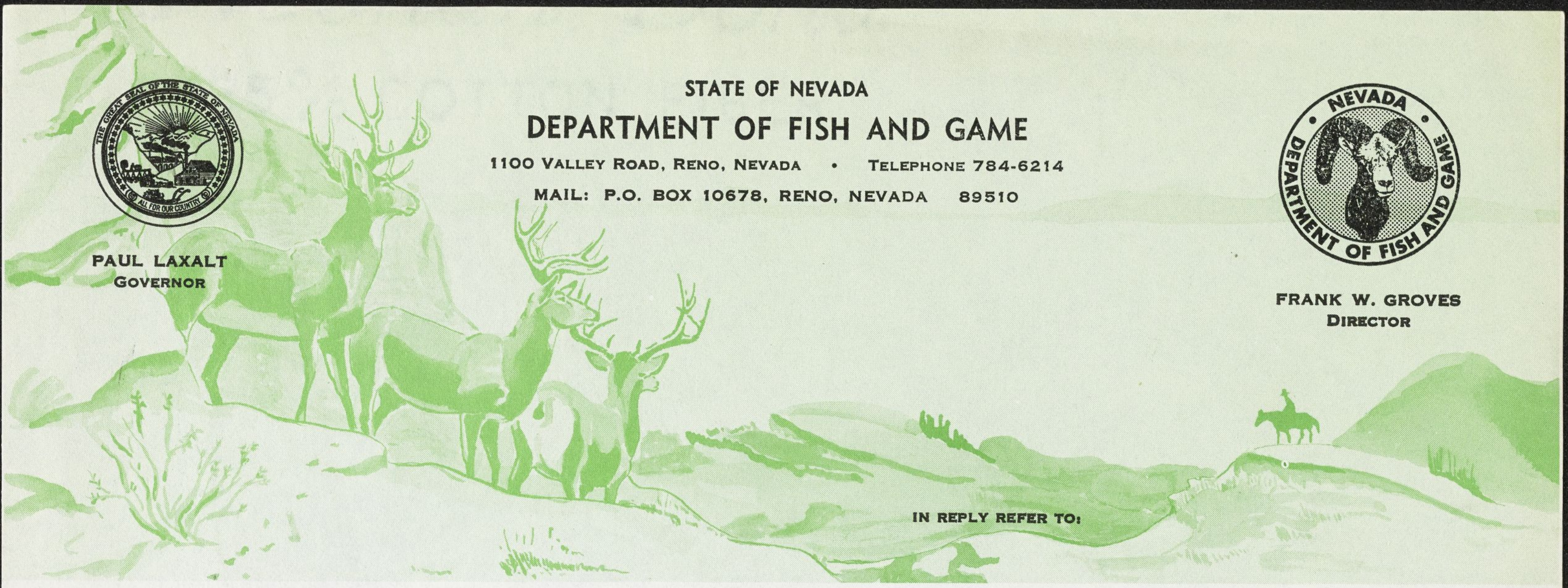

STATE OF NEVADA
DEPARTMENT OF FISH AND GAME
1100 VALLEY ROAD, RENO, NEVADA • TELEPHONE 784-6214
MAIL: P.O. BOX 10678, RENO, NEVADA 89510

PAUL LAXALT
GOVERNOR

FRANK W. GROVES
DIRECTOR

IN REPLY REFER TO:

October 19, 1970

Dr. Robert Behnke
Bureau of Sport Fisheries and Wildlife
Colorado Cooperative Fishery Unit
Colorado State University
Fort Collins, Colorado 80521

Dear Dr. Behnke:

I have recently been requested to present a paper at the January joint session of The Wildlife and American Fisheries Societies. The paper to be presented will be about my work on the cutthroat trout of Pine Creek, Hendry's Creek, etc. This will be my first attempt at this sort of thing and I must confess that I feel I don't know near enough about the subject on which I have been requested to write. You, with your knowledge of the subject, may be my salvation. I have many questions to ask. I only hope you have the time and patience to answer them all.

First, it was not clear to me in your letter of August 17th if you thought the Mill Creek cutthroat were the same as those found in Pine and Hendry's Creeks. You stated that they were in general similar but that they did not have the same compressed chunky body form.

I think that this body form may not be characteristic of the specie but characteristic of individuals found primarily in Pine Creek and to some degreee in Hendry's Creek.

In July of 1960, fifty-four cutthroat were captured from Pine Creek and planted into Goshute Creek about 55 miles north of Ely. This was a barren stream at the time. The fish have reproduced well and are now quite abundant in the stream. The fish do not exhibit the chunky body form.

RI-57

UNITED STATES GOVERNMENT

Memorandum

BUREAU OF SPORT FISHERIES AND WILDLIFE
Federal Bldg. - U. S. Court House
300 Booth Street, Room 4005
Reno, Nevada 89502

TO : Robert Behnke

DATE: 7-2-75

FROM : Gary Rankel
FWS-Reno

SUBJECT:

I have sent to you, under separate cover, heads with attached viscera from four male cutthroat taken from the 1975 spawning run in Mahogany Creek. The fish had fork lengths of 18.8, 19.9, 20.1 and 20.6 inches.

Gary Rankel

White and Sakamoto 1974 A probable relic population of the Bonneville cutthroat (*Salmo clarki utah*, Suckley's Salmonidae) in Salt Lake County, Utah. Proc. Ut. Acad. Sci. Arts Letts 50 (1): 66-68. -

Red Butte Canyon - 1 mi. E. of Univ. Utah campus & Ft. Douglas. A natural history preserve.

N=41 12-29 cm. - lemon-yellow colors - these chunkier than silver cutthroat

2 types "strains" yellow + silver

all but 2 silver fish have med-large spots (2 v/small)

	Silver N=27	Part-yellow N=6	lemon-yellow N=4
Spotting	med-large	med-large	large
	160-85	145-60	145-50
	18-20	18-22	18-19

- Red Butte area closed area since 1870's - first U.S. Army now Forest Ser.

lower end stream blocked since late 1880's by small reservoir - s.

"Stocking of the stream has been rare" -

IN REPLY REFER TO:

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

Gavins Point National Fish Hatchery
Route #1
Yankton, South Dakota 57078

check Hydrobiol Zh 5... 5..
71-72-73(6)

Utah Acad. Sci.
51 pt. 1 :66

1965 42(4):280
1973 50(1): Hollen-s...

August 9, 1976

Dr. Robert Behnke
Colorado State University
Ft. Collins, Colorado 80521

Dear Dr. Behnke,

I understand that you are presently working on a translation of a Russian paper regarding paddlefish.

This project has been involved in the propagation of paddlefish for several years and any additional information would be extremely beneficial.

I would appreciate if you could send us a copy of this translation.

Thank you in advance for your services.

Sincerely,

Roger F Copper
Roger F. Copper
Hatchery Manager

RFC:jh

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

Alta Wheeler
heliographic station

THE UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN, U. S. A. 48104

MUSEUM OF ZOOLOGY

August 28, 1972

Dr. Robert Behnke
Colorado Cooperative Fishery Unit
Colorado State University
Fort Collins, Colorado 80521

Dear Bob:

This is in response to your letter of August 9 to Carl Hubbs. Carl has already answered a number of your queries and I will not comment further on them now.

Nevada Fish and Game does not (or did not as of July, 1971) believe in your Humboldt cutthroat, which is the reason why it does not appear in the list of threatened U.S. freshwater fishes (TAFS, 101 [2]: 239-252). I cannot overemphasize to you that the 305 kinds appearing in that paper had to be approved by the states. So they do not necessarily all meet with my approval; neither are all of the fish on that list which I would like to have seen included. This was a Society-solicited, cooperative paper. I have had a large number of requests for it and, although some 800 reprints have been ordered, none has arrived yet. Next year a list of <u>nationally</u> threatened U.S. freshwater fishes will appear. They number over 100.

I cannot agree with your statement that our 1934 collection of <u>Salmo</u> <u>clarki</u> from Virgin Creek, Nevada (in the Alvord basin) is "very typical <u>S</u>. <u>C</u>. <u>henshawi</u>". The data appear below:

	Dorsal					Anal				Pelvic	
	9	10	11	12	13	9	10	11	12	8	9
(1) Virgin Creek UMMZ 130532	9	11	..	..	..	3	16	1	..	7	33
(2) Summit L. basin UMMZ 141587-88) UMMZ 136872)	..	12	17	7	1		13	19	4	36	38

	Gill rakers					
	22	23	24	25	26	27
(1) Virgin Creek UMMZ 130532	4	8	6	4	1	..
(2) Summit L. basin UMMZ 141587-88) UMMZ 136872)	1	6	8	11	7	1

The vertebral number is virtually identical (60-63, M. 61.5). Virgin Creek specimens differ further from Summit Lake (Snow Creek) material in: (1) lacking spots on the side anteriorly below the lateral line; (2) having a longer upper jaw on the average; and (3) having a larger eye.

These differences, while not great enough for nomenclatural separation, are sufficient in my mind to argue against the view that the Summit Lake trout were stocked in Virgin Creek. I also am interested in the rather high frequency of 8-rayed pelvic fins, especially in the Summit Lake stock. Didn't La Rivers argue that S. c. henshawi was planted in Summit Lake? I take it you do not buy this idea? As Carl explained, the Summit Lake basin formerly flowed down to Soldier Meadows and was blocked by a lava flow that formed the lake. It seems highly likely to me that there was a period of discharge of Summit Lake (perhaps for such a short time that no evidence of a higher lake level survives) into Virgin Creek and that is when the latter stream received its ancestral stock that subsequently differentiated so as to be recognizably different.

It seems most remarkable to me that the redband trout, as I know it most intimately from Sheepheaven Creek, could possibly survive in 83°F (S. Fk. Owyhee R.)!

The fossil from the Alvord basin is probably a Miocene sunfish (not close to Archoplites). I collected a few from Red Butte that Ted Cavender has studied.

Please send me the unidentified minnow from near the Oregon-Idaho border. Neither Jerry Smith nor I am certain what it is from your description.

We have absolutely no help now and won't have a research assistant until about September 8. As soon as he gets onto the routine (he is a new graduate student) I will ask him to wrap the Alvord trout material you wish to see. I have X-rayed much of it (high percentage of vertebral abnormalities) and you are welcome to borrow the radiographs.

I have exciting news on Trout Creek, Utah, trout but will save it for another letter.

Sincerely,
Bob
Robert R. Miller
Curator of Fishes

RRM:mw
cc: Carl L. Hubbs

PS. - I feel fine (anyone feeling as well as I do can't have anything seriously wrong. I have nearly completed a very thorough physical exam and have a conference with the head doctor on September 7.)

P-PS. - Enclosed is a copy of a letter from an Arizona geographer bearing on your one-time contention that Mormons may have introduced S. apache into the Little Colorado. Extremely unlikely, he concludes, considering that the fish were taken there by 1872 and the Mormons didn't explore the Little Colorado prior to 1877 or 1878.

United States Department of Agriculture
Forest Service
Intermountain Research Station
316 East Myrtle
Boise, ID 83702

Reply to: 4200

Date: 4 May 1990

Kurt D. Fausch
Associate Professor of Fishery Biology
Department of Fishery and Wildlife Biology
Colorado State University
Fort Collins, CO 80523

Dear Dr. Fausch:

We would very much appreciate a technical review of the enclosed manuscript entitled "Distribution and Habitat Relationships of Native and Introduced Trout in Relation to Geology and Geomorphology in the North Fork Humboldt River Drainage, Northeastern Nevada" by Rodger L. Nelson, William S. Platts, David P. Larsen, and Sherman E. Jensen. We are intending to submit this manuscript for publication in the Transactions of the American Fisheries Society.

Please complete the accompanying "Technical Manuscript Review Form", and feel free to place other comments directly on the draft. If possible, it would help us greatly if we could receive your comments by 1 June 1990.

Many thanks for your help.

Sincerely,

RODGER L. NELSON
Biological Technician (Fisheries)

Enclosure

Bob –
Are you interested in this?
Just put it in my mailbox
if not.
Kurt

Rodger –

I'm sorry that I won't be able to review this for you. It reached me while on sabbatical in British Columbia where I am involved in intensive field work. I've sent it to Dr. Bob Behnke at Colorado State and asked if he has time to look at it, since he is quite familiar with the fish and the location. I would appreciate a reprint when it is published.

Kurt Fausch –

Second Draft
9 April 1990

DISTRIBUTION AND HABITAT RELATIONSHIPS OF NATIVE AND INTRODUCED TROUT IN RELATION TO GEOLOGY AND GEOMORPHOLOGY IN THE NORTH FORK HUMBOLDT RIVER DRAINAGE, NORTHEASTERN NEVADA

Rodger L. Nelson

USDA Forest Service
Intermountain Research Station
Forestry Sciences Laboratory
Boise, Idaho

William S. Platts

Don Chapman Consultants
3180 Airport Way
Boise, Idaho

David P. Larsen

U.S. Environmental Protection Agency
Environmental Research Laboratory
Corvallis, Oregon

Sherman E. Jensen

White Horse Associates
P.O. Box 123
Smithfield, Utah

Proposed for publication in the Transactions of the American Fisheries Society

[v.121] 1992

Abstract.--We studied the current distribution of native Lahontan cutthroat (*Oncorhynchus clarki henshawi*) and exotic eastern brook trout (*Salvelinus fontinalis*) relative to geologic and geomorphic land classes in the upper North Fork Humboldt River drainage, Nevada, and evaluated measurable components of habitat structure as discriminators among stream reaches in the different land classs, and among reaches that supported trout and those that did not. At a finer level of resolution, we used the habitat attributes with the most discriminatory power to plot the distributions of study areas by land class and by presence or absence of trout along environmental gradients defined by these attributes.

Elevation, substrate embeddedness, and streamflow were the variables with the most discriminatory power among land classes defined by parent geologic material (Geologic Distict); however, gravel abundance in the substrate was more useful than streamflow in further discriminating among land classes at the lower level classes defined by geomorphic character (Landtype Association). Plots of study areas along environmental gradients defined by these variables visibly separated study areas by land class.

Trout distributions were clearly related to geologic district and, to a lesser extent, landtype association. Trout were almost exclusively restricted to the Sedimentary mountains defining the western boundary of the drainage, and occurred elsewhere only in study areas that were upstream from the poorly consolidated valley floor. Of the variables measured, embeddedness was probably the principal cause of this distributional pattern, but unmeasured variables (e.g., temperature, winter conditions, and turbidity) cannot be eliminated. In

the Sedimentary district where trout were common, however, important discriminating attributes were stream width, abundance of large substrate (rubble and boulder), and streamflow, with trout principally associated with wider, well-watered stream reaches containing a high oercentage of large streambottom particles. Study areas meeting these criteria were concentrated in high mountain areas that had been glaciated during the Pleistocene, but were also present in the fluvial canyons.

