning (1952). These papers largely are concerned with laboratory changes.

In natural populations, however, taxonomic characters are not as readily modified as may be indicated by laboratory experiments. This is due to the fact that all cutthroat trout initiate spawning by common

environmental cues and spawning essentially takes place at similar temperatures in nature for the whole species irregardless of where the population lives. Embryonic development then, occurs under comparable conditions.

Effects of environment on meristic characters

Samples of Yellowstone cutthroat, S. c. lewisi, golden trout, S. aguabonita, Lahontan cutthroat, S. c. henshawi and an undescribed subspecies of cutthroat trout from Nevada, representing parental stocks and introduced populations in a variety of new environments, were compared to evaluate the environmental influence on meristic characters. No such comparison of natural populations from essentially common gene pools exposed to different environments have been published and the following data is the first attempt to evaluate environmental influence under natural conditions (some hatchery raised samples are also included). Tables 1A-D provide the values of some meristic characters from these introduced samples compared with the parental source.

Through the use of the t-test at the 95% confidence limit, small, but significant differences are evident in some of the characters between the populations of a given genotype. Despite the large magnitude of intrapopulational variability in some characters such as basibranchial teeth and pyloric caeca, the ranges and mean values remained relatively stable for a given genotype established in a new environment for many generations. Some notable exceptions occurred which call for interpretation. The basibranchial tooth count of Yellowstone Lake cutthroat in South Gap Lake is significantly higher than in the parent stock ($X=33.9$ Range=13-60 $dF=24$, $t=2.1841$ significant). South Gap Lake, located in the Snowy Range of Wyoming at an elevation of 11, 000 feet, provided an

Table 1A Comparisons of parent stock and derived populations of Yellowstone Lake cutthroat trout

Source	Number of specimens in parentheses Vertebrae range and mean	df,t	Gill Rakers range and mean	df,t	Pyloric Caeca range and mean	df,t
Yellowstone Lake (Parent stock) Wyoming	(64) 60-63 61.6		(31) 18-23 20.6		(31) 31-51 41.2	
Montana hatchery[1] brood stock	(15) 61-63 62.0	21 2.0671 N.S.	(15) 18-22 20.2	29 0.0000 N.S.	(15) 30-42 36.6	34 -3.5223 S.
South Gap Lake Wyoming	(9) 60-63 61.2	9 -0.7917 N.S.	(17) 18-21 20.2	39 0.0000 N.S.	(18) 37-51 42.6	40 0.9898 N.S.
Lower Pipestone Lake Wyoming	(9) 61-63 61.8	12 1.2219 N.S.	(9) 20-22 21.1	25 3.2015 N.S.	(9) 33-49 39.1	12 -1.1449 N.S.
Lake Victor Wyoming	(15) 60-63 61.6	21 0.3889 N.S.	(10) 19-21 20.4	13 1.0714 N.S.	(10) 31-46 39.0	18 -0.8843 N.S.
South Park Wheatfield Crk. N.M.[2]	(10) 60-63 61.3	11 -0.6296 N.S.	(17) 19-23 21.1	35 2.7878 S.	(17) 32-41 37.4	45 -3.3923 S.

[1]Hatchery brood stock maintained for 15 years
[2]Uncertain history of introductions, known introductions of rainbow trout.

N.S. Non significant
S. Significant

Table 1A (cont.)

Source	Scales abv. lat. line range and mean	df,t	Scales lat. ser. range and mean	df,t	Basibranchial teeth range and mean	df,t
Yellowstone Lake (Parent stock) Wyoming	(16) 37-46 40.6		(16) 161-187 179.2		(33) 9-46 24.0	
Montana Hatchery	(15) 37-42 39.3	24 -0.9871 N.S.	(15) 156-175 164.7	28 -5.4467 S.	(15) 15-30 21.3	45 -1.3409 N.S.
South Gap Lake Wyoming	(10) 39-45 42.0	23 1.9723 N.S.	(14) 144-193 174.0	21 -1.3971 N.S.	(17) 13-60 33.9	24 2.1841 S.
Lower Pipestone Lake Wyoming	(9) 39-46 42.2	22 2.2164 N.S.	(9) 161-191 175.7	12 -0.8625 N.S.	(9) 7-33 21.3	11 0.0224 N.S.
Lake Victor Wyoming	(10) 41-47 44.2	23 4.3637 S.	(10) 163-204 181.3	14 0.5141 N.S.	(10) 5-31 15.9	15 -1.9995 N.S.
South Pork Wheatfield Crk. N.M.	(9) 40-45 42.3	21 2.2460 N.S.	(10) 170-191 181.0	20 0.6358 N.S.	(18) 7-38 19.3	39 -1.6198 N.S.

Table 1B Comparisons of parent stock and derived populations of California golden trout S. c. aguabonita

Source	Number of specimens in parentheses Vertebrae range and mean	df,t	Gill Rakers range and mean	df,t	Pyloric Caeca range and mean	df,t
South Fork Kern R. (Parent stock) California	(67) 58-62 59.5		(15) 17-21 19.1		(17) 24-36 28.5	
Cottonwood Crk. California	(41) 58-61 59.7	48 1.7984 N.S.	(24) 18-22 20.0	31 2.7289 S.	(9) 28-36 30.8	22 1.8621 N.S.
Pyramid Lake Wyoming	(16) 57-59 58.0	26 -5.6153 S.	(20) 18-21 19.5	33 1.1056 N.S.	(18) 21-31 27.2	29 -1.1746 N.S.
Ed's Lake Wyoming	(14) 58-61 59.4	21 0.3996 N.S.	(10) 18-22 20.0	16 1.8254 N.S.	(10) 23-30 26.5	25 -1.8109 N.S.
Alpine Lake Wyoming	(10) 57-59 57.4	12 -4.7019 S.	(10) 17-20 18.8	21 -0.7753 N.S.	(10) 20-36 26.0	16 -1.4798 N.S.
Surprise Lake Wyoming	(12) 58-60 59.1	20 -0.9013 N.S.	(12) 17-21 19.0	20 -0.2227 N.S.	(12) 23-33 28.1	26 -0.3143 N.S.
Sally Keyes Lake California	(22) 58-61 59.4	66 2.0966 S.	(32) 18-20 18.7	23 -1.3802 N.S.	(17) 21-33 26.8	32 -1.2385 N.S.

N.S. Non significant
S. Significant

Table 1B (cont.)

Scale abv. Lat Line range and mean		df,t	Scales Lat. Ser range and mean	df,t
South Fork Kern R., California (Parent stock)	(9) 38-43 39.9		(14) 151-182 178.0	
Cottonwood Crk. California	(13) 35-43 40.2	20 -.3313 N.S.	(21) 156-214 190.8	33 2.9800 S.
Pyramid Lake Wyoming	(7) 40-48 44.6	11 4.2488 S.	(15) 178-217 198.9	27 5.3625 S.
Ed's Lake Wyoming	(10) 40-47 44.7	15 -4.6451 S.	(10) 180-200 190.5	22 3.6654 S.
Alpine Lake Wyoming	(10) 38-45 40.9	17 -1.0200 N.S.	(10) 162-205 182.1	15 0.6867 N.S.
Surprise Lake Wyoming	(12) 38-42 40.0	14 -0.1346 N.S.	(12) 168-220 185.6	19 1.4144 N.S.
Sally Keyes Lake California	(14) 34-42 39.1	19 -0.9582 N.S.		

Table 1C Comparisons of parent stock and derived populations of an undescribed subspecies of cutthroat trout from White Pine County, Nevada

Source	Vertebrae Range and mean	df,t	Gill Rakers Range and mean	df,t	Pyloric Caeca Range and mean	df,t
	Number of specimens in parentheses					
Pine Creek (parent stock)	(15) 60-64 62.2		(20) 19-25 22.0		(20) 25-41 33.6	
Hampton Creek	(9) 60-63 61.6	18 -1.6277 N.S.	(22) 20-23 21.0	35 -2.3781 S.	(21) 28-39 33.7	32 0.0000 N.S.
Goshute Creek	(18) 61-64 62.3	67 0.3487 N.S.	(21) 17-22 20.0	36 -4.4933 S.	(21) 32-45 36.4	34 2.3043 S.

Source	Scale abv. Lat Line number, range and mean	df,t	Scales Lat. Ser. number, range and mean	df,t	Basibranchial Teeth number, range and meand	df,t
Pine Creek	(20) 33-46 38.9		(20) 120-176 147.0		(20) 8-50 27.3	
Hampton Creek	(22) 35-45 38.4	38 1.1959 N.S.	(22) 136-162 150.4	28 1.0795 N.S.	(22) 5-47 28.6	38 0.3841 N.S.
Goshute Creek	(21) 26-45 39.0	36 0.103 N.S.	(21) 135-162 144.0	32 -0.9138 N.S.	(21) 8-40 28.6	36 0.2872 N.S.

N.S. Non significant
S. Significant

Table 1D Comparisons of parent stock and derived populations of Lahontan cutthroat trout, S. c. henshawi

Source	Number of specimens in parentheses Vertebrae range and mean	df,t	Gill Rakers range and mean	df,t
[1] Heenan Lake California	(9) 59-62 60.8		(28) 20-26 23.0	
[2] Lily Pad Lake California	(21) 60-62 61.4	11 1.7215 N.S.	(21) 21-24 22.6	15 -1.2250 N.S.
Verdi Hatchery Nevada			(18) 21-23 22.1	13 -2.7477 S.
Haegemann Hatchery Idaho			(75) 20-25 22.8	40 -0.6605 N.S.