The central applications of this study are twofold: first, it develops a framework for analyzing existing trout populations in a geologic and geomorphic context, so that questions regarding fisheries capability of the habitat can be stratified first at successively finer levels of differing fishery potential; second, it encourages evaluation of the conditions within land classes relative to their potential as well as existing conditions, so that managers may get a better grip on whether and to what extent habitats have been degraded and how best to rehabilitate them.

INTRODUCTION

The distribution and abundance of organisms has long been a favorite topic of ecological research. Interior populations of trout, like populations of all organisms, have adapted to the habitats in which they occur naturally; consequently, investigation of natural distributions leads to an understanding of the environmental processes that control or limit their numbers. Over a species' range of occurrence, climatic, biologic, geomorphic and hydrologic processes interact on a geologic template to produce an array of local habitat conditions to which trout populations must respond in an adaptive fashion or perish. To complicate matters, however, in many, and perhaps most cases, modern fisheries ecologists are faced with distributions that reflect human influence as well as these natural processes, so that existing trout distributions and habitat conditions, provide only a distorted picture of the natural or potential situation. Although this fact may complicate the study of organism-habitat relationships, it also provides information regarding the environmental tolerance of some species, and increases the importance of understanding such relationships if continued loss of species and populations and species through loss of habitat is to be stopped.

In recent years, a great deal of ecological study has been directed toward establishing species-habitat relationships and the development of "habitat capability models." Some of the better known among these are the Habitat Evaluation Procedures (HEP) standardized by the U.S. Fish and Wildlife Service for use in developing Habitat Suitability Indices (HSI) for modeling habitat suitability (U.S. Fish and Wildlife Service 1980), and HSI models have been developed for a wide array of fish and wildlife species. In fisheries science, there have been several avenues of model development, from rough attempts to predict trout populations from one or two in-stream variables (e.g. FISHSED, Stowell et al. 1983) or to predict trout populations and monetary values from a small number of aquatic and riparian attributes (e.g. COWFISH, Lloyd 1986; Shepard 1989), to models of considerably greater complexity that attempt to incorporate a large number of geomorphic and aquatic conditions, including: the Habitat Quality Index (Binns, 1978, 1979; Binns and Eiserman, 1979); the U.S. Fish and Wildlife Service's Instream Flow Incremental Methodology (IFIM) utilizing Physical Habitat Simulation (PHABSIM) (Bovee 1978; Milhaus et al. 1984); and the Trout Cover Rating Method of the Wyoming Water Research Institute (WRRI) (Wesche 1980). The models developed along these lines have a singular goal: to quantify the habitat needs of certain species so that resource managers can determine whether certain areas are optimal and how proposed management alternatives with anticipated effects on the habitat may influence the organisms that the habitat potentially supports.

Modeling efforts such as these have met with varying degrees of success, and have often had little reliability outside the areas in which they where they were developed. The USFS COWFISH model has been shown to provide reasonable results in eastern Montana (Lloyd 1986; Shepard 1989), but has been shown to have little applicability in a large number of streams in Idaho, Utah, and Nevada (Platts and Contor in press). Similarly, the HSI approach has failed to provide accurate predictions of cutthroat trout numbers in several streams in Idaho, Nevada, and Utah (Persons and Bulkley 1984), including some of the same streams where COWFISH were shown to be inadequate (Platts and Contor in press), and the need to modify HSI coefficients to increase predictive ability has been reported in southeastern Wyoming (Wesche et al. 1987). In addition to these efforts with which we have some direct experience, other workers have cited difficulties with other models, including the IFIM and PHABSIM approach (Mathur et al. 1985; Conder and Annear 1987), and ambivalent results with the HQI technique, even in Wyoming where it was developed (Eifert and Wesche 1982). Fausch et al. (1988) reviewed 99 habitat-based models intended to predict standing crop of fluvial fish populations, and reported similar problems with widespread application of habitat-based models.

We believe that the placement of fish populations in the context of overall ecologic setting is a fundamental parameter that has been largely omitted from habitat-based modeling efforts. Clearly, thorough understanding of the natural distribution of the various varieties of trout and mechanisms underlying their responses to the array of environmental conditions that characterize the habitats they occupy must be addressed. As pointed out by Lanka et al. (1987), trout habitat is to a great extent a function of drainage basin geomorphology, so it stands to reason that investigation of the relationships among geomorphology, trout habitat, and trout populations provides a logical framework for understanding trout population distribution and for developing habitat capability models. In an early effort along these lines, Platts (1979) related stream order and a variety of geomorphologically-determined aquatic habitat attributes to salmonid populations in Idaho. More recently, Lanka et al. (1987) investigated the relationships of geomorphic and other habitat attributes to trout populations using regression and canonical-correlation analyses, and found that geomorphic variables were more useful in describing the variation in standing crops than were on-site habitat variables. In other, related studies, fish assemblages have been shown to vary on a regional basis (Hughes and Omernik 1981; Hawkes et al. 1986; Larsen et al. 1986), indicating that mechanisms determining the responses of fish populations to environmental features is also likely to vary geographically; consequently, development of useful models needs to be stratified by ecoregion (Fausch et al. 1988).

Integration of these factors, however, requires a coordinated system of land classification that includes *but is not limited to* aquatic habitat, and an understanding of the relationship between the existing and potential habitat conditions. In this study, we classified a variety of trout-containing and barren stream settings in the Great Basin of northeastern Nevada by landtype association (broad land areas of similar geomorphology) so that the environmental characteristics of landtype associations that contained one or more species of trout could be characterized and compared with one another and with those that did not support trout. We have also examined the physical characteristics of populated and trout-free reaches to identify the attributes potentially most useful in controlling the distribution of trout in this area. Trout populations in northeastern Nevada, particularly native populations, are ecologically very interesting and serve to exemplify the weaknesses of typical habitat capability modeling. Consequently, our results represent a positive step toward developing a classification system for trout that we hope will lead to more effective understanding of population-habitat relationships and habitat capability modeling.

STUDY AREA DESCRIPTION

Land Systems

The North Fork Humboldt River drainage is located in northeastern Nevada adjacent to the Idaho border. Most water for the river originates from melting of the winter snowpack in the Independence and Adobe mountain ranges and supplied by a complex dendritic tributary system. Physiographically, this area is at the northern boundary of the Central Great Basin subsection of the Great Basin section of the Basin and Range physiographic province (Fenneman 1931; Thornbury 1965; Hunt 1974) (Figure 1). This is an extensive inland region of nearly parallel mountain ranges composed of Paleozoic sedimentary rocks aligned in an approximately north-south orientation and separated by low-lying valleys; in northeastern Nevada, these intermontane valleys are filled principally with light-colored and often unconsolidated sedimentary debris of late Tertiary age. However, the North Fork Humboldt River basin is also heavily influenced by the bordering Owyhee Uplands (Payette) section of the Columbia Plateau Province (Thornbury 1965; Hunt 1974), a region of largely volcanic origin.

The principal mountains of the region are the northerly oriented Independence Range that forms the western boundary of the drainage, and the north-easterly trending Adobe Range that forms the south-eastern boudary. The Independence Range attains an elevation of 10,439 feet above mean sea level at McAffee Peak, whereas the Adobe Range is of considerably lower stature. Both ranges are composed largely of Paleozoic sedimentary rocks that were initially uplifted during Tertiary faulting activity (Kerr 1962; Coats 1987), including various shales, cherts, sandstones, mudstones, siltstones, and conglomerates; the Independence Range, however, also includes a core of orthoquarzite (Coats 1987). The Independence Range was substantially glaciated north of Stump Creek during the Pleistocene; the lower limit of glaciation appears to correspond roughly to the 7,200-ft contour line and glacial outwash has been deposited on the valley floor to as low as the 6,300-ft contour level north of Foreman Creek (interpreted from Coats [1987]). Several perennial streams originate in the Independence Range and constitute the principal sources of water for the upper portions of the North Fork Humboldt River.

On the northwestern flank of the drainage, Wild Horse Ridge[1] is an extensive and convoluted area of rhyolitic extrusions; localized outcroppings of similar material also occur along the interior margins of the Independence and Adobe Ranges. The volcanics of Wild Horse Ridge include a tuffaceous formation that apparently inundated older Paleozoic and Mesozoic sedimentary formations, which are occasionally exposed in "windows" (Coats and Gordon 1972). Few streams originate in these formations, and few of those that do are perennial; some, however, cross them in various places.

The intermontane valley between these three boundary structures consists of detrital material derived from the faulting and volcanism that created the highlands. These sedimentary basin deposits are largely composed of light-colored siltstone, sandtone, claystone, and occasional outcrops of vitric ash;

---

[1] We have elected to call this upland area the Wild Horse Ridge after Wild Horse Mountain, one of the high points along the ridge. In fact, this ridge, which also includes Divide Peak and Double Mountain, appears to be unnamed.

in some areas, the siltstone may have been altered to montmorillonite clay (Coats 1987). In the northern reaches of the North Fork valley, however, Quaternary deposits resulting from Pleistocene glaciation apparently overlay the Tertiary debris that comprises most of the valley floor, and forms the inconspicuous boundary between the North Fork Humboldt (Lahontan Basin) and Owyhee River (Columbia Basin) drainages. Many lower reaches of valley streams also contain Quaternary and Recent floodplain deposits.

Study areas occurred in 3 distinct geologic districts: ***Sedimentary***, comprising the sedimentary formations that form the backbone of the Independence Range; ***Volcanic***, which consists principally of the rhyolitic flows forming the eastern boundary of the upper part of the North Fork Humboldt River Basin; and ***Detrital***, comprising the largely unconsolidated valley fill deposits. These fundamental classes included 3 subordinate categories reflecting local geomorphology: ***Fluvial***, including those areas dissected by the action of running water; ***Glacial***, which consisted of areas influenced by Pleistocene glaciation (including outwash); and ***Alluvial***, comprising the structural valley that contains sediments weathered from adjacent mountains and forms the heart of the upper North Fork Humboldt River basin. These units combined to define the 6 observed landtype associations: ***Sedimentary-Glacial*** land, ***Sedimentary-Fluvial*** lands, ***Volcanic-Fluvial*** land, ***Volcanic-Alluvial*** land, ***Detrital-Glacial*** land, and ***Detrital-Alluvial*** land (Figure 2).

Ecology

The North Fork Humboldt River basin lies wholly within but on the northern border of the Great Basin Sagebrush Section of the Intermountain Sagebrush Province of Bailey (1980) and the Northern Great Basin Ecoregion of Omernik (1986). The area is cold desert shrubsteppe, with annual precipitation ranging from about 8 in on the valley floor to over 20 in on the peaks of the Independence Range, occurring principally as winter snow; evapotranspiration potential considerably exceeds precipitation. Potential climax upland vegetation is predominantly big sagebrush (*Artemisia tridentata*), with inclusions of Palouse-type prairie vegetation (e.g., Bluebunch wheatgrass (*Agropyron spicatum*) and Idaho fescue (*Festuca idahoensis*) from the adjacent Sagebrush-Wheatgrass Section of the province (Kuchler 1964; Bailey 1980) (roughly equivalent to the Snake River Basin High Desert Ecoregion [Omernik 1986]). At higher elevations, stands of subalpine fir (*Abies lasiocarpa*) and quaking aspen (*Populus tremuloides*) occur in protected areas.

The valley floor of the upper North Fork Humboldt River basin and the upland shrubsteppe has been intensively used for livestock production since the 1850's. Livestock were first brought to the area to supply adventurers bound for the gold fields of California who used the east-west trending Humboldt River to cross Nevada. Range use was essentially unregulated for about 80 years; the Humboldt National Forest was established in 1908 to help relieve the range deterioration caused by overuse, and the Taylor Grazing Act, which led to establishment of the Bureau of Land Management, was enacted in 1935. During the early part of the twentieth century, sheep predominated, but cattle are more common today and are managed in accordance with modern range management practices.

Because of the generally dry nature of the area, few streams are truly perennial and normally perennial streams may also dry up during unusually dry years; consequently, available habitat for fish fluctuates considerably from year to year and even from month to month, and few species occur naturally. Naturally occurring fish species include Humboldt cutthroat trout (*Oncorhynchus clarki spp.*)[2], Paiute sculpin (*Cottus beldingi*), and dace (*Rhynichthys sp.*); eastern brook trout (*Salvelinus fontinalis*) have become naturalized in a few areas, whereas rainbow trout (*Oncorhynchus mykiss*) have been planted in the drainage[3] but are no longer present.

The two study years, 1987 and 1988, were exceptionally dry years in northeastern Nevada, and some normally perennial stream reaches were dewatered. Twenty-three of the sites studied in 1988 were dry (only sites with flowing water were studied in 1987, but our survey was intensified in 1988 and dry sites were included) (Figure 3); some, but probably not all, of these sites could be expected to be ephemeral in all but the wettest years. Many of the dry sites were in areas that might otherwise be expected to support trout and may support trout during wetter years or earlier in the summer. In addition, some of these dry reaches may dry up on the surface but continue to flow underground, as occurred on Pratt Creek in 1988 where flowing water was available up- and downstream from a recessional or end moraine over which no water was flowing,

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[2] Our experience with the ecology of these fish (see e.g., Platts and N nelson 1983; Nelson and Platts 1985) leads us to accept the taxonomic considerations of Behnke (1979) regarding fluvial cutthroat trout populations in this area; however, they continue to be formally identified with Lahontan cutthroat trout (*O. c. henshawi*).

[3] Rainbow trout were stocked in Gance Creek, with the last planting occurring in 1955 (Platts and Nelson 1983); in 12 consecutive years of sampling Gance Creek, no rainbow trout have been collected (Platts and Nelson 1988; this study).

and others were on dewatered streams that none-the-less supported beaver ponds near springs that may serve as temporary trout refugia.

METHODS

Land Classification and Mapping

We established 78 study areas in the upper portion North Fork Humboldt River basin, incorporating a diverse assemblage of geomorphic settings, and were selected to thoroughly describe aquatic-riparian ecosystems representative of these settings. The stratification and selection procedure unfortunately sacrificed randomness for thoroughness, but we see no reason to assume that results would be different with randomization; consequently, we are comfortable with our statistical approach.

We classified the entire North Fork Humboldt River watershed above the confluence of Beaver Creek, an area of approximately 597 mi^2, to the Landtype Association level. Boundaries of geologic districts were determined from the 1:500,000 scale geologic map of Nevada (Stewart and Carlson 1978) and the 1:250,000 scale geologic map of Elko County (Coats 1987). Landtype associations (except Detrital-Glacial) were identified with ground-level and aerial reconnaissance, interpretation of 1:12,000 and 1:24,000 scale aerial photographs, and 1:100,000 and 1:24,000 scale topographic maps. Locations of the 78 study areas were determined from 1:100,000 and 1:24,000 scale topographic maps. We produced original maps using ARC-INFO (Environmental Systems Research Institute, Redlands, California)[4], a geographical information system.

Fish Population Sampling

Presence or absence of trout populations was determined by sampling with battery-powered backpack-mounted Smtih-Root electrofishers. Some sites were sampled exhaustively using a four-pass removal-depletion technique[5] (Platts et al. 1983) for detailed population study, whereas other sites were summarily sampled merely to determine whether trout were present. All trout were identified to species[6], handled as carefully as possible, and returned alive to the stream in the vicinty of their capture.

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[4] The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture or the U.S. Environmental Protection Agency of any product or service to the exclusion of others that may be suitable.

[5] Four-passes was the standard approach; however, anytime two consecutive passes produced no fish, electrofishing was terminated for that reach. In addition, two passes were considered adequate if the second pass produced fewer than half the fish collected in the first pass.

[6] All cutthroat trout were assumed to be of the Humboldt strain, and no further taxonomic work was attempted. Unhybridized populations have been reported from several streams in the drainage (Coffin 1982).

Physical Habitat Characteristics.--These measurements described the physical habitat characteristics of the stream in each study site and were collected transects located at 30-ft intervals beginning with a randomly selected starting point as described by Platts et al. (1983, 1987). Physical habitat measurements (except streamflow and elevation) were taken at each transect and sorted by study site to determine average site-specific conditions; streamflow was measured with an electronic flowmeter at the downsteam end of each site where it was measured. Elevations were determined primarily from U.S. Geological Survey 7.5 minute topographic maps; in a very few instances, reference was made to 15 minute maps. All sites comprised 25 or 33 transects, except for three on Gance Creek that comprised 60 or 61 transects[7]. Site means were sorted by geologic district and landtype association to determine average conditions for these ecological taxa, and by presence or absence of trout to determine average conditions in trout-containing and unpopulated habitats. The variables used represent an array of physical habitat characteristics that describe the three-dimensional structure of the stream-riparian ecosystem, with emphasis on variables that were intuitively expected to reveal differences among landtype associations and between trout-producing and unproductive habitats.

Stream width was determined by the amount of wetted streambed directly under the transect line; width was measured to the nearest 1.0 ft (0.30 m). *Stream*

---

[7] Numbers of transects per site vary because some sites were used in concurrent studies that had other objectives besides generating the information presented in this paper.

depth was determined at 3 points directly below the transect line corresponding to 25, 50, and 75% of the wetted width, and divided by 4 (to account for 0 depth at the bank) to obtain the average depth along the transect; depths were measured to the nearest 0.1 ft (0.03 m). *Width-depth ratio* was computed as width divided depth for each transect. *Pools* were identified as that portion of the water column that was relatively slower and deeper than surrounding portions, and that typically possessed an unbroken surface (glides or runs included); *riffles* constituted the remainder of the wetted width. Water column habitats not clearly distinguishable as pool or riffle were classified as pool. *Pool-riffle* ratio was calculated by dividing pool width by riffle width for each transect. *Streamflow* was measured at each site using a Marsh-McBirney electronic current meter.

Streambank angle was measured in degrees with a clinometer at the interface between the stream and streambank (no attempt is made here to distinguish between channel and bank in a geomorphological sense; bank is simply used to indicate the transition from water to land) to determine the downward slope of the bank to the water, and were measured on each bank and averaged for each transect; angles less than 90° indicate an undercut condition, those over 90° an outsloped condition. *Streambank undercut* was a direct horizontal measurement to the nearest 0.1 ft (0.30 m) of the depth of the dominant undercut (if any) on each bank, and averaged to obtain the transect value. *Percent eroded banks* was measured as the proportion of transects (by bank) along which eroded banks were observed.

Streambottom surface materials were classified into five size classes, and the extent of each size class was measured to the nearest foot under each transect and converted to percent of stream width. Size classes were defined as: *fines*, those particles smaller than 0.19 in (4.75 mm) in diameter; *gravel*, those particles larger than large fines but smaller than 3.0 in (76.1 mm) in diameter; *rubble*, those particles larger than gravel but smaller than 12.0 in (305.0 mm) in diameter; and *boulders*, all larger particles. *Embeddedness*, measured in percent, estimated the gasket effect of fine sediments surrounding larger particles.

Data Quality Assurance and Quality Control

The individuals that collected field data were initially trained and tested for several days before collecting actual data to assure comparability among measurements collected by different individuals, and crew leaders were responsibitiy for maintaining comparability of measurements taken by individual members of each crew. In addition, replicate measurements were taken for 5 study sites between 10 and 45 days later; most differences between replicates could be accounted for by actual changes brought about by changes in such factors as falling stream discharge, irrigation withdrawal, and livestock grazing intensity. Some habitat measurements were devised specifically for this study and have not had factors pertaining to bias accuracy, and precision fully elucidated; however, most techniques are described in detail in Platts et al. (1983), where good documentation of reliability is presented. Map procedures were limited by the accuracy of the reference maps, scales of which are listed in the appropriate methodology section.

Statistical Analysis

Basic Statistics.--We obtained univariate summary statistics using the SAS MEANS procedure (SAS 1987); since input data values were site means (except for flow and elevation), each was weighted by the number of transects per site. It is most reasonable to look for important habitat factors influencing trout populations in land groups that contain a mixture of populated and unpopulated sites. As will be seen, trout were largely restricted to the Sedimentary geologic district and were nearly ubiquitous in the Sedimentary-Glacial landtype association; consequently, mean habitat conditions of sites in the other two districts were tested for significant differences (α=0.10) relative to mean habitat conditions in the Sedimentary district, and comparisons between sites with and without trout were performed only overall, within the Sedimentary district as a whole, and within the Seimentary-Fluvial landtype association. Similarly, the numbers of sites in each landtype association in the Volcanic and Detrital districts were too small to make sigmificance testing meaningful; consequently, we only tesdted differences in mean habitat conditions between sites in the Sedimentary-Glacial and Sedimentary-Fluvial associations were tested. Differnces were tested by rgression using dummy variables with the SAS REG procedure (SAS 1987), and site means were weighted by the number of transects per site.

Of potentially serious statistical concern is the lack of randomness in our selection of study sites. We sacrificed randomness in order to ensure a thorough survey of existing stream-riparian systems in each geomorphic land class. Consequently, it should be realized that comparisons are presented to illustrate apparent differences in study areas among land classes and between certain categories within land classes, and not differences among the classes themselves. In addition, statements of statistical probability, while tainted by our deviation from randomness, appear reasonable and worthy of consideration by the reader.

Discriminant Analysis.--Multivariate discriminant procedures provide useful tools for quantitatively analyzing the differences between known classes of objects. We used the SAS CANDISC procedure (SAS 1987) to analyze physical differences between these categories based on the measured habitat variables. Canonical discriminant analysis was selected because of its ability to functionally summarize differences between classes (as opposed to developing numerical criteria for assigning objects to a class). Canonical correlation coefficients (H_0:r=0) and mean values of canonical variables between classes (H_0:no difference) were tested for significance using multivariate analysis of variance and the F value associated with the likelihood ratio.

Multivariate statistical techniques are useful tools for exploring patterns in ecologic data, but attaching ecologic meaning to the results of such analyses is often perplexing. Although coefficients of canonical discriminant functions are often used, Williams (1981) and Raphael (1981) suggest looking at the correlations between the canonical variable and individual habitat variables. We used the total canonical structure to assess correlations of individual variables with the canonical variable. The number of canonical variables that can be derived is limited to one less than the number of class levels.

For discrimination among geologic districts we were able to extract two canonical variables. After determining the canonical structure, we located study sites by geologic district in two-dimensional coordinate space defined by the canonical variables, and in three-dimensional coordinate space defined by the two habitat variables most highly correlated with the first canonical variable, and the one habitat variable most highly correlated with the second canonical variable.

For discrimination among landtype associations, five canonical variables were allowed, but only the first two were of interest. We considered discrimination between landtype associations to be an extension of the discrimination between geologic districts, so after determining the canonical structure associated with these six classes, we selected the variable most highly correlated with the second canonical variable[8], and plotted it with habitat variables that were most highly correlated with the first and second canonical variables from the geologic district analysis. This approach provide a three-dimensional separation based on individual habitat variables useful in discriminating between landtype associations.

Since trout were essentially restricted to the Sedimentary geologic district, so we decided to concentrate on variables useful for discriminating between presence and absence of trout only in that district. Discrimination was approached in two ways: presence and absence of trout within the Sedimentary

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[8] We selected the second canonical variable because the first canonical variable was very similar to the first canonical variable derived from the three-level analysis of geologic districts; the rationale becomes more apparent with the presentation of the results of the analysis.

geologic district as a whole, and within the Sedimentary-Glacial and Sedimentary-Fluvial landtype associations. For graphical representation of the discrimination between presence and absence of trout, we selected the three habitat variables most highly correlated with the single allowable canonical variable to use as coordinate axes and plotted the study areas in the three-dimensional space defined by the axes. This appraoch suggests ecological gradients to which trout populations respond.

RESULTS

Physical Characteristics of Land Systems

Geologic Districts.--Multivariate testing indicated that the physical habitat conditions of study sites geologic districts were significantly different overall (likelihood ratio [Wilks' Lambda] = 0.0961 with 76 d.f., F=5.4616, P=0.0001) among the three geologic districts. The physical habitat characteristics of sites in Sedimentary geologic district, which occupies a higher elevational zone, differed considerably from those of the Volcanic and Detrital districts (Table 3). Five of the 10 (50%) measured habitat variables (elevation excluded) differed significantly between the Sedimentary and Detrital districts, and 6 of the 10 (60%) differed significantly between the Sedimentary and Volcanic districts. The characteristics of sites in the Volcanic and Detrital districts, on the other hand, were, except for streamflow, quite similar.

The most obvious physical habitat differences between the Sedimentary district and the others were composition and structure of the streambottom stream width; sampled stream reaches in the Sedimentary district were narrower. Surface substrate particles of gravel size and larger were much more prevalent and embeddedness was lower than in either the Volcanic and Detrital districts, where the substrate was typically smaller and highly embedded. There were no statistical differences in mean streambank angles and undercuts among districts, possibly because of the region's extensive historic use for livestock grazing, but the percentage of eroded banks was considerably less in the Volcanic district than in the the other districts, presumably because of the resistant nature of the parent material; the most eroded banks, on average, were observed in the Detrital district, but the variance was high and the differences were not significant.

Canonical discriminant analysis (Table 5) selected two useful canonical variables, the first (R=0.92, P=0.0001) serving to best separate the Sedimentary district from the other two, the second (R=0.63, P=0.10) better separating the volcanic and Detrital districts (Figure 4); both canonical correlations were significant at our specified alpha level of 0.10[9]. Plotting the study areas along axes defined by three habitat variables highly correlated with the canonical variables illustrates the ecologic importance of gradients defined by these variables, and the discrimination potential of these three variables alone (Figure 5).

Landtype Associations.--Multivariate testing indicated that the physical habitat conditions of the study sites were significantly different overall (likelihood ratio [Wilks' Lambda] = 0.0137 with 169.7 d.f., F=3.1856, P=0.0001) among landtype associations. Comparisons between landtype associations within individual geologic districts (Table 4) was most meaningful within the Sedimentary district because there were several study areas in each association. In the Sedimentary geologic district, there were several significant differences in habitat means between the two landtype associations. The highest average elevation was recorded in the Sedimentary-Glacial district, and there was

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[9] The probability associated with the second canonical correlation coefficient was actually 0.104, which we have chosen to accept as significant after rounding to 0.10.

significantly more gravel and less boulder and rubble in streambottom sediments in the Sedimentary-Glacial district; mean substrate embeddedness was higher in the Sedimentary-Fluvial district. Despite the small number of sites in the Detrital-Glacial district (n=2), however, there were some significant and potentially important differences in average habitat characteristics. The abundance of gravel substrate and eroded banks were significantly higher in the Detrital-Glacial association, whereas pool-riffle ratio was significantly smaller.

Canonical discriminant analysis classified at the landtype association level allowed extraction of five canonical variables for the complete data set; however, only the correlation coefficients associated with the first two (R=94 and R=0.81, respectively) were significant (F=3.19, P=0.0001 and F=1.89, P=0.0059, respectively). These two variables effectively separate landtype associations along gradients related principally to elevation, boulder-rubble substrate, and substrate embeddedness, and gravel substrate and eroded banks (not shown). The first canonical variable was very similar to the first canonical variable in the geologic district analysis, but the second canonical variable indicated that abundance of gravel substrate was a better disciminating factor than flow or eroded banks at the landtype association level. Thus, plotting of study areas along environmental gradients comprising three of the individual habitat variables with the most discriminatory power (elevation, eroded bank, gravel) separated landtype associations quite well (Figure 6).

Clearly, the Sedimentary-Glacial and Sedimentary-Fluvial landtype associations were characterized by high elevation, moderately eroded banks, and predominantly gravel substrate, and were separated from one another principally by the proportion of gravel in the substrate. In contrast, the other four landtype associations were generally similar to one another and distinguished mainly along the eroded bank gradient, though the Detrital-Glacial sites were clearly distinguishable from the sites in the Detrital-Alluvial association by higher elevation and a greater proportion of gravel in the substrate; similarly, the site in the Volcanic-Fluvial association was characterized by more gravelly substrate than sites in the Volcanic-Alluvial association.

Trout Distribution

In those 55 study sites with flowing water, most trout occurred in the Sedimentary geologic district that forms most of the Independence Range; only 2 of the 28 sites containing trout (7%) occurred in either the volcanic or Detrital districts (Table 6). In both of these instances, the site supporting trout was near the demarcation line between the its geologic district and the Sedimentary district (Figure 7); no trout were encountered out on the Tertiary detrital fill of the valley floor or in the notch-shaped rhyolytic canyons of the North Fork Humboldt River or its tributaries once they had debauched from the fluvial canyons of the Independence Range. Study areas in these sedimentary district streams constituted 89% of the sites in which trout were encountered.

Most trout collected were the native cutthroat trout of the Humboldt River system, but only Eastern brook trout were collected in Pratt Creek and sympatric populations of cutthroat and brook trout occurred in the North Fork; one allopatric population of brook trout occurred in the North Fork near the confluence of McAffee Creek (Figure 8). The brook trout population encountered in the North Fork near the confluence of McAffee Creek was the only trout population observed in the Detrital geologic district, and the individual fish appeared stressed and perhaps on the verge of extirpation[10]. These fish may have been washed into this area during spring flooding, and prevented from returning to more favorable habitats upstream by a falls above the site on McAffee Creek. Although sympatric populations were noted in the North Fork, trout communities tended to be dominated by one or the other species. Rainbow trout (*Oncorhynchus mykiss*) were not encountered in the drainage, though we know that they were introduced into Gance Creek in the past; long-term conditions are apparently largely outside the tolerance range of this species (Platts and Nelson 1983).

The habitat differences between geologic districts were reflected in the habitat differences between sites that contained trout and sites without (Table 6), as would be expected with the strong association of presence of trout with the Sedimentary geologic district and the clear habitat differences between the Sedimentary and the other two districts. It is also revealing to note that the minimum elevation at which trout were encountered (6190 ft) is similar to the maximum elevation of the Detrital-Alluvial landtype assotion from which no trout were collected.