[1] Parent stock, hatched at Hot Creek Hatchery, California

[2] From Alpine Hatchery, California

N.S. Non significant
S. Significant

unusual environment. A short growing season occurs at this altitude and a much longer life span is noted in this Yellowstone cutthroat population. The specimens examined from South Gap Lake were 10-11 years of age which was verified by known stocking records and otolith aging. According to Bulkey (1961) the maximum age of the cutthroat in Yellowstone Lake is 6-7 years. Since the fish in South Gap Lake were stocked as yolk-sac fry a slight influence on the meristic characters could be a result of the hatchery environment. However, basibranchial teeth increase in number during early ontogeny until the size of the fish is 70-100 mm or more. Evidently the slow growth of Yellowstone cutthroat trout in South Gap Lake resulted in prolonged development and higher ultimate numbers of basibranchial teeth.

Although major differences occur in the gill raker number in the samples from Pine Creek (parent stock) and derivative populations in Hampton and Goshute Creeks (X's: 22.0, 21.0, 20.0 respectively) the new populations were established from a few adult trout planted into tiny barren streams and are likely examples of the "founders principle" (Mayr, 1963) whereby the founder of a new population is not representative of the modal values of the parental stock but is from more extreme examples of the normal range of variability.

One specimen of each of the samples of S. aguabonita from Ed's Lake and Pyramid Lake, Wyoming, had a single basibranchial tooth--a character not found in the parent stock. This is evidence that a slight introgression with cutthroat trout has occurred in these populations and some of the other character variability may be attributable to this influence.

Hybrids can be detected in populations by noting the meristic characters. Usually hybrids have intermediate values between the two

parents depending on the degree of hybridization but intermediate values are not uniformly expressed for all characters. Table #2 presents typical meristic numbers found in rainbow trout and hybrids between S. gairdneri and S. clarki pleuriticus.

Table 2 Recognizeable effects of rainbow trout hybridization on cutthroat trout populations

Trout	Vertebrae	Gill Rakers	Pyloric Caeca	Lat Ser Scales	Scales abv. Lat Line	Pelvic Fin Rays	Basibran. Teeth
Typical Rainbow Trout (*S. gairdneri*)	62-65 63±1	18-21 19-20	40-70 50-60	120-240 125-130	24-30 26-28	10	Absent
Typical Colorado River cutthroat (*S. c. pleuriticus*) composite of samples	60-63 61.2	18-21 19.0	30-40 35.0	150-200 180.0	40-50 43.0	9	Present
Rainbow-cutthroat hybrids:							
Home Creek tributary Green River Wyoming	61-63 62.0	19-21 19.6	31-42 36.5	148-187 168.6	31-42 38.0	9-10 9.5	Present in 3 of 8
Beaver Creek tributary Green River Moffat Co. Colorado	60-62 61.3	16-20 18.3	30-49 39.1	165-202 183.1	38-47 41.5	9-10 9.4	Present in 8 of 15
E. Middle Fork of Parachute Creek Garfield Co. Grand Valley, Colorado	60-61 61.5	17-21 18.9	24-42 34.0	160-183 169.2	44-54 47.4	9-10 9.4	Present in 8 of 20

Historical Review

Rio Grande cutthroat trout, S. c. virginalis

Coronado's expedition to the New World in 1539 made reference to the Rio Grande cutthroat trout. The expedition found that: "There were very good trout in the upper Pecos River" (Rostlund, 1952: 25). Not much new information on the trout native to the Pecos drainage of the Rio Grande basin has emerged since Coronado's time.

The type locality of the Rio Grande cutthroat trout, S. c. virginalis is Ute Creek, Colorado. The U.S. army established Fort Massachusetts on Utah Creek (now Ute Creek) in Costilla County, Colorado in 1852. Ute Creek eventually flows into the Rio Grande in the San Luis Valley. It flows westward from the Sangre de Cristo Mountains, joining Sangre de Cristo Creek, which is tributary to Trinchera Creek. In 1853, the first collection of Rio Grande trout was made by a Pacific Railroad Survey expedition from Ute Creek at Fort Massachusetts (called "Utah Creek" in original description). Girard (1856) examined these specimens and described a new species, "Salar virginalis." Fort Massachusetts was abandoned in 1858 and Fort Garland established six miles to the south and nearer to Sangre de Cristo Creek. Collections of Rio Grande trout were later made from near Fort Garland and were examined by Cope who described a new species "Salmo spirulus" (Cope, 1872). The locality for the type specimens of spilurus was "Sangre de Cristo Pass," probably Sangre de Cristo Creek. Cope had known of Girard's description of virginalis from Ute Creek, but at that time the typological concept and criteria for species was prevalent in taxonomy and Cope thought that spilurus was a valid species because it was: "not so slender as virginalis." Cope also believed that another species, "S. pleuriticus," (Colorado River cutthroat) lived in the Rio Grande basin near the Fort

Garland area (Cope and Yarrow, 1875). Confusion of the type locality of virginalis caused later authors to consider "Utah Creek" as a tributary to Utah Lake (Bonneville Basin cutthroat trout) and the name spilurus was used for the Rio Grande cutthroat trout while virginalis was applied to the Bonneville basin trout until Jordan (1920 b) and Snyder (1921) corrected the error.

The original range of the Rio Grande trout is unknown. Cope (1886) mentioned two "black-spotted" trout with "teeth on the basihyal bone," from southern Chihuahua, Mexico. Jordan and Evermann (1896) assumed Cope's specimen came from the Rio Grande basin and gave the range of "spilurus" to Chihuahua, Mexico. Unfortunately, the fate of Cope's specimen and their exact collection locality is unknown. Cope listed the locality as: . . . "streams of the Sierra Madre, at an elevation of 7,000 and 8,000 feet, in the southern part of Chihuahua near the boundaries of Durango and Sinaloa." His site could be in the Rio Conchos drainage, tributary to the Rio Grande in Chiuahua, or possibly streams flowing west into the Gulf of California. Trout collections from around the Gulf of California have been discussed by Needham and Gard (1959) from various Pacific Coast streams (Rio Fuerte, Rio Sinaloa, and Culiacan) but no trout have been reported from the Rio Conchos.

Needham and Gard (1964) described a distinctive golden trout from tributaries of the Gulf of California, Salmo chrysogaster. This trout does not appear to be derived from or closely related to the Rio Grande cutthroat. Cope had mentioned basihyal teeth (basibranchial) indicating that these specimens were true cutthroat and not the trout from the Pacific drainage of Chihuahua. No further evidence of cutthroat trout occurring in Mexico is known. Miller (1972) mentioned late Pleistocene fossil vertebrae from Lagode San Marcos, Mexico, which are similar to S. clarki vertebrae.

The occurrence of native trout in Texas has never been authenticated according to Clark Hubbs (1957). Presently, one stream, McKittrick Creek in the Guadalupe Mountains, contains the only population of self-reproducing trout in Texas, and they are introduced rainbow trout. Old reports contain stories of native trout existing far outside the present distribution. Daniel (1878) related his fishing experience in a letter to Forest and Stream. While working as Assistant Surgeon in the Second Texas Rifles during the Civil War, Daniel thought he remembered fishing for trout at San Felipe Spring, a tributary to the Rio Grande near Del Rio on the Mexican border. Daniel has a "distinct recollection" of catching "speckled trout" from Devil's River near Fort Hudson. Devil's River is a tributary of the Rio Grande located in Val Verde County. While stationed at Fort Davis Daniel recalled catching many trout from the Limpia River (tributary of the Pecos River, Jeff Davis County). While serving at Fort Stanton, he observed trout in the Rio Bonito, a tributary of the Pecos River, Lincoln County, in southern New Mexico. Daniel had lived in New Haven, Connecticut, and was acquainted with the eastern brook trout Salvelinus fontinalis. He believed the trout he caught in Texas and New Mexico were also brook trout.

Further information of earlier trout collections in Texas was supplied by Taylor (1878) in a note to Forest and Stream. Taylor wrote that Dr. D. I. Hunter, a Confederate Army Surgeon, stationed at Fort Davis on the Limpia River, thought eastern brook trout (Salvelinus fontinalis) inhabited the Limpia River. The Limpia was described as a clear, cool, sparkling stream with an elevation of near 5,000 feet. Taylor also recalled a story from a buffalo hunter. The hunter recollected catching "wagon loads" of "speckled trout" in the Texas Panhandle from streams of the Canadian and Red Rivers. Taylor verified the story

with a D. S. Hinkle who worked with Emory's Boundary Survey in the Panhandle area. At that time the Texas Panhandle extended into part of the present day New Mexico. The former part of Texas located in the Canadian River basin contained habitat suitable for trout. However, the existence of trout in the Red River basin must be considered highly dubious. Johnson (1880) noted in Forest and Stream that he didn't believe that trout existed in Texas. He stated: "There may be genuine trout in Texas, but if so they are very far from the limits of civilization for I have fished Texas waters since 1848 and never saw a speckled trout other than what is called in the South 'Salt water trout' and in the North, 'weak fish.'"

The existence of native trout in the Canadian River system has not been clearly established. An article in Forest and Stream by an anonymous author (1877) signing himself as "Apache" mentioned that Rio Grande cutthroat trout were abundant . . . "at the headwaters of the Vermejo." Colorado Division of Wildlife records do not list any stream named Vermejo in the Rio Grande basin and the reference most likely refers to the Vermejo River in the Canadian River Basin of New Mexico. Fowler (1912) listed the locality of ancient specimens of cutthroat trout in the collection of the Philadelphia Academy, as: . . . "Ute Creek, Fort Garland, a tributary of the Canadian River, New Mexico." But, he was almost certainly referring to specimens collected at Ute Creek, Fort Garland, Colorado. A fish survey by the New Mexico Department of Fish and Game in the Canadian River basin from 1953 to 1956 listed the presence of many excellent trout streams in the headwater tributaries of the Candaian River in the Sangre de Cristo Mountains. Biologists of the New Mexico Fish and Game Department examined the streams and found introduced brown, brook and rainbow trouts inhabiting most of these streams but the reports stated: . . . "native cutthroat still dominate most of the upper most headwaters." The term

"native trout" is typically used to denote cutthroat trout in general, without reference to indigenous or introduced. The report did mention that extensive introductions of cutthroat trout (mostly Yellowstone Lake stock) have been made in the Canadian River basin since at least 1907 and it is not known if cutthroat trout were present before man's activities. A recent specimen collected in 1971 from the headwaters of the Vermejo River in Costilla County, Colorado is a typical rainbow-cutthroat hybrid. The upper Canadian and Pecos basins share several fish species in common and natural headwater transfer may have occurred. If trout were native to the Canadian River they would be expected to be similar to the S. c. virginalis native to Pecos basin. At present, however, the evidence that trout naturally occurred in the Canadian River basin is inconclusive. There are no known authentic records or actual preserved specimens collected before introductions occurred.

Indian Creek, a small stream on the west slope of Sierra Blanca Peak, tributary to the White Sands desiccating basin in Otero County, New Mexico (Tularosa Basin), has recently been found to represent the southernmost population of Rio Grande cutthroat trout (Behnke, MS 1967). Indian Creek is a tributary to Three Rivers whose waters disappear in the desert of the Tularosa Valley, an independent desiccating basin now isolated from the main Rio Grande. The stream system draining westward from Sierra Blanca Peak (Rio Bonito) is tributary to the Pecos. In the Late Pleistocene the Tularosa Valley contained a large lake and was probably a tributary to the Rio Grande (Hubbs and Miller, 1948). Due to the topography and steep gradient it is doubtful that the present population is a natural occurrence from the Tularosa basin, but more likely carried over from the Pecos basin by man from the other side of Blanca Peak. The large, sparse spots resemble museum specimens of Pecos cutthroat more than they do the S. c. virginalis

of the Rio Grande: The Indian Creek population may be the only known pure stock of Pecos cutthroat.

The Rio Grande cutthroat has existed in a drainage basin with two major segments long isolated from each other by waters barren of trout. Due to this natural isolation between the Pecos and Rio Grande cutthroat populations, independent evolution and some genetic divergence should be expected. Koster (1957) stated that there is a greater similarity of fish species between the upper Pecos River and the Canadian River system than there is between the Pecos River and the upper Rio Grande. Pecos basin trout are rare in museum collections. The University of Michigan Museum of Zoology collection contains a few Pecos basin trout and these specimens appear to differ from the typical upper Rio Grande virginalis by having fewer and larger spots. Presently, Indian Creek is the only location which is assumed to have a pure population of the Pecos basin cutthroat. Their meristic characters suggest close relationship to the typical virginalis.

The native trout of the Rio Grande most likely originated from the Colorado River and/or Arkansas River drainages. Jordan and Evermann (1896) believed the sequence of origin was the South Platte-Arkansas stomias giving rise to Rio Grande virginalis which in turn gave rise to pleuriticus of the Colorado basin. This was based on the erroneous assumption that cutthroat trout once extended down the Missouri River to the Platte (actually the Yellowstone River is the most downstream natural occurrence of cutthroat trout in the Missouri drainage). The sharp escarpment of the Sangre de Cristo Range in Colorado, separating the Arkansas and Rio Grande drainages would suggest that headwater stream transfer more likely occurred from the Colorado drainage into the Rio Grande. Both S. c. pleuriticus and S. c. stomias are big spotted

cutthroat trout. The spotting pattern of the Pecos River virginalis appears more similar to pleuriticus and stomias than does the virginalis of the main Rio Grande basin.

Yellowfin cutthroat trout of Twin Lakes, S. c. macdonaldi

During D. S. Jordan's collecting trip to Twin Lakes, Colorado, in 1889, besides several specimens of the greenback cutthroat trout, a silvery trout with smaller spots was also collected. Jordan and Evermann (1890) described this trout as the yellowfin cutthroat trout, "Salmo mykiss macdonaldi." Understanding the more typological approach to taxonomy and some of Jordan's errors with cutthroat trout systematics, it would be logical to assume that only a single form of cutthroat trout was indigenous to Twin Lakes. Jordan could have based his description of macdonaldi on an abberant color phase of S. c. stomias. However, comparative examination of 7 specimens of S. c. macdonaldi (believed to be the total number of existing specimens of this taxon) and eight specimens of S. c. stomias all collected on July 25-26, 1889, from Twin Lakes, leaves little doubt that Jordan's collection of trout from Twin Lakes consisted of two distinct and reproductively isolated groups of cutthroat trout. If the yellowfin was indigenous to Twin Lakes or introduced by man, perhaps from the Eagle River, is not known, but some temporal and or spatial separation during spawning must have provided natural isolation between the two distinct populations of cutthroat trout.

The first mention in the literature of the "yellowfin" trout in Twin Lakes is in the Biannual Report of the Colorado Fish Commission for 1885-1886. Hallock (1877) stated that the fishing at Twin Lakes was only "tolerably good." Hallock mentioned only small trout were

taken from Twin Lakes. He stated that by backpacking a short distance from Twin Lakes and following the Arkansas River up to its origin at Tennessee Pass, much larger fish could be caught in the headwaters of the Eagle River. The possibility exists that someone carried the Eagle River cutthroat trout over Tennessee Pass to Twin Lakes during the 1870's or earlier. Jordan (1891) described a specimen of S. c. pleuriticus from the Eagle River near Gypsum, Colorado, and concluded it looked very similar to the yellowfin trout of Twin Lakes (small spots, silvery color). No sample from the Colorado drainage since Jordan's collections from the Eagle River has produced evidence of a yellowfin type of cutthroat trout. Recent investigations of cutthroat populations in the headwaters of the Eagle River produced mostly rainbow and cutthroat hybrids with large spots. The origin and taxonomic validity of S. c. macdonaldi likely will never be known.

Introductions of rainbow trout had occurred in Twin Lakes prior to 1889. Examination of Jordan's collection of 1889 from Twin Lakes showed evidence of hybridization. Two of three specimens from the U.S.N.M. collection #76061 are definitely rainbow-cutthroat hybrids.

Juday (1906) sampled the fish population in Twin Lakes in the summers of 1902 and 1903 and concluded rainbow trout made up the largest percentage of trout. No yellowfin cutthroat trout were found and Juday (1906) assumed this trout was extinct. However, the Report of the United States Commissioner of Fisheries of 1905 mentioned yellowfin trout were still being artificially propagated in the Leadville hatchery near Twin Lakes. It is not known whether these trout propagated as yellowfin were hybrids or "pure" macdonaldi. After 1905 no further mention of yellowfin cutthroat is found in the United States Fisheries Commissioner Reports and no additional specimens were ever collected. The greenback cutthroat trout in Twin Lakes soon followed the yellowfin trout into oblivion.

S. c. pleuriticus, Colorado River cutthroat trout

Cope (1872) described "Salmo pleuriticus" in Hayden's Geological Survey of Wyoming. Cope's interpretation of pleuriticus actually comrised a composite of specimens from both the upper Missouri drainage and from the Green River, near Fort Bridger, Wyoming, and streams in Idaho and Montana of the Columbia River basin. Cope did not designate a type specimen. The basis of recognition was a "cranial keel" which was almost certainly an artifact due to preservation which forced an elevation of the juncture of the frontal bones on the surface of the skull. However, the name pleuriticus is the first published name available for Green River (Colorado River Basin) cutthroat trout.

Since Cope's inadequate description, little useful information has been added to the taxonomy of the Colorado basin cutthroat trout. Jordan (1891) provided some notes on coloration, spotting and scale counts that have been repeated to the present day to serve to diagnose this subspecies. The great geographical separation of native trout distribution between the upper Green River drainage and the main Colorado basin, would suggest considerable natural variability in this subspecies (Behnke, MS, 1970.) Several samples of isolated populations from the Green River basin of Wyoming closely agree in their meristic characters. A diagnosis of S. c. pleuriticus based on evaluation of consistant meristic values and the spotting and coloration from these samples was attempted.

Most samples from the main Colorado drainage, in Colorado exhibit large variability. Hybridization has probably influenced virtually all cutthroat trout populations in the main Colorado drainage and adequate comparisons with the Green River populations is difficult. Only three populations of relatively pure pleuriticus were found in tributaries of the main Colorado River and thus no statement on the degree of divergence between the Green River and the main Colorado can be made with authority.