At a finer level of resolution, multivariate testing of Sedimentary district sites with and without trout indicated significant overall difference in physical

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[10] Red spotting on the bodies of these fish and their generally poor apparent condition suggested the presence of bacterial infections associated with marginal conditions for survival and probability of imminent extirpation.

habitat (Likelihood ratio [Wilks' Lambda=0.2793 with 22 df, F=2.5806, P=0.0655); those habitat conditions associated with presence of trout included sites with higher flows, greater stream width, and more rubble-boulder substrate and bank erosion. The proportion of pool in the water column was substantially lower where trout were present (44.4% *vs.* 56.6%), but the difference was not statistically detectable at α=0.10. Both landtype associations within the Sedimentary geologic district contained sites supporting trout trout populations, and physical habitat discriminators among sites with and without trout differed from those between landtype associations within this district.

Canonical discriminant analysis on the basis of presence or absence of trout within the Sedimentary geologic district reflected similar habitat differences to the above analysis. The one allowable canonical variable was most highly correlated with stream width, rubble-boulder substrate, and streamflow (Table 7). Inspection of canonical structure would appear to suggest that different environmental gradients are important in the Sedimentary-Fluvial and Sedimentary-Glacial landtype associations, but we think this is only apparent and due largely to the fact that only one site in the Sedimentary-Glacial association was without trout. This one site was in a glacial cirque on Pratt Creek above a terminal moraine that passed no surface water. Overall, there seems little justification for regarding the Sedimentary-Glacial and Sedimentary-Fluvial landtype associations differently with respect to fishery potential; however, although no attempt was made to analyze distributional differences between cutthroat and brook trout, brook trout were present only in streams that had been glaciated[11]. Consequently, only the distribution of trout in the Sedimentary district as a whole was plotted on environmental gradients (Figure 9), with stream width, rubble-boulder substrate, and streamflow as the selected gradients.

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[11] Although the study areas in the canyon of the North Fork itself were not classified as sedimentary/glacial, there was glaciation in the headwaters region of the river, which may have residual downstream effects that went unnoticed.

DISCUSSION

Location of study areas within discrete land classification taxa provides a great deal of preliminary information about trout fishery potential based on habitat characteristicts. Streambank conditions in all areas were similar, probably due to similar grazing histories, but because of differences in geologic setting and geomorphic character, cultural practices have affected stream reaches in each geologic district and landtype association somewhat differently.

Study sites in the Detrital geologic district were characterized by sluggish, highly embedded streams with deteriorated streambank conditions, and canonical discriminant analysis indicated that embeddedness and eroded banks were the two best variables for discriminating among geologic districts. Specific causes of the poor physical conditions in these sites have not been adequately documented, but it seems clear that they reflect a history of alterations resulting from cultural practices (e.g., farming, grazing, and irrigation withdrawal). Streams in this district are often entrenched and xerophytic vegetation often encroaches upon the streamside zone, further suggesting overall deterioration away from natural conditions. Streamside soils in the Detrital-Alluvial landtype association appear to be highly susceptible to erosion and the clayey particles are readily suspended in the water column; in addition, the low gradients typical of streams in the Detrital district as a whole are conducive to heavy sediment deposition from upstream areas.

The Volcanic and Detrital geologic districts were very similar to one another, except that streambanks in the Volcanic district were much more resistant to erosion. Most volcanic district sites were downstream from detrital district sites, and instream conditions probably reflect the continuum nature of stream systems. This concept is supported by the fact that the only Volcanic district site to contain trout was also the only Volcanic district located upstream from the Detrital district. In addition, streambanks in the Volcanic district appear to be much more resistant to erosion, but the typically low gradients still lend themselves to deposition of fine material introduced from upstream. Consequently, there seems to be no reason to believe that streams in the volcanic district should be incapable of supporting trout populations, except when they are located downstream from reaches flowing through the Detrital district other areas of active excessive sediment delivery.

At a finer level of resolution, some moderation of habitat characteristics was detected by comparisons between landtype associations. In the Detrital district, areas that with glacial influence (Detrital-Glacial landtype association), sedimentaion and b~~e~~ank erosion conditions seemed less severe than other areas in the district. A similar situation apparently occurred in the Volcanic-Alluvial landtype association, where bank erosion was less severe than on other areas in the district, but the alluvial nature of the landtype association was still conducive to sedimentation and embeddedness was only slightly less; however, the inclusion of only one study area in the Volcanic-Alluvial landtype association precludes the formulation of concrete conclusions. In the Sedimentary geologic district, differences between landtype associations were very pronounced. Streams were wider, larger surface substrate material, and less embeddedness and bank erosion in the Sedimentary-Glacial association.

Trout populations in the North Fork Humboldt River drainage were clearly distributed in a manner that reflects geomorphic history, making stream reach location within a particular land classification taxon a valuable starting point for habitat capability analysis. Trout were largely restricted to a single geologic district, the Sedimentary district defined by the Independence Range, and even when they occurred elsewhere, their occurrence was adjacent to and doubtless influenced by proximity to the Sedimentary district. Substrates in these reaches were typically larger and less embedded than in the Detrital or Volcanic districts, and streambanks seemed to be somewhat less eroded than in the Detrital district. Canonical discriminant analysis of trout presence or absecnce suggests that, at the geologic district level, trout may respond to environemental gradients related to embeddedness and, less reliably, eroded streambanks. Only one site in the Detrital district supported trout at the time of sampling, and these were in a site located in the Detrital-Glacial landtype association and associated with substrate material that was larger and less embedded than normally encountered in the district; bank erosion was also less. Similarly, study areas in the Volcanic district influenced by upstream reaches in the Detrital district were highly embedded and without trout, and the only Volcanic district site located above the Detrital district supported trout; trout productivity potential in the Volcanic geologic district appears to be related fundamentally to a stream reach's relationship to the Detrital district.

Because nearly all study areas in the Sedimentary-Glacial landtype association and most of the study areas in the Sedimentary-Fluvial landtype association contained fish, inspection of trout occurrence in the Sedimentary district overall should provide the most insight into the general habitat preferences of indigenous trout. In general, trout appeared to be principally limited by availabilty of water (or living space), as reflected in streamflow and average width. However, the amount of rubble and boulder sized substrate particles also appeared to be important, and may account for the nearly ubiquitous presence of trout in the Sedimentary-Glacial association. Such substrate not only provides needed cover for juvenile fish, but may also be influential in limiting streambank erosion and preserving favorable bank conditions; indeed, extent of eroded banks was an important gradient related to presence or absence of trout in the Sedimentray/Glacial district. In addition, there appeared to be a weak relationship between brook trout and the residual effects of glacial formative processes; cutthroat trout, on the other hand, were well distributed throughout the glacial and fluvial situations.

The Sedimentray district as a whole is at higher average elevation than either the Volcanic or Detrital districts, but elevation *per se* does not seem to be a principal determinant of fishery potential; however, it may be locally important within a given watershed in that the upper reaches of otherwise productive streams often had very reduced flows and no trout. Elevation was an apparently important gradient in the Sedimentary-Fluvial landtype association, but we believe its importance was principally a function of its influence on streamflow. Broadly speaking, trout are probably likely under present conditions, flow permitting, to occur in an elevational band that ranging from about 6200 to 6700 feet at the southern end of the Independence Range to about 6500 to 7800 feet in the north. The lower elevational limit roughly coincides with the maximum elevation of the valley floor (i.e., the Detrital geologic district) where streams debauch from the sedimentary mountains. Stream reaches in both the Detrital and Volcanic geologic districts historically contained trout, even in recent years, and it seems likely that their absence during our study period reflects the altered habitat conditions, possibly exacerbated by recent drought.

We did not include an evaluation of stream temperature or insolation in this study, but it is certainly a variable of potential importance with respect to trout distribution. The insolation potential of stream reaches in the relatively flat topography of the Detrital geologic district is clearly much higher than for reaches in the narrow fluvial canyons of the Independence Range or in the deeper notch-shaped canyons of the Volcanic district. Other studies (e.g., Platts and Nelson, in press) have suggested that insolation is indeed a critical factor, in which case the highly eroded banks and lack of statuesque riparian vegetation in the Detrital district may be of fundamental importance. This question should receive further study. We also have not addressed turbidity, except to note that it was very visible in most study sites in the Detrital and Volcanic geologic districts, nor have we considered winter conditions, which may be very important in this region, particularly in view of the lack of riparian cover in the Detrital district. These may be critical factors and merit additional study.

The results of this study clearly illustrate successful application of land systems classification to studies of trout distribution and habitat characteristics, and emphasises not only the importance of rather broad taxonomic units (e.g., Ecoregions), but also the utility of looking at much smaller taxa. Using our approach, one can readily develop preliminary criteria for assessing fishery potential on a regional scale measured in square miles, conserving time, effort, and expense for detailed habitat analysis where it will do the most good. Additional studies along these lines should be used in areas of different geoclimatic influence. The nearby Ruby and East Humboldt Mountains, for example, are chiefly granitic structures that were more heavily glaciated than the Independence range. Physical habitat charactérics, taxonomic units and their relationship to trout distribution are likely to be quite different. The Ruby/East Humboldt ranges are geomorphically similar to the Sawtooth Range of the Northern Rockies Ecoregion, and one might expect a similar array of locat habitat characteristics; widely different indigenous trout species occur in the two areas, however, offering the opportunity to expand our understanding of trout distribution patterns in relation to land systems. Similarly glaciation becomes less and less a geomorphic factor farther south in the Great Basin, and adaptations of trout populations to habitat conditions may reflect greater influence of fluvial and alluvial mechanisms.

Use of this classification approach provided a means of stratifying a watershed into geographic units that supported or did not support trout, then allowed us to determine physical characteristics that differentiated these regions in a gross sense. By selecting only productive regions, it was then possible to discover how the variables acted together to influence trout presence or absence, and then to select the individual factors that were most influential overall, and what other factors were likely to be important in certain situations. Thus, it is clear that, flows permitting, essentially all stream reaches in the Sedimentary geologic district should be capable of producing trout, and most do an adequate job under current management conditions. If some are not producing trout, extent of eroded bank, potentially a direct consequence of cultural practices such as livestock grazing, may be at fault. Similarly, since areas presently devoid of trout in the Detrital and Volcanic districts once contained them, it would be worthwhile to examine how existing conditions differ from alternative conditions that may be achieved through management, with emphasis placed on reduction of embeddedness and bank erosion and restoration of vigorous riparian vegetation. This approach will help us achive the regional stratification called for by Fausch et al. (1988), and, coupled with determination of potential conditions at even finer levels of stratification, will help us develop more effective empirical models using habitat variables to estimate fishery potential.

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Table 1.--Descriptions of the 6 major landtype associations mapped in the North Fork Humboldt River drainage, Nevada, including dominant landforms comprising the valley-bottom landtype in each class (after Jensen et al. 1989).

Landtype Association		Description
Sedimentary	Glacial	Glaciated valleys within the Independence Range, including the following valley bottom types: glacial basins, glacial trains, and glacial outwash units.
	Fluvial	Stream-cut valleys within the Independence and Adobe Ranges, including the following valley bottom types: V-shaped depositional and V-shaped erosional units.
Volcanic	Fluvial	Stream-cut valleys within the lavas of the Rough Hills, including the following valley bottom types: notch-shaped erosional and notch-shaped depositional.
	Alluvial	Valley floodplains within the lavas of the Rough Hills, including the following valley bottom types: confined floodplain.
Detrital	Glacial	Glacial valley floor deposits, including the following valley bottom type: glacial outwash.
	Alluvial	Valley floor floodplains including the following valley bottom types: confined floodplain and unconfined floodplain.

Table 2.--Occurrences of trout of trout by landtype association, North Fork Humboldt River drainage, Nevada.

Landtype Association		Number of sites	Proportion with trout	Species
Sedimentary	Glacial	9	89	CT,EB
	Fluvial	25	72	CT,EB
Volcanic	Fluvial	4	0	-----
	Alluvial	1	100	CT
Detrital	Glacial	2	50	EB
	Alluvial	14	0	-----

Table 3.--Comparison of physical habitat means and standard errors among geologic districts, North Fork Humboldt River drainage, Nevada[a].

	Geologic district														
	Sedimentary					Volcanic					Detrital				
Variable	Mean	S.E.[b]	Max	Min	N	Mean	S.E.	Max	Min	N	Mean	S.E.	Max	Min	N
Elevation (ft)	6955	74.0	6420	8370	28	5952*	117.6	6260	5690	6	5989*	63.2	6440	5740	13
Stream width (ft)	5	1.9	9	2	34	10*	15.4	18	2	6	10*	6.9	18	3	13
Rubble-boulder (%)	32.5	20.96	74.9	0.0	34	24.6*	66.07	80.2	0.0	6	7.3*	15.22	34.2	0.0	13
Gravel (%)	48.2	17.82	80.3	16.9	34	20.0*	27.79	44.0	7.3	6	31.3*	37.30	87.0	0.3	13
Embeddedness (%)	49	13.7	79	17	34	72*	37.6	90	39	6	82*	15.8	100	71	13
Pool (%)	46	19.0	100	19	34	81*	30.7	95	57	6	78*	24.7	100	45	13
Eroded bank (%)	33.4	22.55	100.0	1.9	26	17.6	27.09	36.0	8.0	5	42.0	35.80	94.0	10.0	12
Streamflow (cfs)	1.17	0.248	5.40	0.00	28	2.80	1.294	6.32	0.10	5	0.95	0.339	3.13	0.00	13
Width-depth ratio	19.0	7.23	45.5	9.1	34	15.3	17.85	29.2	7.6	6	17.8	10.85	35.0	8.6	13
Bank angle (deg)	137	8.9	162	118	34	134	33.6	159	118	6	142	23.4	158	101	13
Undercut (ft)	0.1	0.07	0.3	0.1	26	0.1	0.08	0.2	0.1	5	0.1	0.20	0.4	0.0	12
Canonical variable 1[c]	1.90	----	----	----	--	-2.23	----	----	----	--	-2.72	----	----	----	--
Canonical variable 2	0.04	----	----	----	--	-1.90	----	----	----	--	0.71	----	----	----	--

[a] Means denoted by an asterisk (*) are significantly different than corresponding means from the Sedimentary geologic distict ($\alpha=0.10$), as tested by regression.

[b] S.E. - standard error of the mean.

[c] The canonical variables were derived in the canonical discriminant anlysis, and were not explicity tested for significant differences.

Table 4.--Comparison of site-specific physical habitat characteristics by landtype association, North Fork Humboldt River drainage, Nevada[a].

	Statistic									
Variable	Mean	S.E.[b]	Max	Min	N	Mean	S.E.	Max	Min	N
	Sedimentary-Glacial					**Sedimentary-Fluvial**				
Elevation (ft)*	7353	155.7	8370	6790	9	6812	63.9	7620	6420	25
Stream width (ft)*	7	2.7	9	5	9	5	2.32	9	2	25
Rubble-boulder (%)*	62.1	18.90	74.9	43.9	9	23.7	17.54	56.7	0.0	25
Gravel (%)*	54.7	11.82	35.4	16.8	9	54.7	18.07	80.3	21.8	25
Embeddedness (%)*	43	13.1	56	33	9	51	17.8	79	17	25
Pool (%)	46	14.6	58.0	34.0	9	19	25.48	100.0	18.7	25
Eroded bank (%)	27.0	20.6	50.0	10.0	8	36.2	31.23	100.0	1.9	18
Streamflow (cfs)	1.65	0.333	2.63	0.37	8	0.98	0.316	5.40	0.00	20
Width-depth ratio	18.3	10.18	30.5	12.1	9	19.3	9.23	45.5	9.1	25
Bank angle (deg)	135	12.2	149	123	9	138	11.3	162	118	25
Undercut (ft)	0.1	0.09	0.2	0.1	8	0.2	0.10	0.3	0.1	18
Canonical variable 1[c]	3.23	----	----	----	--	1.37	----	----	----	--
Canonical variable 2	-0.65	----	----	----	--	0.58	----	----	----	--
	Volcanic-Fluvial					**Volcanic-Alluvial**[d]				
Elevation (ft)	5862	105.9	6260	5690	5	6190	----	----	----	1
Stream width (ft)	13	14.7	18	3	5	2	----	----	----	1
Rubble-boulder (%)	30.7	74.56	80.2	0.0	5	0.0	----	----	----	1
Gravel (%)*	17.3	21.25	30.5	7.3	5	44.0	----	----	----	1
Embeddedness (%)	73	45.8	90	39	5	69	----	----	----	1
Pool (%)	82	35.8	95	57	5	71	----	----	----	1
Streamflow (cfs)	3.28	1.556	6.32	0.10	4	0.92	----	----	----	1
Eroded bank (%)	19.5	32.76	36.0	8.0	5	10.0	----	----	----	1
Width-depth ratio	19.6	17.70	29.2	12.4	5	7.6	----	----	----	1
Bank angle (deg)	142	32.1	159	124	5	118	----	----	----	1
Undercut (ft)	0.1	0.10	0.2	0.1	5	0.1	----	----	----	1
Canonical variable 1	-1.87	----	----	----	--	-2.48	----	----	----	--
Canonical variable 2	-2.17	----	----	----	--	0.03	----	----	----	--
	Detrital-Alluvial					**Detrital-Glacial**				
Elevation (ft)*	5947	58.7	6370	5770	11	6340	100.0	6440	6240	2
Stream width (ft)	9	8.1	18	3	11	7	3.2	7	6	2
Rubble-boulder (%)	5.8	17.91	34.2	0.0	11	4.0	17.75	7.5	0.4	2
Gravel (%)*	23.7	31.00	69.2	0.3	11	73.2	69.18	87.0	59.4	2
Embeddedness (%)	84	17.45	100	71	11	73	7.5	75	72	2
Pool (%)*	82	22	100	59	11	52	7.1	45	59	2
Streamflow (cfs)	0.85	0.359	3.13	0.00	11	1.54	1.220	2.76	0.32	2
Eroded bank (%)*	36.4	32.21	64.0	10.0	10	70.0	24.00	120.0	46.0	2
Width-depth ratio	16.8	12.41	35.0	8.6	11	17.7	26.70	23.0	12.3	2
Bank angle (deg)	140	27.7	158	101	11	144	14.8	147	141	2
Undercut (ft)	0.1	0.23	0.4	0.0	10	0.1	0.05	0.1	0.0	2
Canonical variable 1	-3.14	----	----	----	--	-2.57	----	----	----	--
Canonical variable 2	-0.33	----	----	----	--	4.19	----	----	----	--

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[a] Variables (within a single geologic district) denoted by an asterisk (*) have significantly different means (α=0.10), as tested by regression.

[b] S.E. - standard error of the mean.

[c] The canonical variables were derived in the canonical discriminant anlysis, and were not explicity tested for significant differences.

[d] Because of small sample (n=1), there was no variance associated with these values.

Table 5.--Canonical discriminant analysis of study area habitat characteristics at geologic district and landtype association class levels.

	Canonical Structure			
	Geologic District		Landtype Association	
Variable	Canonical Variable 1	Canonical Variable 2	Canonical Variable 1	Canonical Variable 2
Elevation (ft)	0.88	0.04	0.90	0.11
Stream width (ft)	-0.50	-0.07	-0.43	-0.37
Rubble-boulder (%)	0.59	-0.35	0.70	-0.36
Gravel (%)	0.36	0.23	0.27	0.76
Embeddedness (%)	-0.85	0.23	-0.83	0.05
Pool (%)	-0.70	0.03	-0.70	-0.28
Eroded bank (%)	-0.02	0.48	-0.05	0.53
Streamflow (cfs)	-0.11	-0.52	-0.03	-0.30
Width-depth ratio	0.13	0.02	0.16	0.03
Bank angle (deg)	-0.05	0.22	-0.05	0.14
Undercut (ft)	0.04	0.02	0.00	-0.13
Canonical correlation	0.93	0.64	0.95	0.81
Likelihood ratio	0.0771	0.5893	0.0106	0.1096
Numerator df	22.0	10.0	55.0	40.0
Denomenator df	54.0	28.0	114.7	96.7
F-value	6.3879	1.9516	3.4746	1.9128
Probability > F	0.0001	0.0798	0.0001	0.0052

Table 6.--Comparison of site-specific physical habitat characteristics for sites containing trout and sites from which trout were absent, North Fork Humboldt River drainage, Nevada[a].

	Statistic									
	Trout Present					Trout Absent				
Variable	Mean	S.E.[b]	Max	Min	N	Mean	S.E.	Max	Min	N
Overall										
Elevation (ft)*	6845	68.2	7720	6190	28	6337	140.5	8370	5690	25
Stream width (ft)	6	2.1	9	2	28	8	5.9	18	2	25
Rubble-boulder (%)*	35.4	24.13	74.9	0.0	28	15.4	21.50	80.2	0.0	25
Gravel (%)*	46.6	18.67	74.1	16.8	28	34.0	25.93	87.0	0.3	25
Embeddedness (%)*	51	14.6	75	25	28	70	22.9	100	17	25
Pool (%)*	46	18.5	84.9	18.7	28	73	23.5	100.0	18.7	25
Eroded bank (%)	32.2	17.34	60.0	10.0	20	35.5	29.80	100.0	1.9	23
Streamflow (cfs)	1.54	0.285	5.40	0.02	22	1.06	0.359	6.32	0.00	24
Width-depth ratio	19.1	8.70	45.5	7.6	28	17.5	7.00	35	8.6	25
Bank angle (deg)	138	9.7	162	118	28	138	15.3	159	101	25
Undercut (ft)	0.1	0.06	0.2	0.1	20	0.1	0.12	0.4	0.0	23
Sedimentary Geologic District										
Elevation (ft)	6893	63.9	7720	6460	26	7158	233.5	8370	6420	8
Stream width (ft)*	6	2.1	9	3	26	3	1.7	5	2	8
Rubble-boulder (%)*	38.1	24.29	74.9	4.9	26	19.9	35.54	64.3	0.0	8
Gravel (%)	46.2	20.01	74.1	16.8	26	51.8	41.13	80.3	21.8	8
Embeddedness (%)	50	14.5	72	25	26	47	36.2	79	17	8
Pool (%)*	44	19.0	84.9	18.7	26	57	50.3	100.0	18.7	8
Eroded bank (%)*	32.7	17.84	60.0	10.0	18	35.0	64.32	100.0	1.9	8
Streamflow (cfs)*	1.51	0.306	5.40	0.02	20	0.34	0.237	1.96	0.00	8
Width-depth ratio	19.8	8.98	45.5	12.0	26	16.5	8.87	26.83	9.11	8
Bank angle (deg)	139	9.7	162	118	26	133	20.4	144	118	8
Undercut (ft)	0.1	0.06	0.2	0.1	18	0.2a	0.20	0.3	0.1	8
Canonical variable[c]	-2.10	----	----	----	--	1.12	----	----	----	--
Sedimentary-Fluvial Landtype Association										
Elevation (ft)	6745	50.9	7340	6460	18	6984	180.8	7620	6420	7
Stream width (ft)*	6	2.7	9	3	18	3	1.6	5	2	7
Rubble-boulder (%)*	27.6	22.15	56.7	4.9	18	13.6	18.62	26.4	0.0	7
Gravel (%)	54.6	19.47	74.1	28.4	18	55.1	43.53	80.3	21.8	7
Embeddedness (%)	53	19.6	72	25	18	48	41.0	79	17	7
Pool (%)	45	27.0	84.9	18.7	18	57	58.1	100.0	18.7	7
Streamflow (cfs)	1.33	0.440	5.400	0.02	13	0.34	0.274	1.960	0.00	7
Eroded bank (%)	38.4	25.67	60.0	18.0	11	32.8	73.23	100.0	1.9	7
Width-depth ratio	20.5	12.09	45.5	12.0	18	16.4	10.21	26.8	9.1	7
Bank angle (deg)	140	13.2	162	118	18	135	22.1	144	118	7
Undercut (ft)	0.1	0.08	0.2	0.1	11	0.1	0.23	0.3	0.1	7
Canonical variable	-3.11	----	----	----	--	2.72	----	----	----	--

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[a] Variables (within a single geologic district) denoted with an asterisk (*) have significantly different means (α=0.10), as tested by regression.

[b] S.E. - standard error of the mean.

[c] The canonical variables were derived in the canonical discriminant anlysis, and were not explicity tested for significant differences.

Table 7.--Total canonical structure of discriminant analysis of trout occurence within the Sedimentary geologic district.

Variable	Sedimentary Geologic District	Sedimentary-Fluvial Landtype Association
Elevation (ft)	-0.16	-0.21
Stream width (ft)	0.83	0.79
Rubble-boulder (%)	0.70	0.76
Gravel (%)	-0.39	-0.24
Embeddedness (%)	-0.14	-0.13
Pool (%)	-0.39	-0.32
Eroded bank (%)	-0.02	0.20
Streamflow (cfs)	0.53	0.42
Width-depth ratio	0.01	0.01
Bank angle (deg)	0.41	0.41
Undercut (ft)	-0.18	-0.12
Can. correlation	0.90	0.96
Likelihood ratio	0.1930	0.0761
Numerator df	11.0	11.0
Denominator df	11.0	3.0
F-value	4.1819	3.3102
Prob. > F	0.0128	0.1767

Figure 1.--Location of the North Fork Humboldt River and major tributaries in the Lahontan Basin of northeastern Nevada.

Figure 2.--Distribution of major landtype associations in the North Fork Humboldt River drainage, northeastern Nevada (base map).

Figure 3.--Streamflow status of the 78 study sites with respect to landtype associations, North Fork Humboldt River drainage, northeastern Nevada.

Figure 4.--Discrimination of study areas by canonical disriminant anslysis of Sedimentary, Volcanic, and Detrital geologic districts classes. Study areas are plotted by lantype association environmental gradients described by the two derived canonical variables, the first (hozontal axis) related principally to elevation, substrate particle size, and embeddedness, the second (vertical axis) related principally to flow and eroded banks.

Figure 5.--Distribution of study areas in by geologic district along gradients of elevation, substrate embeddedness, and streamlow, North Fork Humboldt River drainage, Nevada.

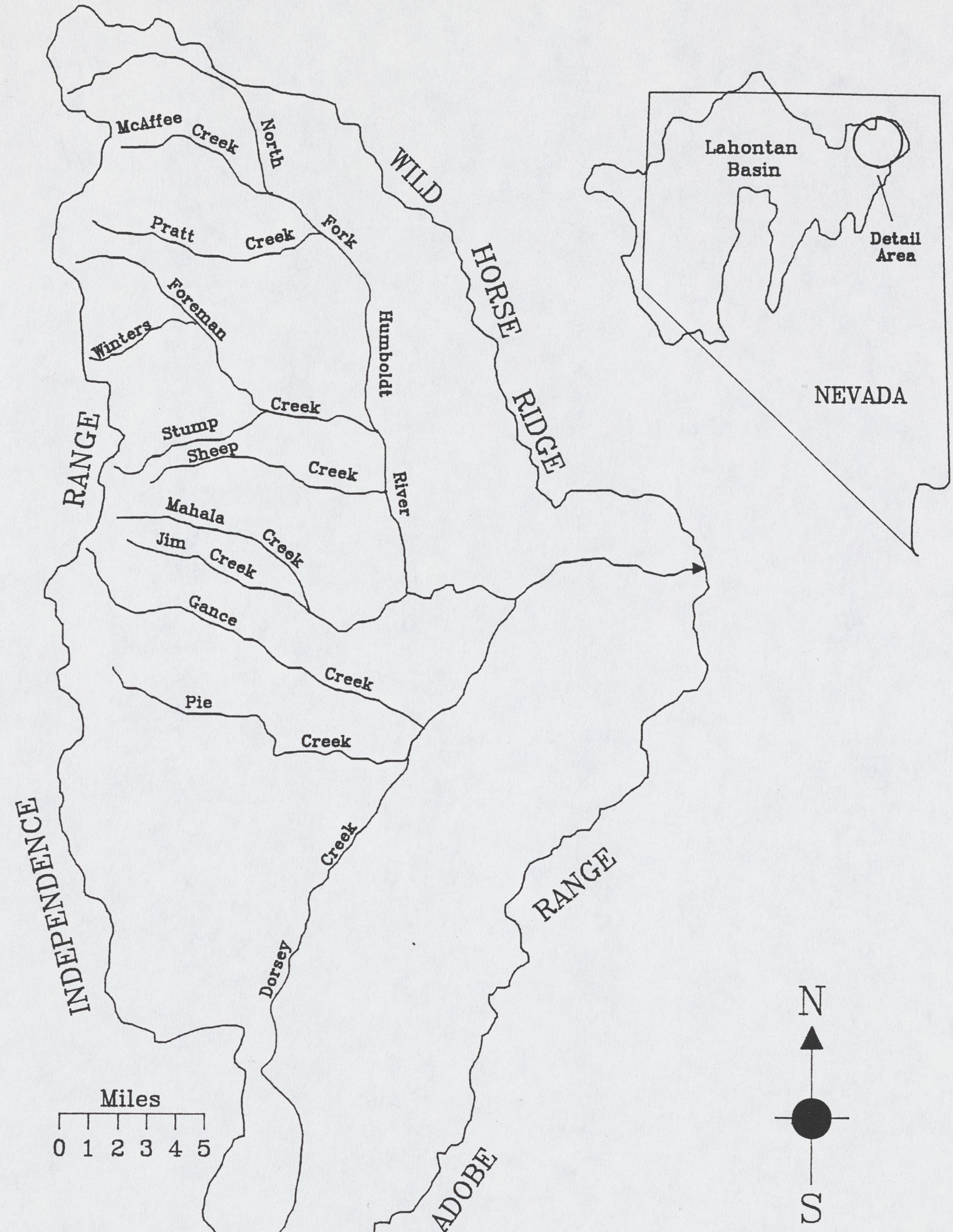
Figure 6.--Distribution of study areas landtype association along gradients of elevation, percent eroded bank, and percent gravel substrate, North Fork Humboldt River drainage, Nevada.