S. c. stomias, Arkansas and South Platte cutthroat trout

In 1856 W.R. Hammond, M.D. with a U.S. Army expedition under the command of Lt. F.T. Bryant collected two trout specimens on a round trip journey from Ft. Riley, Kansas, to Fort Bridger, Wyoming. The collection site of the specimens is not known. The specimens were labeled only Ft. Riley, Kansas, and shipped to the Philadelphia Academy of Natural Science. The expedition traversed parts of the Kansas, Platte and Green river drainages in Kansas, Colorado and Wyoming. At that time the only river systems containing trout were the Green River, (S.c. pleuriticus), and the South Platte River drainage in Colorado. The expediton came down the Cache la Poudre River to the South Platte on the return trip. The Poudre River, at that time, had an abundant population of cutthroat trout. An article on trout in the Rocky Mountains signed "B" in Forest and Stream (Anon., 1878) called the Cache la Poudre River "the trout stream par excellance" in northern Colorado.

After examining these specimens at the Philadelphia Academy of Natural Science, Cope (1865) listed these specimens as "Trutta lewisi" (Girard) and the locality as the Kansas River. Later, Cope (1871) described a new species, Salmo stomias based on these two specimens, but gave the type locality as the "South Platte River, Ft. Riley, Kansas." The only "distinguishing" characters listed in the original description by Cope was 42 scales above the lateral line and a "large mouth." Cope and Yarrow (1875) changed the locality to the Kansas River, Fort Riley, and added further confusion when they concluded that several trout "species" lived together in Colorado's waters such as stomias, pleuriticus, virginalis, and spilurus. The native South Platte trout was listed as S. pleuriticus by Cope in later publications and he maintained that the type locality of stomias was the Kansas River. Jordan and Gilbert (1883) extended the range of stomias to include the Upper Missouri and the Kansas River.

Jordan and Evermann (1896) assumed that cutthroat trout moved freely down the Missouri River and up the Platte River. This assumption was in error. Evermann and Cox (1896) investigated the Black Hills area and found it barren of trout. Jordan (1891) pointed out that trout did not occur within 500 miles of Fort Riley, Kansas, and assumed that the type locality of stomias was the South Platte River of Colorado. Jordan was the first author to use the common name of "greenback" trout for S. c. stomias.

Fowler (1912) listed ancient cutthroat specimens catalogued in the Philadelphia Academy of Science as "S. stomias" which presumably are specimens identified and labeled by Cope. Besides the two types from "Kansas," other specimens were from the St. Vrain River, Colorado, and Ute Creek, ("Fort Garland, tributary of the Canadian River, New Mexico.") Undoubtedly the last reference is to specimens collected from Ute Creek at Fort Garland, Colorado, from which S. c. virginalis was named. The Ute Creek in the Canadian River basin referred to by Fowler is a major tributary to the Canadian River basin in New Mexico. It flows more than 100 miles at an elevation between 6,000 and 4,000 feet. No authentic record of trout, native or introduced, has been found for this river system. According to a job completion report on the Canadian River prepared by the New Mexico Department of Fish and Game (1956), this Ute Creek supports only warm water species. Fowler's note on the ancient specimens, indicated that Cope applied the name stomias to specimens from the South Platte drainage (St. Vrain River) and the Rio Grande basin (Ute Creek), although Cope did not state this in any publication.

The actual situation becomes clearer due to the assistance of Dr. James Boehlke, curator of fishes at the Philadelphia Academy of Science. Dr. Boehlke checked the three collections listed by Fowler as stomias.

Philadelphia Academy numbers 7825 and 7826 are the original two specimens collected by Dr. Hammond in 1856. The original "Trutta lewisi" label by Cope (1856) is in the bottle but lewisi has been crossed out and "stomias Cope" written above it. The label further states: "Ft. Riley, Kansas, Dr. Hammond." Evidently, Dr. Hammond sent another specimen of cutthroat trout from the 1856 expedition. It is number 14869 in the Philadelphia Academy collection and the label simply says "Hammond." Cope did not mention this specimen in his description.

Numbers 18985-87 are the specimens that Fowler (1912) listed as being from "Ute Creek, Fort Garland, Canadian River, New Mexico." The oldest label of this collection obtained by the Wheeler Survey is of "U.S. Engineer Department, Exploration west of the 100th Meridian, Ute Creek, Camp Garland, July 30, 1872, collectors Cope and Shedd." Comparing collection sites and dates of the Wheeler Survey leaves no doubt that these specimens listed as stomias by Fowler (1912) and probably identified as such by Cope, are Rio Grande cutthroat trout (topotypes of virginalis).

St. Vrain specimen number 20453 included a label stating "Trout, N. Fk. St. Vrain," which the museum register says was donated by Cope.

Dr. R. R. Miller, University of Michigan, examined the type specimens of stomias. In a letter to Dr. Behnke, Miller stated that he counted only about 150 scales in the lateral series of these trout, but pointed out that the specimens are in poor condition and accurate counts were impossible. As mentioned previously, Cope apparently had specimens from the St. Vrain (South Platte), Ute Creek (Rio Grande) plus the two specimens collected by Hammond in 1856, which could have been from the South Platte or the Green River drainages, all considered as stomias. The possibility exists that Cope or an

assistant at the Philadelphia Academy may have mixed specimens to the extent that the types (7825, 7826) are not Hammond's specimens, but trout from another collection. Of the subspecies of western cutthroat trout, only Rio Grande, S. c. virginalis and Bonneville, S. c. utah, commonly have scale counts as low as 150.

The original range of the greenback cutthroat included only the South Platte and Arkansas River basins. Populations probably existed only in the mountains and foothill region of these river systems. All evidence points to the fact that trout were not native to the North Platte drainage (Land, 1913, Jordan, 1920a).

Variability and diagnosis of S. c. virginalis

Distinguishing characters of the Rio Grande cutthroat, S. c. virginalis are not sharply set off from other subspecies of S. clarki. Mean and modal values of a complex of characters from a sample of a population however, can provide an evaluation of relative purity and particularly the presence of hybridization with rainbow trout can be detected. Adequate museum material representative of populations before introductions is lacking for S. c. virginalis, but samples from several disjunct localities in the Rio Grande basin were compared for their degree of homogeneity. Some samples revealed a high degree of similarity and can be assumed to represent a valid approximation of the original genotype of S. c. virginalis (upper Rio Grande drainage). As with S. c. pleuriticus, two distinct types of virginalis based on spotting and coloration were historically reported from the Rio Grande drainage system (Anon. ["Apache"], 1877: Jordan, 1891; Land, 1913; Ellis, 1914). No specimens of the fine-spotted, silvery trout were encountered in the present study and their reality, as a distinct genotype, is doubted. Presumably the early reports were based on polymorphism associated with age and environment. There is likely some significant geographical variation in S. c. virginalis due to the complete and probably long duration of isolation between populations indigenous to the Rio Grande proper and to the Pecos River basin and the possibility that trout were native to the headwaters of the Canadian River basin.

Specimens from Trinchera Creek on the Forbes Trinchera Ranch Costilla County, Colorado, essentially represent a pure cutthroat population from the upper Rio Grande basin. As mentioned above, Ute Creek, the original type locality of virginalis, is a tributary of Trinchera Creek. The

Rio Chiquito, Taos County, New Mexico, a tributary of the middle Rio Grande in New Mexico and Canones Creek, a tributary of the Rio Chama of the middle Rio Grande in Rio Arriba County, New Mexico, maintain relatively pure cutthroat populations (Table 5). The differences in the number of vertebrae and pyloric caeca between the Trinchera Creek, Rio Chiquito and Canones Creek populations can be attributed to slight genetic divergence from the upstream populations during a long period of isolation.

The sample from Indian Creek, Otero County, New Mexico, is probably a pure population of Pecos drainage cutthroat. This site is an isolated stream in the Tularosa dessicating basin, Otero County, New Mexico (Hubbs and Miller, 1948). As mentioned previously, Indian Creek was likely stocked by man from the headwaters of the Rio Bonito a nearby tributary of the Pecos River on the east slope of Sierra Blanca. This sample and notes on UMMZ collections 113543 and 118194 of Pecos River and Canadian River cutthroat are the only indication of the characteristics of native Pecos cutthroat. Larger and fewer spots were noted on these collections, but meristic counts are sufficiently similar to the upper Rio Grande cutthroat trout that there is no justification to suggest taxonomic separation. Table 5 represents information on samples of cutthroat trout from the Rio Grande drainage. Indian and Rio Seco Creeks in Costilla County, Colorado, appear to have relatively pure populations of upper Rio Grande cutthroat. However, the absence of basibranchial teeth in 5 of 33 specimens collected from these localities may indicate a slight rainbow trout introgression that is not apparent in other characters. Rio Grande cutthroat trout, in general, have fewer and smaller basibranchial teeth.

than is typical of other subspecies of S. clarki. Other meristic characters are nearly identical to Trinchera Creek cutthroats and provide a good character diagnosis of S. c. virginalis from near the type locality.

Haypress Lake near Creede, Colorado, is the source of cutthroat trout eggs for the Southwest Region of the Colorado Division of Wildlife. The lake was constructed in 1924 and has been used by both federal and state hatcheries as an egg source of "native trout." Natural reproduction does not occur at Haypress Lake. The substation at Creede was constructed in 1930 by the United States Bureau of Fisheries to artificially propagate cutthroat trout and other species. The Haypress Lake stock was maintained by reintroduction from the Creede hatchery and there is a good possibility that each year class reintroduced from the hatchery was from a different or mixed source.

By 1931, Yellowstone Lake cutthroat were transferred to the hatchery along with cutthroat eggs from private sources of unknown genotype. Lahontan cutthroat trout, S. c. henshawi, and rainbow trout were also handled by the Creede substation. Many possible combinations may have played a role in determining the present genotype of the stock maintained at Haypress Lake. The range of variability found in the meristic characters suggest a "heterozygous" genotype. Some high vertebral numbers and low scale counts are evidence of rainbow trout influence in the brood fish presently inhabiting Haypress Lake. The influence of the Yellowstone cutthroat genotype is probably manifested in the basibranchial teeth count (16.4). In any event, the Haypress Lake cutthroat, currently being propagated as "native" trout in the Rio Grande basin by Colorado can not be considered as a typical representative of S. c. virginalis.