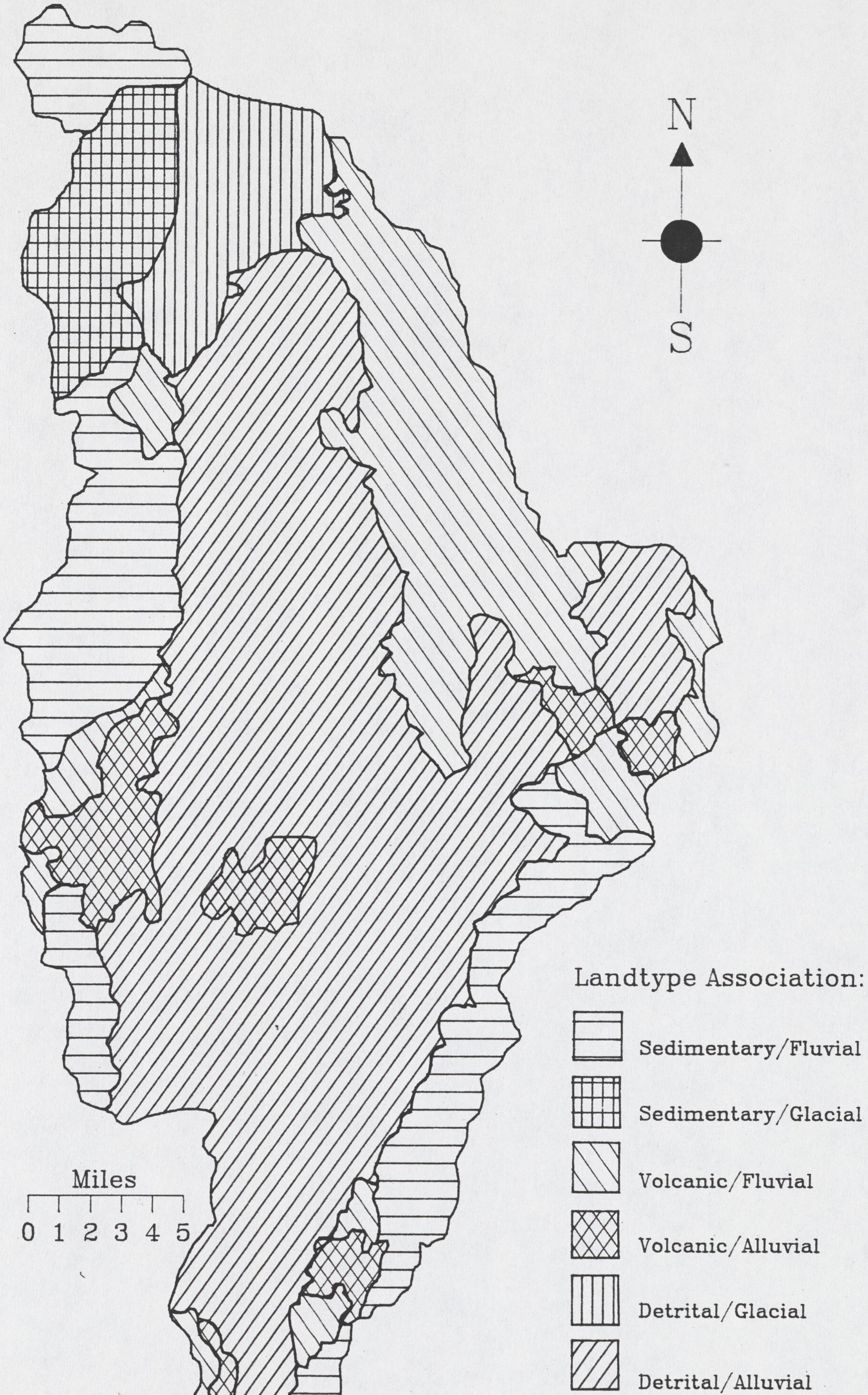
Figure 7.--Distribution trout populations observed in the North Fork Humboldt River drainage, 1987-88, northeastern Nevada.

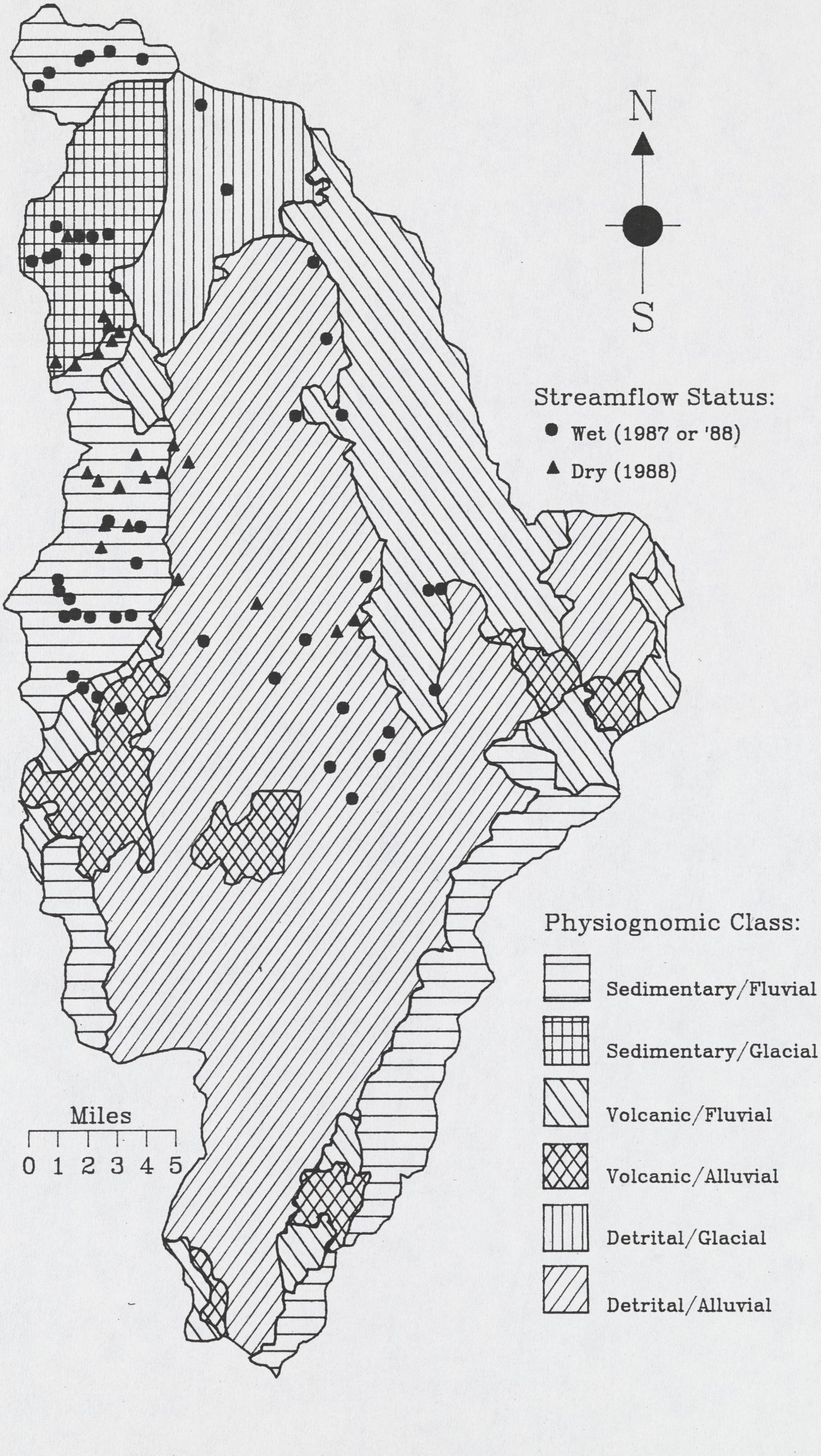
Figure 8.--Distribution of trout species collected in 1987-88, North Fork Humboldt River drainage, northeastern Nevada.

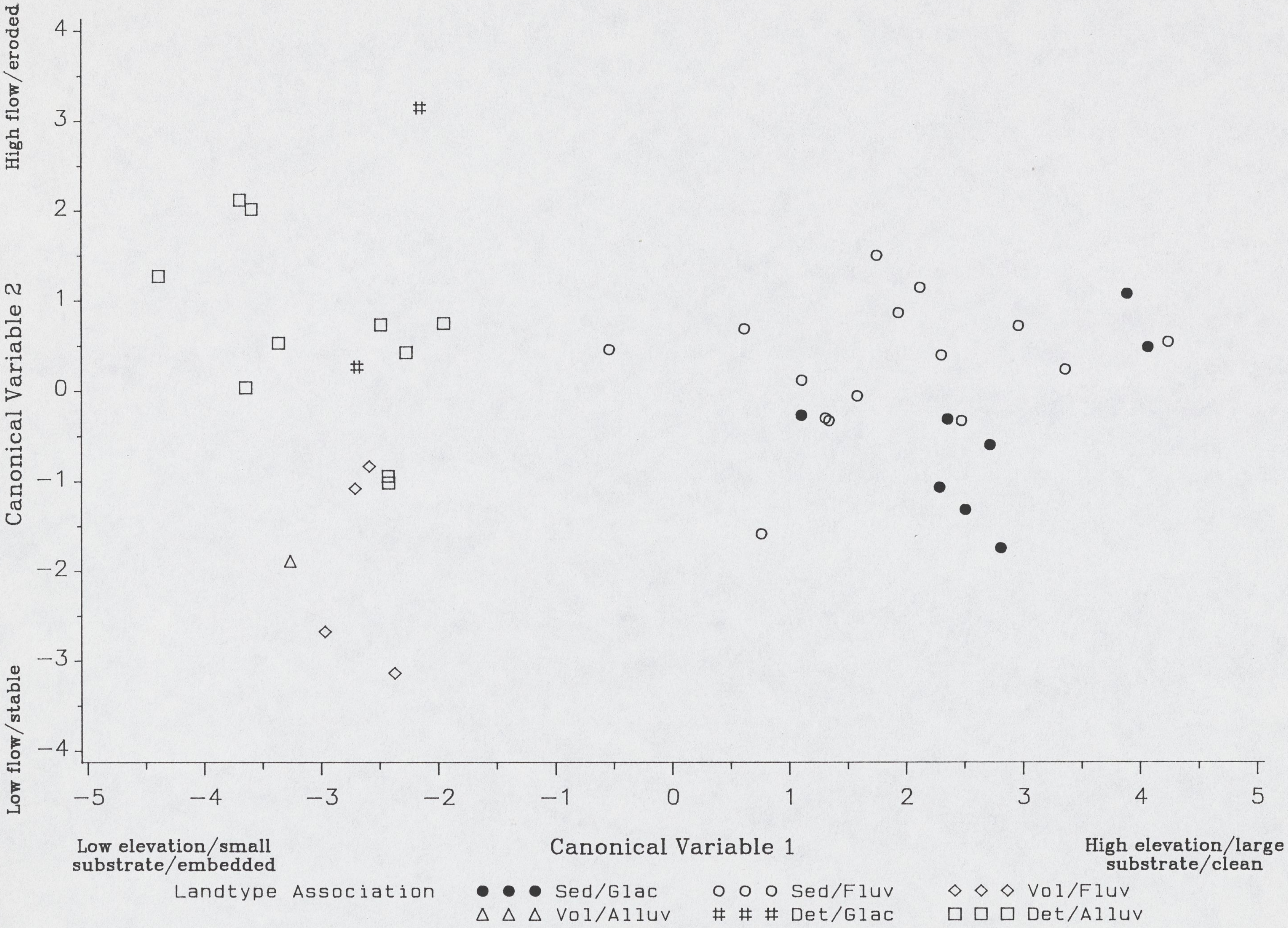
Figure 9.--Distribution of study areas with and without trout populations in the Sedimentary geologic district along gradients of stream width, rubble-boulder substrate, and streamlow, North Fork Humboldt River drainage, Nevada.

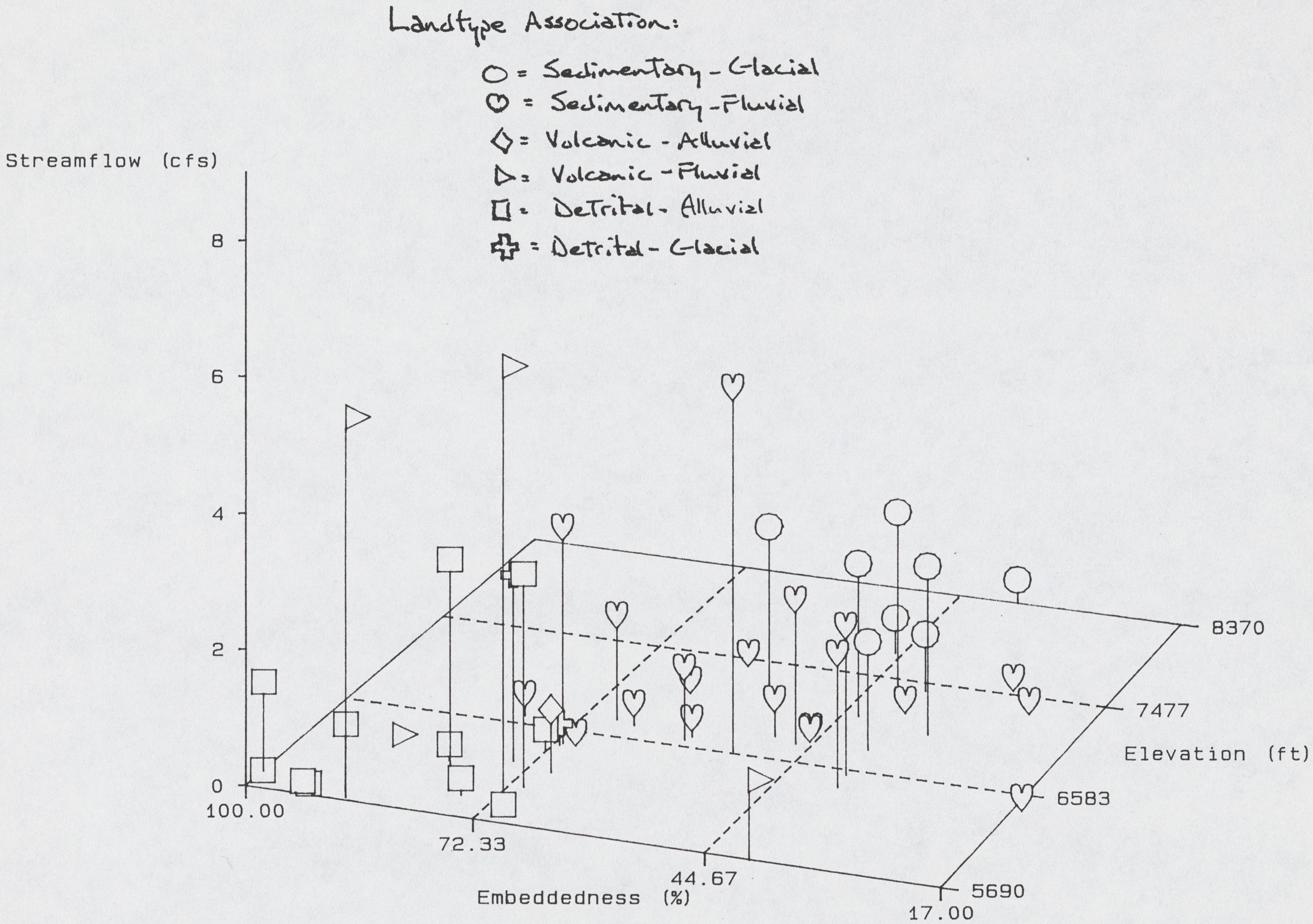
Figure 10.--Distribution of study areas with and without trout populations in the Sedimentary-Fluvial landtype association along gradients of stream width, rubble-boulder substrate, and streamlow, North Fork Humboldt River drainage, Nevada.

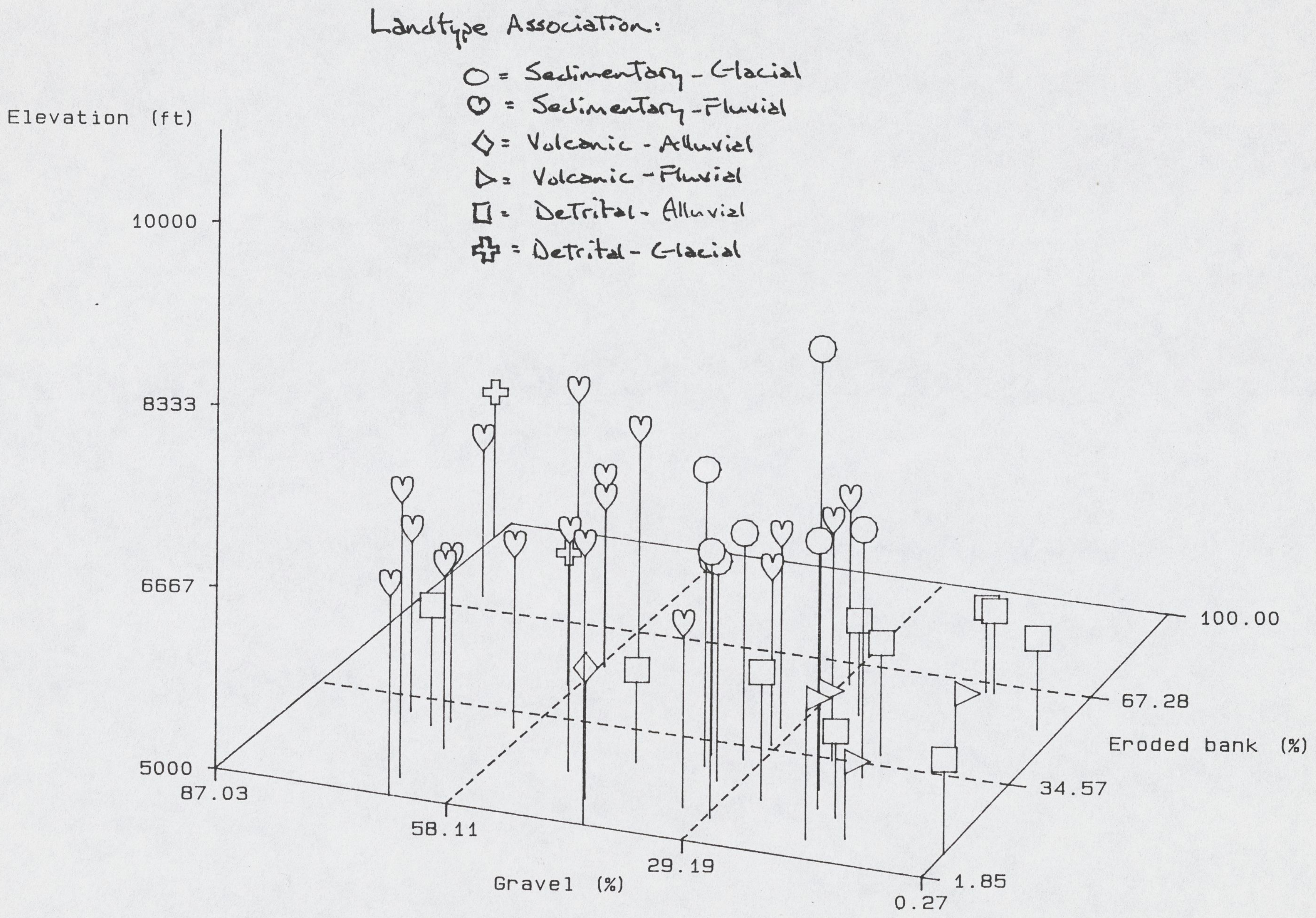

McAffee
Creek
North
Fork
WILD
HORSE
RIDGE
Pratt
Creek
Foreman
Winters
Humboldt
River
Creek
Stump
Sheep
Creek
RANGE
Mahala
Creek
Jim
Creek
Gance
Creek
Pie
Creek
Dorsey
Creek
INDEPENDENCE
RANGE
ADOBE
Lahontan
Basin
Detail
Area
NEVADA
N
S
Miles
0 1 2 3 4 5

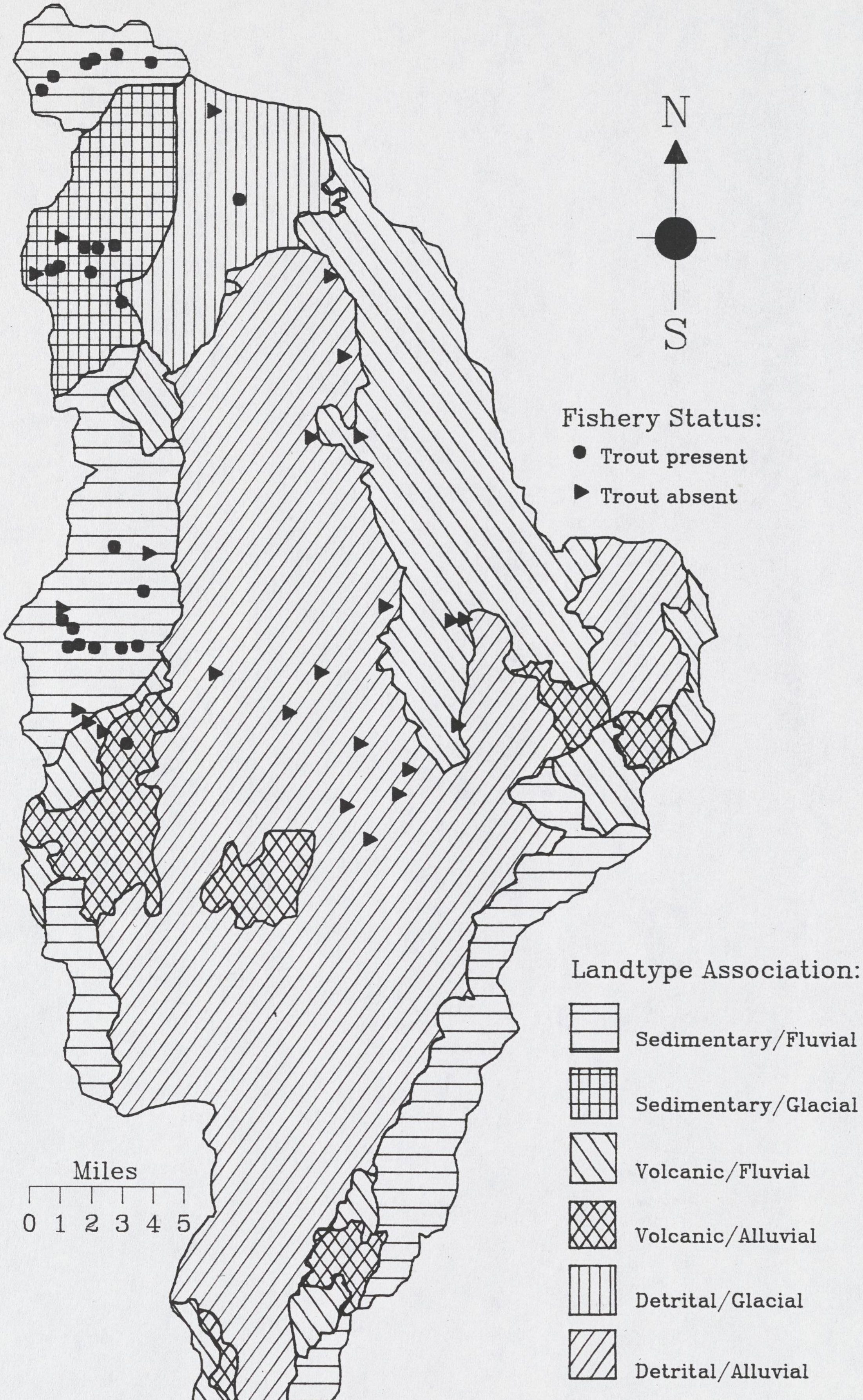

N
S
Miles
0 1 2 3 4 5
Landtype Association:
Sedimentary/Fluvial
Sedimentary/Glacial
Volcanic/Fluvial
Volcanic/Alluvial
Detrital/Glacial
Detrital/Alluvial

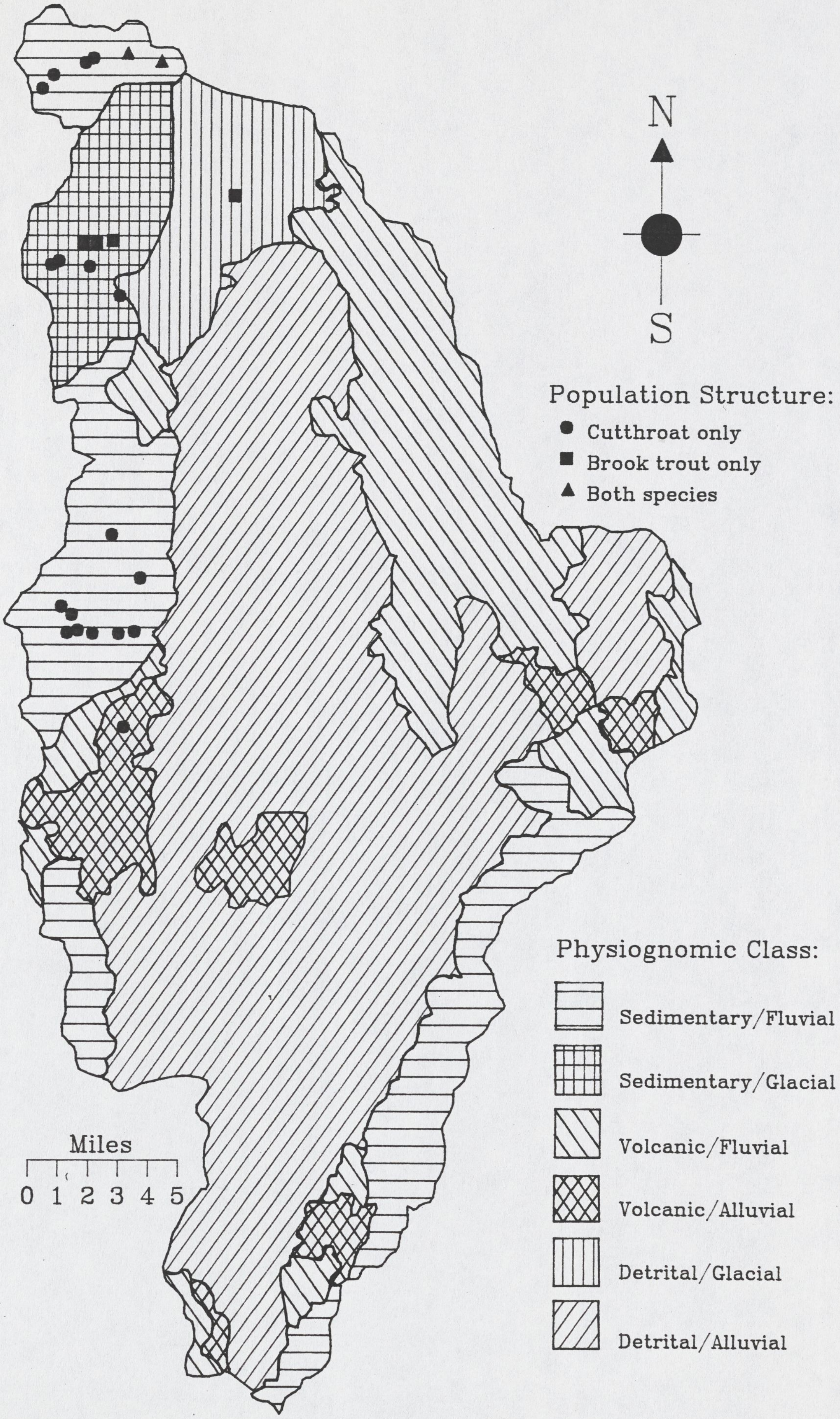

N
S
Streamflow Status:
● Wet (1987 or '88)
▲ Dry (1988)
Physiognomic Class:
Sedimentary/Fluvial
Sedimentary/Glacial
Volcanic/Fluvial
Volcanic/Alluvial
Detrital/Glacial
Detrital/Alluvial
Miles
0 1 2 3 4 5


High flow/eroded
Low flow/stable
Canonical Variable 2
4
3
2
1
0
−1
−2
−3
−4
−5
−4
−3
−2
−1
0
1
2
3
4
5
Low elevation/small substrate/embedded
Canonical Variable 1
High elevation/large substrate/clean
Landtype Association
● ● ● Sed/Glac
○ ○ ○ Sed/Fluv
◇ ◇ ◇ Vol/Fluv
△ △ △ Vol/Alluv
Det/Glac
☐ ☐ ☐ Det/Alluv


Landtype Association:
○ = Sedimentary - Glacial
♡ = Sedimentary - Fluvial
◇ = Volcanic - Alluvial
▷ = Volcanic - Fluvial
□ = Detrital - Alluvial
✚ = Detrital - Glacial
Streamflow (cfs)
8
6
4
2
0
100.00
72.33
44.67
17.00
Embeddedness (%)
5690
6583
7477
8370
Elevation (ft)