The upper Rio Grande cutthroat can be characterized with the following typical modal values: vertebrae, 61-62; gillrakers, 18-20; scales in the lateral series, 155-170; scales above the lateral line, 35-45; pyloric caeca, 35-45; and basibranchial teeth, 0-10. Spotting and coloration can be typified as follows: medium sized spots usually concentrated in the posterior region; pink or yellowish-orange tints ventrally; reddish-pink lateral band present on side; adipose fin usually rimmed with black border; lower fins with orange or red color; prominent red or orange cutthroat mark present; parr marks usually present on specimens up to about 10 inches in length.

The Pecos River type of virginalis observed in Indian Creek, Tularosa basin, New Mexico, have fewer but larger spots mostly on the caudal peduncle region and no black rim is found on the adipose fin. Vertebral numbers and scale counts are somewhat higher in the Indian Creek population ($x = 62.1$ and 174.0 respectively) while gillraker and caecal numbers are slightly lower than in the typical upper Rio Grande samples ($x = 19.0$ and 36.7 respectively).

S. c. virginalis differs from both pleuriticus and stomias in more subdued colors (pastel-like shades), slightly smaller spots and fewer scales in the lateral series and above the lateral line.

Table 3 Meristic characters of samples of cutthroat trout from the Rio Grande basin

Number of specimens in parentheses

Collection Locality	Vertebrae	Gill Rakers	Pyloric Caeca	Scales Abv. Lat. Line	Scales in Lat. Ser.	Basibranchial Teeth
Rio Grande, Del Norte Colo. 1889 (Cal. Adad. Sci.)	(1) 62	(1) 20	--	(1) 40	--	--
Trinchera Crk. Costilla Co., Colo. 1967	(67) 60-63 61.7	(34) 18-21 19.5	(38) 33-59 46.0	(10) 39-47 41.9	(26) 146-186 164.0	(10) 4-12 7.3
Rio Chiquito Taos Co., N.M. 1966, 1970	(18) 60-62 60.9	(18) 17-22 19.7	(20) 28-42 35.6	--	(17) 154-180 165.0	(14) 1-8; 3.9 3 with no teeth
Indian Crk. and Rio Seco Crk. Costilla Co., Colo. 1958	(30) 61-63 61.8	(34) 18-21 19.5	--	(15) 39-43 40.8	(26) 146-186 164.3	(28) 1-6; 3.2 5 with no teeth
Canones Crk., Santa Fe Nat. For. Arriba Co., N.M. 1968	(6) 60-62 61.2	(6) 17-19 17.8	(6) 38-49 41.2	(5) 41-43 40.8	(5) 157-176 164.2	(6) 1-6 2.5
Coyote Crk. Canadian R. basin, N.M. 1937 (UMMZ 118194)	--	(3) 16-18 17.0	--	(3) 42-44 42.7	(3) 173-180 175.0	(3) 3-5 4.7

Table 3 (cont.)

Collection Locality	Vertebrae	Gill Rakers	Pyloric Caeca	Scales Abv. Lat. Line	Scales Lat. Ser.	Basibranchial Teeth
Indian Crk. Tularosa Basin Otero Co., N.M. 1966, 1968 (Probably derived from Pecos Basin)	(13) 61-63 62.1	(10) 17-21 19.0	(14) 31-41 36.7	(6) 38-41 40.0	(8) 168-180 174.0	(11) 4-38 18.0
Haypress Lake Mineral Co., Colo. 1970 (brood stock for hatchery propagation)	(24) 60-63 61.6	(10) 18-21 19.3	(10) 35-63 44.7	(9) 31-48 38.8	(10) 144-191 160.7	(9) 7-24 16.4

Diagnosis of *S. c. macdonaldi*

The yellowfin cutthroat trout is presumed extinct. Specimens collected by Jordan on July 25 and 26, 1889, from Twin Lakes are the only tangible evidence of the reality of this taxon. Table 6 presents data obtained from museum specimens of yellowfin trout and greenback trout from Twin Lakes and Colorado River cutthroat obtained from the Eagle River in 1889. A scale count from the rear of the adipose fin to the lateral line is included in the table.

Spotting on the museum specimens of the yellowfin trout is quite distinct from the greenback specimens collected on the same dates from Twin Lakes. Small, profuse star-shaped spots covered the dorsal and caudal regions of the specimens. No spots were observed on the pectoral, pelvic or anal fins. Coloration was impossible to note on the old collections, but descriptions by Jordan (1890) and Jordan and Evermann (1890) stated the yellowfin was silvery in color with yellow colors on the anal, pectoral, and pelvic fins. According to Jordan, red was found only on the throat. By further comparison of meristic characters recorded from the greenback and yellowfin specimens from Twin Lakes, two distinct populations are evident (Table 6). The yellowfin trout was reputed to reach a much larger size than the greenback in Twin Lakes (8-9 lbs. vs 1 lb.). As mentioned previously, Jordan believed the yellowfin originated from the Colorado River cutthroat, *S. c. pleuriticus* and specimens of *pleuriticus* taken from the Eagle River near Gypsum, Colorado, collected by Jordan in 1889, are similar to the yellowfin cutthroat in their spotting pattern. As mentioned above, the yellowfin trout has been long extinct in Twin Lakes and no specimens with similar spotting patterns have been collected from the Eagle River system since Jordan's visit in 1889. It is not likely that the taxonomic validity of *S. c. macdonaldi* will ever be established

with any authority; but it is apparent from the specimens of macdonaldi and stomias collected by Jordan from Twin Lakes in 1889 that there were two distinct types of cutthroat trout inhabiting Twin Lakes at that time and they were maintaining reproductive isolation from each other.

Table 4 Comparison of S. c. macdonaldi and S. c. stomias from Twin Lakes, Colorado, July, 1889

Location or Museum Number	Vertebrae	Number of specimens in parentheses Gill Rakers	Pyloric Caeca	Scal. Abv. Lat. Line	Scales Lat. Ser.	Scales to Adipose	Basibranchial Teeth
USNM 41730, Holotype, macdonaldi	--	(1) 20	--	(1) 43	(1) 185	(1) 31	(1) 18.0
USNM 41641 macdonaldi	(4) 60-61 60.7	(4) 20-22 21.0	(4) 32-49 42.0	(4) 38-43 40.7	(3) 149-172 161.7	(4) 26-27 27.0	--
Stanford Univ., Cal. Acad. Sci. 512 macdonaldi	(2) 60-61 60.5	(2) 21-22 21.5	--	(2) 38-46 42.0	--	--	(2) 15-16 15.5
Cal. Acad. Sci. 6453 and 8249 stomias	(7) 61-62 61.7	(7) 18-20 19.5	(2) 31-33 32.0	(7) 46-53 49.0	(7) 170-202 186.5	(7) 29-33 31.3	(7) 6-14 11.0
*USNM 41653 Eagle R. S. c. pleuriticus	--	(2) 18 18.0	--	(2) 46-51 48.5	(2) 194-200 197.0	--	(2) 2-4 3.0
*Cal. Acad. Sci. 606 Eagle R. S. c. pleuriticus	--	(1) 24	--	(1) 37	--	--	--

* Fine spotted specimens similar to macdonaldi

Variability and diagnosis of S. c. pleuriticus

As mentioned previously, a great amount of natural isolation is found between the various populations of S. c. pleuriticus particularly between the upper Green River and the upper Colorado River, and a large range of variability would be expected. In order to obtain basic taxonomic information on this subspecies, specimens were collected from locations with reputed pure populations of cutthroat trout from the upper Green River drainage, which is the type locality (near Fort Bridger, Wyoming) of the taxon pleuriticus. By comparing and evaluating data for consistency between these samples, some taxonomic diagnosis of the indigenous cutthroat trout of the upper Green River system can be obtained. Until recently no samples of suspected pleuriticus exhibiting consistent similarities had been collected from the main Colorado River system.

Cutthroat trout samples from Douglas Creek, Carbon County, Wyoming, a tributary of the Little Snake River, of the Green River drainage; Little West Fork of the Black Fork of the Green River, Summit Co., Utah; North Fork of Beaver Creek of the Green River, Sublette Co., Wyoming; and Rock Creek, a tributary of LaBarge Creek of the Green River, Sublette Co., Wyoming, exhibit almost identical meristic characters, spotting, and coloration. Cunningham Creek, tributary to the Frying Pan River of the Colorado River, Pitkin Co., Colorado, Northwater Creek, a headwater tributary of Parachute Creek, Garfield Co., Colorado, and the very headwater source of the Colorado River, Rocky Mountain National Park, Colorado, contain cutthroat trout populations judged to be predominantly S. c. pleuriticus. No evidence of rainbow hybridization is found in these samples and they probably represent essentially pure, remnant populations of the native trout of the Colorado River. The cutthroat trout from

Northwater Creek and Cunningham Creek show similarities to the greenback trout. The vertebrae and caeca numbers (60.9 and 32.7) found in the Northwater Creek fish are close to counts taken from typical greenbacks. The lateral series scale count (193.7) of the Cunningham Creek sample is quite typical of the greenback cutthroat trout.

In the Parachute Creek drainage a hybrid population occurs in the East Middle Fork, below a barrier. Table 5 contains information of S. c. pleuriticus and hybrids collected from the East Fork of Parachute Creek. A definite rainbow trout influence is noted especially in the lack of basibranchial teeth in 12 of 20 specimens, lower lateral series scale count, and higher vertebral number.

No specimen was found in any sample which resembled the small-spotted pleuriticus collected from the Eagle River by Jordan in 1889 and no definitive statement can be made about the status of the Eagle River cutthroat and its relationship to the Colorado River cutthroat.

The spotting pattern from the samples judged as essentially pure pleuriticus was characterized by large, pronounced black spots mainly on the posterior region. Coloration which was observed only from recently collected specimens, was usually brilliant, often with crimson covering the ventral region. This color is particularly accenturated in mature males during spawning season. A pink-red band was evident on the side of the fish overlaying a bronze-gold background.

Based on recent collections, S. c. pleuriticus (upper Green River drainage) can be characterized with the following typical values: Vertebral number, 60-63; pyloric caeca, 35-40; scales above the lateral line, 42-48; scales in the lateral series, 175-210; large, round pronounced black spots which are concentrated more towards the caudal peduncle, bright colors often with crimson covering the entire ventral region and with a pink-red tinge on the side overlaying a bronze-gold background.

Trapper's Lake of the Green River drainage is one of the major sources of cutthroat trout eggs for the state of Colorado. Yellowstone cutthroat, S. c. lewisi, were formerly stocked in large numbers in Trapper's Lake and it was generally believed that the native genotype had been largely replaced by Yellowstone trout (Snyder and Tanner 1960). However, from analysis of specimens collected during the spawning run in 1971, no evident influence of Yellowstone cutthroat or rainbow trout was found. The present phenotype is probably representative of the original genotype. Data found in tables 5 and 1A provide a comparison of Trapper's Lake cutthroat trout and Yellowstone Lake cutthroat. Although gill raker and caecal counts are similar between Yellowstone and Trapper's Lake cutthroat trout, scale counts, number of vertebrae and basibranchial teeth are substantially different in the samples. Trapper's Lake cutthroat trout exhibited brilliant coloration while the Yellowstone Lake fish appears drab in comparison.

The headwaters of Cross Creek, tributary of the Eagle River has a population of cutthroat which may represent an introduction of the Trapper's Lake genotype. Vertebral and gill raker number are within 0.5 of the values found in the Trapper's Lake sample. Scale counts and basibranchial teeth are also similar. Rainbow-cutthroat trout hybrids were noted while collecting the Cross Creek specimens, and the slight difference in the meristic counts is probably a result of other introductions made in the headwaters of Cross Creek.

The cutthroat trout in the very headwaters of the Colorado River above Lulu City, Rocky Mountain National Park are not physically isolated as are the other populations judged as pleuriticus. The cutthroat trout here appear to be surprisingly pure despite well established rainbow, brook and brown trout populations only one mile downstream with no

obvious physical barriers to prevent mixing. The lateral series scale count of this sample is the highest of any collection studied from the Colorado-Green River basin.

A sample from Battlement Creek near Rifle phenotypically resembles a pure population with low numbers of vertebrae and pyloric caeca (61.0 and 26.7) but the lower than expected scale counts 41.6 and 177.6 suggest some non-native influence.

Sawyer Lake lies about 1500 feet above the Frying Pan River on a small plateau. Stocking records of the last thirty years for the region did not mention any introductions into Sawyer Lake, but trout must have been stocked prior to the 1940's because there is no possible way for fish to move up to Sawyer Lake from the Frying Pan River. Spawning occurs in an outlet stream. The population of trout in the lake are brightly colored, closely resembling typical pleuriticus. However, an absence of basibranchial teeth in 3 of 11 specimens, some low lateral series scale counts and a few high caecal counts indicates that rainbow trout were stocked into the lake after the cutthroat population was established. The original stocking probably occurred directly from the Frying Pan River or from Trapper's Lake stock.

Table 5 Meristic data on cutthroat trout samples from the Colorado-Green River basin

Number of specimens in parentheses

Collection local	Vertebrae	Gill Rakers	Pyloric Caeca	Scal. Abv. Lat Line	Scales Lat Ser.	Basibran. Teeth
Eagle R. Jordan 1889 USNM 41653	--	(2) 18 18.0	(2) 46-51 48.5	(2) 46-51 48.5	(2) 194-200 197.0	(2) with teeth
Douglas Creek, Wyoming, 1964	(14) 61-63 62.0	(14) 18-21 19.4	(14) 31-42 37.1	(14) 31-42 41.4	(14) 159-197 178.6	(14) All with teeth
Little West Fork Black Fork, Summit Co., Wasatch N.F., Utah	(21) 61-63 62.2	(10) 18-21 19.1	(10) 32-41 37.4	(10) 39-47 43.7	(10) 164-204 185.4	(10) 2 without teeth
North Fork Beaver Creek, Sublette Co., Wyoming, 1970	(14) 60-62 61.4	(15) 18-22 20.2	(15) 35-44 39.4	(15) 42-52 47.0	(13) 163-197 182.3	(15) All with teeth
Rock Creek trib. Labarge Creek, Wyoming, 1971	(14) 60-64 62.0	(8) 18-20 18.8	(8) 27-46 35.4	(8) 43-49 46.0	(8) 175-200 187.3	(8) All with teeth
Cunningham Creek trib. Frying Pan R., Pitkin Co., Colo., 1972	(8) 61-62 61.6	(9) 16-19 17.2	(9) 32-40 36.9	(6) 42-47 44.3	(7) 182-202 193.7	(9) All with teeth
Northwater Creek Garfield Co., Colo., 1972	(9) 60-62 60.9	(19) 17-20 18.9	(18) 23-46 32.7	(17) 44-51 47.1	(10) 173-188 181.6	(19) All with teeth
* E. Middle Fork Parachute Creek, Garfield Co., Colo., 1972	(13) 60-63 61.5	(20) 17-21 18.9	(20) 24-42 34.1	(20) 44-54 47.4	(20) 160-183 169.2	(20) 12 without teeth

Table 5 (cont.)

Collection Locality	Vertebrae	Gill Rakers	Pyloric Caeca	Scal. Abv. Lat Line	Scales Lat. Ser.	Basibran. Teeth
Trapper's Lk. trib. White R. Garfield Co., Colo. 1970	(24) 59-63 60.5	(15) 18-22 20.1	(15) 35-63 42.3	(14) 39-47 42.7	(15) 165-220 191.1	(9) All with teeth
Hdwtrs. Colo. R. Grand Co., Colo 1970	(14) 61-63 62.1	(10) 18-23 20.3	(10) 32-43 37.1	(10) 44-49 45.7	(10) 187-226 195.1	(10) All with teeth
Cross Crk., trib. Eagle R., Eagle Co., Colo. 1969	(14) 60-63 61.5	(10) 19-21 19.6	(10) 28-41 35.5	(9) 35-48 41.8	(10) 160-204 185.3	(10) All with teeth
Battlement Crk. Garfield Co., Colo. 1970	(5) 60-62 61.0	(6) 19 19.0	(6) 22-30 26.7	(5) 39-43 41.6	(5) 163-194 177.6	(6) All with teeth
Sawyer Lk. trib. Frying Pan R. Pitkin Co., Colo. 1969	(12) 60-63 61.2	(10) 19-22 20.3	(10) 31-50 37.6	(11) 40-49 44.2	(11) 148-184 166.9	(11) 3 without teeth

* Probable hybrids

Diagnosis and variability of *S. c. stomias*

Although, as with other subspecies of *S. clarki*, no single character can positively identify the greenback cutthroat, the summation of average values of the number of vertebrae, scales, and caeca and the size of spots on the caudal penduncle, provide an adequate diagnosis to evaluate the relative purity of samples from the South Platte and Arkansas River basins. Table 6 lists some diagnostic characters from historic museum collections and other samples of suspected *S. c. stomias* populations.

A pure population of *stomias* was found in Como Creek, a tributary to North Boulder Creek, Roosevelt National Forest, Boulder County, Colorado, at the University of Colorado Artic and Alpine Research Station. Virtually pure populations of *S. c. stomias* exist in the following waters: Big Thompson River in Forest Canyon, Rocky Mountain National Park, Colorado; Island Lake, a reservoir in the city of Boulder's watershed in the headwaters of North Boulder Creek; head of Little South Poudre River, Roosevelt National Forest, Larimer County, Colorado; and the very headwaters of South Huerfano Creek, a tributary to the Arkansas River, Huerfano County, Colorado. Large prominant spots concentrated posteriorly and brilliant colors were characteristic of the specimens from these waters.

From an evaluation of these samples and from museum material *S. c. stomias* can be characterized as follows; large or oblong spots mainly on the posterior region of the body with spots usually absent from the head; spots are larger than in any other subspecies of *S. clarki*; coloration usually brilliant, particularly on the males during spawning season; colors on the sides of the body vary from dull brass to bright golden yellow with pink or reddish hue around the lateral line but not in a distinct band as in rainbow trout; ventral region cream to orange or red; lower fins

typically orange or red; cutthroat mark is usually crimson, sometimes orange; mean values of lateral series scale count, 185-215 and 44-55 scales above the lateral line; vertebral number, 59-62; pyloric caeca, 25-40, and 2-15 basibranchial teeth.