Landtype Association:
○ = Sedimentary - Glacial
♡ = Sedimentary - Fluvial
◇ = Volcanic - Alluvial
▷ = Volcanic - Fluvial
□ = Detrital - Alluvial
✚ = Detrital - Glacial
Elevation (ft)
10000
8333
6667
5000
87.03
58.11
29.19
0.27
Gravel (%)
100.00
67.28
34.57
1.85
Eroded bank (%)

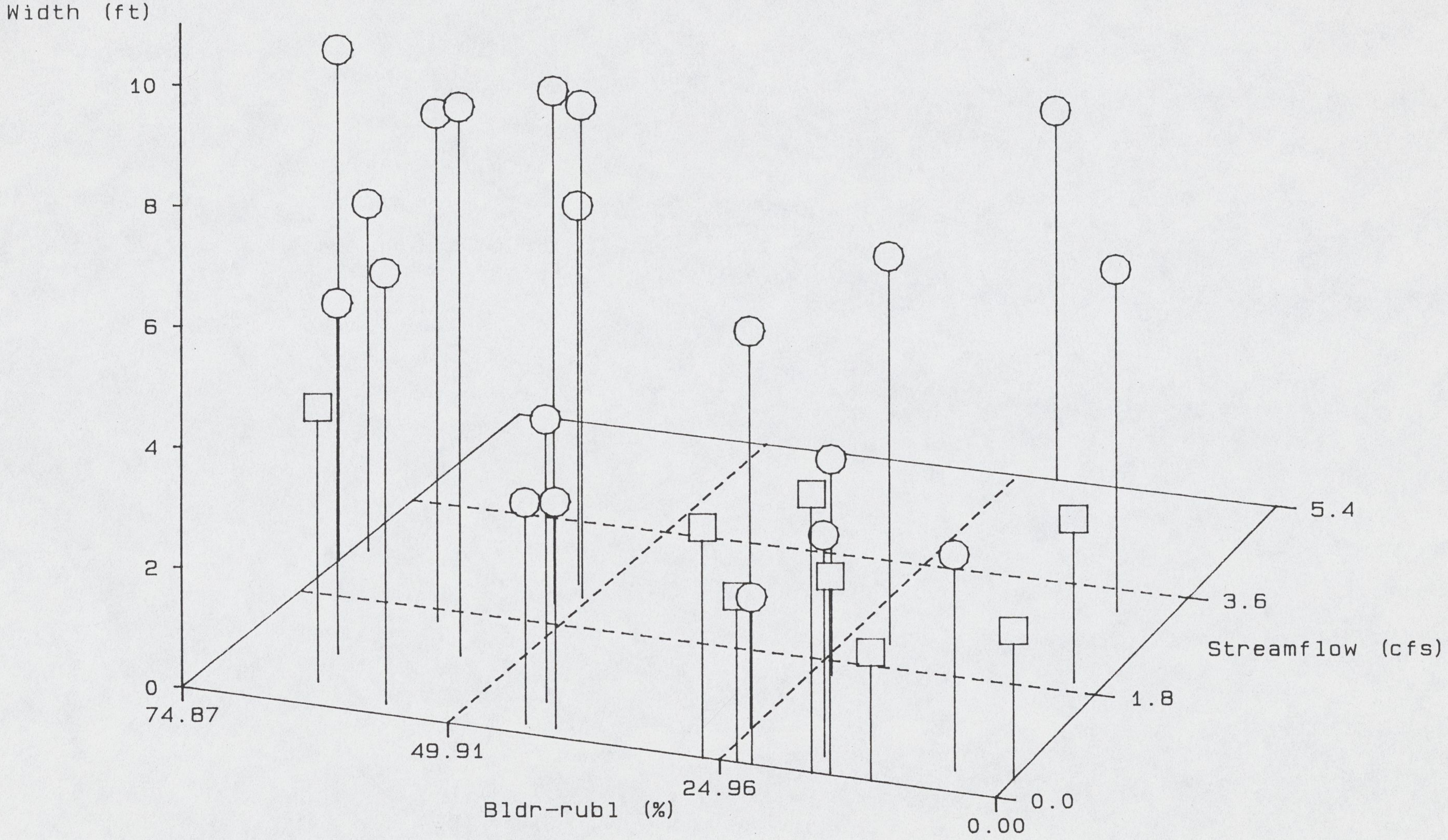

N
S
Fishery Status:
● Trout present
▶ Trout absent
Landtype Association:
Sedimentary/Fluvial
Sedimentary/Glacial
Volcanic/Fluvial
Volcanic/Alluvial
Detrital/Glacial
Detrital/Alluvial
Miles
0 1 2 3 4 5


N
S
Population Structure:
● Cutthroat only
■ Brook trout only
▲ Both species
Physiognomic Class:
Sedimentary/Fluvial
Sedimentary/Glacial
Volcanic/Fluvial
Volcanic/Alluvial
Detrital/Glacial
Detrital/Alluvial
Miles
0 1 2 3 4 5

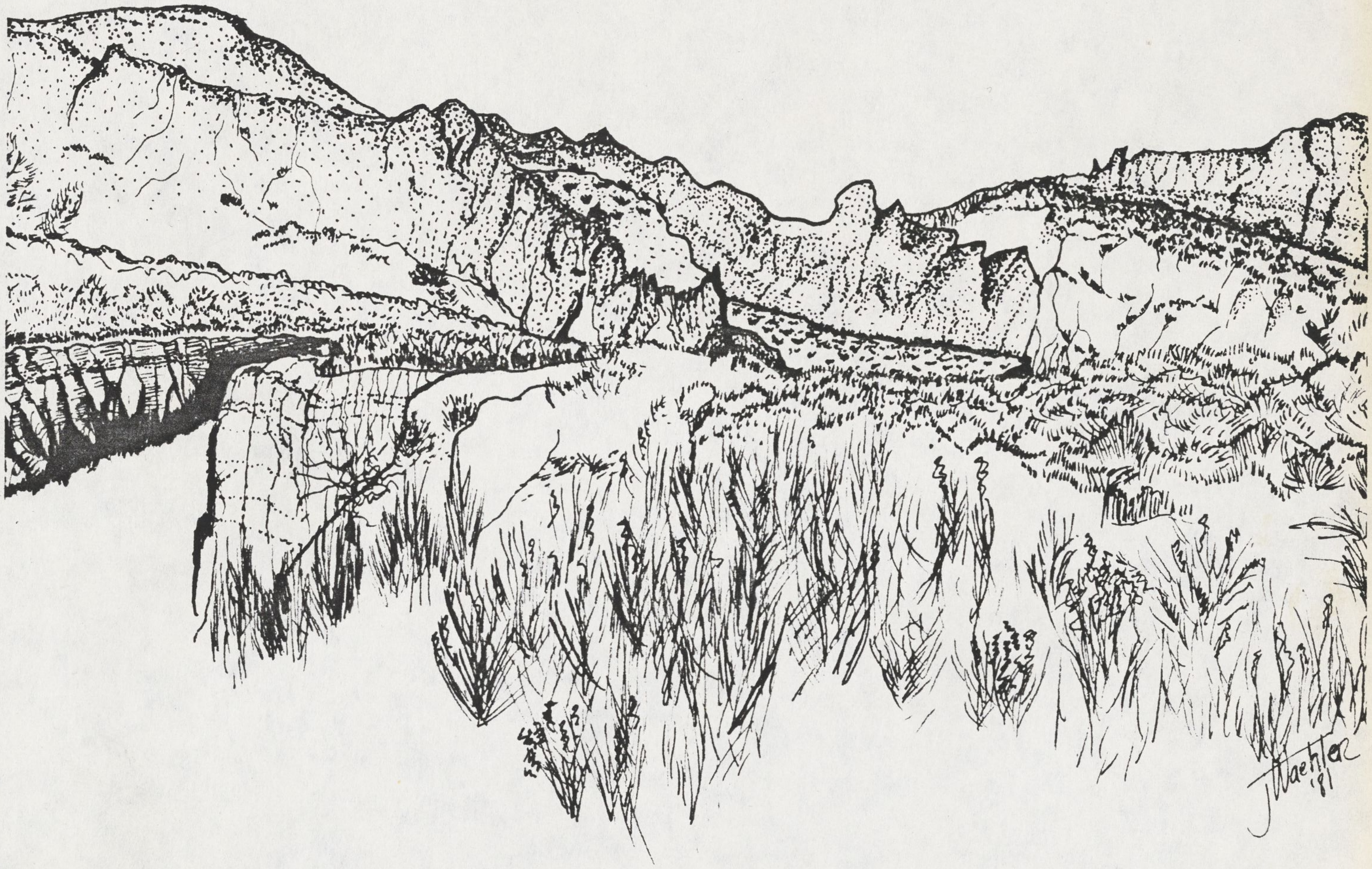
Trout Status:

○ = Present

□ = Absent



CONDOR CANYON PRESERVE



A Proposal From

THE NATURE CONSERVANCY

The universal decline of fishes in all desert areas is more than the tragic demise of a few species. It signals the destruction of the desert's most precious resource: acquatic ecosystems... We must act now...Neither the fishes nor the habitats can be regenerated once they are radically altered or destroyed.

David Soltz

The state of Nevada has long been known for its extensive rangelands and vast expanses of arid open space. Lying at the heart of the basin and range province, the state's alkalai soils, dry lake beds, dune systems and miles and miles of desert shrub vegetation are harsh reminders of the Great Basin's unforgiving environment - an environment which has demanded remarkable adaptability from the few life forms hearty enough to survive in such a dry climate.

In spite of its pervasive aridity, Nevada is also, curiously enough, a land of many outstanding water associated natural areas. Tucked away in the far corners of the state are remarkable spring fed acquatic ecosystems which support unusual desert fish species in some of the most restricted animal habitats in the world. Condor Canyon in Lincoln County ranks as one of the least disturbed of these unique acquatic ecosystems. The Nature Conservancy is now working to assure that Condor Canyon, together with its important rare and endemic fish habitat, is preserved.

IDENTIFICATION

The story of Condor Canyon is the story of the once thought to be extinct Panaca Big Spring spinedace (Lepidomeda mollispinis pratensis).

In 1938, the noted ichthyologists, Dr. Carl Hubbs and Dr. Robert Miller first collected Lepidomeda at the type locality of Big Spring, just a mile northeast of the town of

Panaca. The waters of Big Spring flow at 84° into a large pool which even then was being used as a favorite bathing spot and irrigation source for the community of Panaca.

The spinedace Dr. Hubbs and Dr. Miller found in 1938 were small fish, 48 to 56 mm long, distinguished by hard spines on the leading rays of their dorsal and pelvic fins, a bright silvery color overall, and a tendency to have distinctive lemon to orange coloration on their tail fins. Using exact morphological measurements, the two ichthyologists concluded that the spinedace in the Panaca Big Spring were clearly different from other members of their species. Remarkably, by being isolated in the relatively small Panaca Big Spring habitat since the close of the Pleistocene 15,000 to 20,000 years ago, these fish had developed into a distinct subspecies.

A few years after Dr. Hubbs and Dr. Miller's first visit to Panaca, the town Council members decided to "clean out" and divert Big Spring so as to make it more "sanitary" as a swimming hole and more effective as a source of irrigation water. The result of this unfortunate decision was the apparent extinction and actual extirpation of the species. Upon their return in 1959, the two ichthyologists collected a few endemic mountainsuckers (Pantosteus) and an impressive number of endemic speckled dace (Rhinichthys osculus), but not one Lepidomeda was found. After an extensive search and inventory of neighboring acquatic systems, the two men officially declared Lepidomeda extinct.

RESURRECTION

For 19 years, ichthyologists assumed the Panaca spinedace had gone the way of the passenger pigeon until a remarkable occurrence took place which rekindled hope for the once abundant Lepidomeda.

In the fall of 1978, Mr. Cal Allen of the Nevada Division of Wildlife was conducting a stream survey near Panaca when he decided to follow Meadow Valley Wash well into the northern reaches of Condor Canyon past what may have been its prehistoric juncture with Big Spring. Perhaps, Cal Allen reasoned, collections had never been made along the entire course of Meadow Valley Wash. A relict population of Lepidomeda might have survived close to the stream's northernmost spring source.

Much to his delight, Cal Allen did indeed happen upon a healthy population of Lepidomeda approximately one mile south of the head of the Canyon in a large pool at the base of a 20 ft waterfall. The once thought to be extinct species had been rediscovered.

PROTECTION

In the fall of 1981, The Nature Conservancy began investigating ways to assure the long term viability of Lepidomeda's Condor Canyon habitat. Apart from its resurrected fish species, Condor Canyon supports healthy populations of the same endemic mountainsuckers and speckled dace which Dr. Hubbs and Dr. Miller identified in 1938 and 1959. The Canyon's scenic 200 to 300 foot walls, its willows, box elders and cattails, its bobcats, quail and visiting ducks - all combine to highlight the biological significance of this remarkable natural area. Most importantly, the stretch of Meadow Valley Wash running through Condor Canyon is one of the few sections of stream in Nevada which is totally free of exotic fish species.

After careful study, Conservancy field representatives have concluded that the proper protection of Condor Canyon will require acquiring some private land and securing water rights over 3 miles of Meadow Valley Wash. Though the southern portion of the Canyon is in public ownership, private ownership of important northern parcels close to the stream's spring source presents threats to the Canyon's important fish habitat downstream.

On June 24, 1981, the Conservancy was able to negotiate an option for a key 40 acre parcel near the head of the Canyon which supports some of the best fish habitat. Optioning this property has allowed the Conservancy to file for water rights over 2 3/4 miles of additional fish habitat downstream from TNC's proposed preserve on public land.

If sufficient funds are obtained, the Conservancy will exercise its Condor Canyon option on December 1, 1981. The end result will be the protection of an extensive natural area larger than the proposed preserve property itself for the modest cost of one 40 acre acquisition and an extended water rights application. TNC's ownership of the 40 acre parcel will make possible the protection of in-stream flow water rights over the entire length of Condor Canyon's important fish habitat.

THE NEED

The following budget summarizes Conservancy protection costs for our proposed Condor Canyon Preserve:

Land Acquisition	$10,000
Water Rights	3,000
Stewardship Endowment	5,000
TOTAL	$18,000

Fortunately, due to the high priority of this project, $4,000 in surplus funds from other projects in the Western Region has been credited to TNC's Condor Canyon account. As a result, the total fundraising goal for Condor Canyon is $14,000. This amount must be received before December 1, 1981.

Few preservation projects in the Great Basin deserve support more. The Conservancy's proposed Condor Canyon Preserve protects a once thought to be extinct species, two other fish species which are endemic to the region, an impressive desert acquatic system free from exotics and an important natural area overall.

Please lend your support. Send contributions to:

The Nature Conservancy
Condor Canyon Project
156 2nd Street, 5th Floor
San Francisco, CA 94105

52
17
$69 — Furnace Crk Lodge 3 nites

43(63) - Aladdin hotel - 2 nites

-$125 vgs L.V.
-$30 - D.V.
-$140-meals
21 parking
32 mileage
149- air fare
— rept. —