Albion Creek in the city of Boulder's watershed contained a pure population of greenback cutthroat until 1969. The few remaining cutthroats were removed and transplanted into Black Hollow Creek, a tributary of the Poudre River, Larimer County, Colorado. In 1967, all of the fish in Black Hollow Creek were eradicated and a barrier was erected to prevent upstream migration of brook and rainbow trouts. Additional stocking of S. c. stomias from Como Creek in 1970 has established a self-reproducing population of greenbacks in Black Hollow Creek.

Dieffenbach (MS, 1964) examined the original cutthroat trout population in Black Hollow Creek prior to the eradication in 1967 and concluded the cutthroat trout from this creek apparently represented the native greenback. Dieffenbach's count of lateral line scales produced a mean of 137.2. Jordan (1891) stated that stomias had a lateral line scale count of about 140. However, it has been found that the scale count in the lateral line is highly variable and unreliable as a diagnostic character. After re-examination of the spotting patterns on the Black Hollow Creek specimens an influence of rainbow trout is definitely noted. Vertebral counts of Dieffenbach's fish (61.9) and caecal counts taken by Dieffenbach indicate that rainbow trout introgression had influenced the genotype of the cutthroat trout population in Black Hollow Creek by 1964. (Rainbow trout occurred in the lower reaches of Black Hollow Creek and no physical barrier prevented mixing.)

The city of Colorado Springs' water supply consists of seven lakes located on the South slope of Pikes Peak (Arkansas River drainage). These seven lakes contain cutthroat trout which are the source of cutthroat eggs for the Southeast region of Colorado Division of Wildlife. Originally natural lakes, they were increased in size for a greater water supply around the turn of the century. These lakes have been used since 1913 for state and federal cutthroat propagation. However, stage coach roads and resort hotels were established near Pikes Peak prior to the use of the lakes as an egg source and there is a likelihood that individuals may have carried trout from Beaver Creek to the lakes and established greenback populations. Beaver Creek is a tributary to the Arkansas River which lies below the lakes on Pikes Peak. After examining specimens collected from Lake 5, evidence of the native Arkansas River greenback genotype is still apparent in the phenotype. The vertebrae number (61.1) is near the counts of pure greenbacks but the caecal number is higher (41.6) and more variable. Scale counts (44.2, 181.2) are somewhat lower than typical stomias specimens. The most likely source of contamination from non-native trout is from the Yellowstone Lake cutthroat, S. c. lewisi, which were stocked in great numbers throughout Colorado during the first part of the twentieth century. Stocking records at the Colorado Springs office of the Colorado Division of Wildlife note cutthroat trout from the Leadville Hatchery (Yellowstone Lake stock) were introduced into the Pikes Peak Lakes as early as 1909. It is likely Colorado River cutthroats S. c. pleuriticus, widely introduced from Trapper's Lake, Colorado, by the State of Colorado, also influenced "Pikes Peak" cutthroat. The brilliant colors exhibited by the Pike Peak trout is suggestive of stomias and pleuriticus, whereas Yellowstone Lake trout typically lacks gaudy colors.

Brown's Creek, a tributary of the Arkansas River near Mt. Antero, Colorado, contains a population of cutthroat which also appears to represent hybrids between the greenback and Yellowstone cutthroat. The vertebral number (62.4) of the Brown's Creek fish is high for greenback while the caeca number (38.7) and scale counts (46.2 and 184.4) are close to mean values found in stomias populations. The brilliant coloration found in pure greenback populations was not evident in these specimens, giving further evidence of Yellowstone integration in the population.

Evidently, the cutthroat trout of the Arkansas and South Platte River systems have their closest affinities to the trout native to the Colorado River basin from which they most likely were derived. Typically, the greenback has larger spots, more scales, fewer vertebrae and caeca than S. c. pleuriticus and these differences are more pronounced between stomias and S. c. virginalis, the Rio Grande cutthroat trout.

Table 6 Meristic characters of cutthroat trout samples from South Platte and Arkansas River basins

Collection Locality	Number of specimens in parentheses Vertebrae	Gill Rakers	Pyloric Caeca	Scal. Abv. Lat. Line	Scales Lat Ser.	Basibran. Teeth
Twin Lakes, Jordan CAS 8319; 1889	--	(1) 18	(1) 33	(1) 46	(1) 200	(1) with teeth
Twin Lakes, Jordan CAS 6453, 8249; 1889	(7) 61-62 61.7	(8) 18-20 19.5	--	(7) 46-53 49.0	(7) 170-202 186.5	(8) All with teeth
Twin Lakes, Juday USNM 63760; 1902-3	(13) 59-62 61.1	(8) 18-21 19.0	--	(6) 46-53 48.3	(6) 179-190 185.5	(7) All with teeth
Bear Crk., Morrison Colo., Jordan CAS 8228; 1889	(1) 59	(1) 19	--	(1) 44	(1) 195	--
Arkansas R. Jordan USNM 41702; 1889	--	(1) 20	(1) 31	(1) 47	(1) 191	(1) with teeth
Arkansas R. Jordan Leadville, Colo. CAS 8247; 1889	(6) 60-62 61.0	(2) 21-22 21.5	--	(2) 46-49 47.5	(2) 198-213 205.5	(2) with teeth
Como Crk., trib. North Boulder Crk. Roosevelt Nat. For. Boulder Co., Colo 1969	(14) 59-61 60.2	(14) 17-21 19.0	(14) 24-42 29.4	(14) 46-53 48.4	(14) 174-205 189.3	1 of 14 without teeth

Table 6 (cont.)

Collection Locality	Vertebrae	Gill Rakers	Pyloric Caeca	Scal Abv. Lat Line	Scales Lat Ser.	Basibran. Teeth
Big Thompson R. Rocky Mtn. Nat. Pk. Larimer Co., Colo. 1968	(31) 60-62 60.6	(5) 18-22 19.0	(29) 29-46 35.9	(7) 48-54 50.6	(17) 187-204 192.4	--
Little S. Poudre, Roosevelt Nat. For., Larimer Co., Colo. 1970	(11) 60-63 61.9	(12) 19-23 21.3	(12) 27-50 35.4	(7) 52-62 55.6	(8) 205-236 216.5	(12) All with teeth
S. Huerfano Crk. trib. Arkansas R., Huerfano Co., Colo. 1963	(17) 60-63 61.2	(23) 16-20 18.4	(15) 25-41 33.1	(10) 41-51 45.5	(10) 170-205 185.0	(10) All with teeth
Albion Crk. trib. N. Boulder Crk., Boulder Co., Colo. 1957-64	(39) 58-62 60.1	(6) 17-20 18.5	(6) 29-46 34.1	(8) 41-47 44.6	(8) 168-203 189.3	--
* Black Hollow Crk. trib. Poudre R., Larimer Co., Colo. 1964-72	(41) 60-63 61.9	--	(50)** 37.0	(10) 41-48 44.2	(10) 175-216 196.6	(50)** 7.0
* Pikes Peak Lk. #5 trib. Arkansas R., Teller Co., Colo 1970	(13) 60-62 61.1	(22) 17-21 19.4	(21) 32-51 41.6	(19) 42-48 44.2	(22) 162-205 181.2	(22) All with teeth
* Brown's Crk. trib. Arkansas R., Chaffee Co., Colo. 1972	(9) 61.64 62.4	(10) 18-21 19.3	(15) 33-51 38.7	(4) 44-50 46.2	(9) 163-215 184.4	(9) All with teeth

* Probable hybrids
** From Dieffenbach (MS, 1964)

Discussion and Management Recommendations

The major goals in the managment of the native cutthroat trout in the Rocky Mountain region are: 1) increase the numbers of the native trout by introductions into new waters that are barren of fish or where all fishes have been eliminated and 2) find additional sources of indigenous cutthroat trout.

Historical land use practices of irrigation, logging, mining, etc. have eliminated much cutthroat trout habitat and the changing environment has stimulated hybridization with rainbow trout. Massive stocking of rainbow trout and non-native cutthroat trout (mainly Yellowstone Lake stock and some stock of uncertain ancestry) has left very few uncontaminated populations of native trout in the Rocky Mountain region. Attempts to artificially propagate native cutthroat have been largely unsuccessful.

Rio Grande cutthroat trout

In Colorado all known pure populations of *S. c. virginalis* are on the Forbes Trinchera Ranch. Presently, the ranch is developing a subdivision for vacation homesites. The presence of the native cutthroat trout population is known by the Wildlife Manager of the Forbes Corporation, Mr. Errol Ryland, and he has stated his intention to protect the native cutthroat trout.

A plan to propagate Rio Grande cutthroat from Trinchera Creek in Lower Dome Lake, a tributary of the Gunnison River, Colorado, with a goal of developing brood stock for *S. c. virginalis* failed when the dam was found unstable. The lake had to be drained for repair and brook trout became re-established in the tributaries above the lake.

Region III of the U.S. Forest Service(Albuquerque, New Mexico) has been a leader in initiating projects to save rare and endangered

fishes through habitat protection and improvement. Management plans have been prepared for the Rio Grande cutthroat and data on public fishing on the Rio Chiquito in relation to the native cutthroat trout has been collected.

South Platte and Arkansas River cutthroat trout

The Roosevelt National Forest and Rocky Mountain National Park biologists are enthusiastically supporting programs to increase the numbers of greenback cutthroat trout. In 1973, a project is planned in Rocky Mountain National Park to restore greenbacks to Hidden Valley Creek. Brook trout will be eliminated and greenbacks will be transplanted from Como Creek.

An attempt to artificially propagate greenbacks at the Leadville National Fish Hatchery failed. Adults from Albion Creek and from Forest Canyon were held in an attempt to establish a brood stock. The Albion Creek cutthroats perished and the males and females from Forest Canyon did not ripen at the same time.

Colorado River cutthroat trout

Special management considerations on the streams containing some of the pure populations will be necessary. Most of the populations are under threat of reclamation projects, oil shale development or oil explorations. Northwater Creek is administered by the Bureau of Land Management and is on Naval Oil Shale Reserve lands. Cunningham Creek is part of the Frying Pan-Arkansas water diversion project. The Bureau of Reclamation has plans to drastically reduce the flow of this creek. The Little West Fork of the Black Fork population, currently isolated from contamination by natural barriers would be threatened by the proposed Bureau of Reclamation's China Meadows Dam. North Beaver Creek is located on Bureau of Land Management land and is in a prime area for exploratory oil drilling.

The B.L.M. land in the Green River drainage area of Sublette, County, Wyoming, appears to be suitable for habitat restoration projects. Protection from overgrazing should greatly increase the cutthroat trout habitat. Re-introductions of S. c. pleuriticus in Rocky Mountain National Park from the headwaters of the Colorado River within the Park would help increase the abundance of pleuriticus. Further collections from the upper Colorado River basin in Utah, Colorado and Wyoming may result in the discovery of more pure populations. This drainage covers an enormous area containing many isolated streams.

Unique sport fisheries, based on rare and beautiful native trouts, as planned by Rocky Mountain National Park, should popularize these fish and provide the impetus for expanding their role in fisheries management programs, thereby increasing their abundance and distribution and insuring their perpetuation.

LITERATURE CITED

Anonymous. 1877. Rio Grande Trout. Forest and Stream, 9(4):67.

Anonymous. 1878. Trout in the Rocky Mountains. Forest and Stream, (9)25:268-269.

Behnke, R. J. 1966. Relationships of the far eastern trout, Salmo mykiss Walbaum. Copeia, 1966:346-348.

_____. 1967. Rare and Endangered Species Report: The Rio Grande cutthroat trout Salmo clarki virginalis. Colo. Coop. Fish. Unit, Mimeo: 17 p.

_____. 1970. Rare and Endangered Species Report: The native trout of the Colorado-Green River basin, Salmo clarki pleuriticus. Colo. Coop. Fish. Unit, Mimeo: 7 p.

_____. 1972. The rationale of preserving genetic diversity. Proc. West. Assn. Game and Fish Comm., 52:559-561.

Bulkey, R. V. 1961. Fluctuations in age composition and growth rate of cutthroat trout in Yellowstone Lake. U.S. Fish and Wildlife Service, Bur. Sport Fish. and Wldlf. Res. Rep. 54. 31 p.

Cope, E. D. 1865. Notes on the fishes brought from the Platte River, near Fort Riley, by Dr. Wm. A. Hammond. Proc. Acad. Nat. Sci. Philad., 85-87.

_____. 1871. Report on recent reptiles and fishes obtained by the naturalists on the expedition. U.S. Geol. Surv. Wyoming and portions of contiguous territories, Prelim. Rep. 2:432-442.

_____. 1872. Report on the reptiles and fishes. U.S. Geol. Surv. Montana and adjacent Terr. (Hayden's Surv.), Part 4:Zoology and Botany: 467-476.

_____ and H. C. Yarrow. 1875. Report on the collections of fishes made in portions of Nevada, Utah, California, New Mexico, and Arizona during the years 1871, 1872, 1873, and 1874. Rep. Geog. and Geol. Explor. and Surv. W. 100th Merid. (Wheeler Surv.), 5:635-703.

Daniel, J. W. 1878. The salmonidae of Texas. Forest and Stream 10(48): 339.

Dieffenbach, W. H. 1964. Taxonomy and selected life history of the cutthroat trout (Salmo clarki Richardson) of the South Platte drainage, Colorado. MS. thesis, Colorado State University: 49 p.

Ellis, M. M. 1914. Fishes of Colorado. Univ. Colo. Studies, 11(1): 5-137.

Evermann, B. W. and U. O. Cox. 1896. Report upon the fishes of the Missouri River basin. Rep. U.S. Fish. Comm. 1894(1896), 20:325-429.

Fowler, H. W. 1912. Notes on salmonid and related fishes. Proc. Acad. Nat. Sci. Philad., 63:551-571.

Gabriel, M. L. 1944. Factors affecting the number and form of vertebrae in Fundulus heteroclitus. Jour. Exptl. Zool. 95(1):105-147.

Girard W. 1856. Notice upon the species of the genus Salmo of authors observed chiefly in Oregon and California. Proc. Acad. Nat. Sci. Philad., 8:217-220.

Hallock, C. 1877. The sportsman's gazetteer and general guide. New York: 688 p.

Hubbs, C. L. 1926. The structural consequences of modifications of the developmental rate in fishes, considered in reference to certain problems of evolution. Am. Natur. 60:57-81.

_____. 1927. The related effects of a parasite on a fish; a retardation of early growth, the retention of larval characteristics and an increase in the number of scales. J. Parasitol. 14(2):75-84.

_____ and C. Lagler. 1947. Fishes of the Great Lakes region. Cranbrook Inst. Sci., Bull. (26) Bloomfield Hills, Mich. 3rd Print., 1952:186 p.

_____ and R. R. Miller. 1948. Correlation between fish distribution and hydrographic history in the desert basins of western United States. Bull. Univ. Utah, 38(20) (Biol. Ser., 10[7]: 17-166.

Hubbs, Clark. 1957. Distribution patterns of Texas freshwater fishes. The Southwestern Naturalist, 2(2-3):89-104.

Johnson, S. M. 1880. Texas Trout. Forest and Stream. 15:49.

Jordan, D. S. 1879. Notes on a collection of fishes from Clackamas River, Oregon. Proc. U.S. Nat. Mus., 1:69-119.

_____. 1891. Report of explorations in Colorado and Utah during the summer of 1889, with an account of the fishes found in each of the river basins examined. Bull. U.S. Fish. Comm., 9:1-40.

_____. 1920a. Planted trout in the Platte drainage. Copeia (81):27.

_____. 1920b. Trout of the Rio Grande. Copeia (85):72-73.

_____ and B. W. Evermann. 1896. The fishes of North and Middle America. U.S. Nat. Mus. Bull. (47), Pt.1:1240 p.

_____ and B. W. Evermann. 1898. Ibid., Pt. 3:2183a-3136.

Jordan, D. S., B. W. Evermann, and H. W. Clark. 1930. Checklist of the fishes and fishlike vertebrates of North and Middle America north of the northern boundary of Venezuela and Columbia. U.S. Comm. Fish. Rep. 1928, Pt. 2:670 p.

_____ and C. H. Gilbert. 1880. Notes on a collection of fish from Utah Lake. Proc. U.S. Nat. Mus. 3:459-465.

_____ and C. H. Gilbert. 1883. Synopsis of the Fishes of North America. Bull. U.S. Nat. Mus. 16:1-1018.

Juday, C. 1906. A study of Twin Lakes, Colorado, with especial consideration of the foods of the trouts. Bull. U.S. Bur. Fish., 26:147-178.

Koster, W. J. 1957. Guide to the fishes of New Mexico. Univ. New Mexico Press:116 p.

Land, S. E. 1913. The black-spotted mountain trout (Salmo stomias and related species). Trans. Am. Fish. Soc. 42:183-189.

Mayr, E. 1963. Animal species and evolution. Harvard Univ. Press, Cambridge, Mass. 797 p.

_____. 1969. Principles of systematic zoology. McGraw-Hill Inc. 428 p.

McDowall, R. M. 1972. The Species Problem in Freshwater fishes and the taxonomy of diadromous and laustrine populations of Galaxias maculatus (Jenyns). Jour. Roy. Soc. New Zealand, 2(3):325-367.

Miller, R. R. 1972. Classification of the native trouts of Arizona with the description of a new species, Salmo apache. Copeia (3): 401:422.

Needham, P. R. and R. Gard. 1959. Rainbow trout in Mexico and California with notes on the cutthroat series. Univ. Calif. Pub. Zool. 67(1): 1-124.

_____. 1964. A new trout from central Mexico. Salmo chrysogaster, the Mexican golden trout. Copeia (1):169-173.

New Mexico Department of Game and Fish. 1956. Fish Survery, Canadian and Cimarron River drainages in New Mexico 1953-1956. William H. Wolfarun project leader.

Rostlund, E. 1952. Freshwater fish and fishing in native North America. Univ. Calif. Pub. Geog., 9:1-313.

Schreck, C. B. 1969. Trouts of the upper Kern River Basin, California. M.S. Thesis. Colorado State Univ. 120 p.

Snyder, J. O. 1921. Notes on some western fluvial fishes described by Charles Girard in 1856. Proc. U.S. Nat. Mus., 59:23-28.

Snyder, G. R. and H. A. Tanner. 1960. Cutthroat trout reproduction in the inlets to Trappers Lake. Colo. Dep. Game and Fish Tech. Bull. 7:86 p.

Taning, A. V. 1952. Experimental study of meristic characters in fishes. Biol. Rev. 27(2):169-193.

Taylor, N. A. 1878. Answer to inquiry on Salmo fontinalis in Texas. Forest and Stream, 10(13):236.

Vladykov, V. D. 1934. Environmental and taxonomic characters of fishes, Trans. Roy. Can. Inst. 220:99-140.