

Final Report to National Park Service and
Cooperative Research Unit
Utah State University on

ECOLOGICAL SURVEY AND ANALYSIS
OF THE AQUATIC AND RIPARIAN
FAUNA AND FLORA OF
ESCALANTE CANYON, UTAH

Regarding

Contract No. CS 12004 B035³⁴

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INTRODUCTION

Proposed energy developments, are placing heavy burdens on the desert ecosystems of Southwestern United States. Coal fired electrical plants and the resultant coal mines are major perturbations proposed for Southern Utah's deserts and high plateaus. Unfortunately little is known of the environmental consequences of such disturbances, especially concerning aquatic ecosystems.

The present study surveyed the aquatic fauna and flora of Escalante Canyon in south central Utah. Dams have been proposed that would affect the Escalante River and its tributaries. The dams are for water storage for coal fired electrical plants. The study was made to determine the composition of the aquatic ecosystem of Escalante Canyon and probable changes if flash flooding and river level were decreased. Emphasis was placed on fishes in the river and plants in the riparian community. This final report details the findings to date.

STUDY AREA

Location and Extent:

The Escalante River is located within western Kane and Garfield counties, latitudes $37^{\circ} 30''$ - $37^{\circ} 45''$, longitudes $111^{\circ} 30''$ - $111^{\circ} 45''$. The upper river runs in an east-west direction from the Table Cliffs to the town of Escalante with major tributaries entering from the Aquarius Plateau to the north. From here the river runs in a north-south direction to Lake Powell. Major tributaries enter this section of the river from the west and east in an east-west manner.

The study area is the lower 80 km. of the Escalante River from Harris Wash to Coyote Wash. Sampling started 200 m. above the mouth of Silver Falls Creek, on the Escalante, and ended on the Escalante 200 m. below the mouth of Coyote Wash. Sampling included the river channel and the riparian community along the edge of the river.

Administration and Use:

The river, north of Harris Wash is administered by the Bureau of Land Management, Kanab District. Most of Harris Wash and the Escalante River down to and including Coyote Wash are administered by the Park Service through the Glen Canyon National Recreation Area (GCNRA). Below Coyote Wash, the canyon is mostly flooded by Lake Powell and comes under the jurisdiction of the GCNRA.

Land use along the Escalante is primarily confined to cattle grazing, backpacking and horse travel. Grazing exists to about 15 km. below Harris Wash from which point terrain becomes unsuitable for cattle. Backpacking and horse travel for the scenic amenities are probably the most important uses at present. Due to the recent publicity in the Escalante area, and its unique wilderness situation, backpacking and backpacking activities have become much more popular and constitute the major land use on the lower Escalante.

Topography and Geology:

Within the study area, several distinct stratigraphic units can be differentiated. These units have a distinct effect on the physical appearance of the river canyon and are important in determining canyon cross section, width, depth, stream gradient, and alluvial-colluvial deposits, hence influencing the flora and fauna.

From 0-15 km. the river character is influenced by the Navajo and Kayenta formations. Harris Wash also cuts through these formations. The Navajo is a very resistant sandstone and downcutting through this section has been slow. Similarly, the Kayenta is also resistant but less so than the Navajo. This has given the canyon a very broad floor 90-150 m. wide with headwalls as wide as one-half km. Meanders traverse the canyon floor but do not touch the canyon side walls. The stream gradient is 3.0 m/km. Alluvial deposits are extensive, consisting mostly of sand and silt sized particles. Colluvial deposits are lacking due to the resistant nature of the sandstone.

From 15-43 km., the canyon cuts through the Windgate Formation. In this section, the canyon narrows, meanders less and has a greater stream gradient of 5.0 m/km. Entrenchment within the canyon is greater with almost no meandering from side wall to side wall. Canyon profile is different from the previous section with canyon width being narrower.

The river enters the Chinle Formation at 43 km. and continues through this section until the 58 km. mark. It is apparent that the Chinle Formation has formed a small anticline at this point, which the river cuts into but does not pass through. The Chinle is a moderately soft limestone formation that is easily eroded. The canyon opens through this section, but the river remains entrenched. The river does not meander within the canyon probably due to the soft nature of the limestone that allows rapid downcutting.

From 58 km. to Lake Powell, the river re-enters the Windgate Formation. Canyon characteristics are very similar to those found upstream where the River had previously cut the Windgate Formation.

Plant Community:

Vegetation in the study area can be broken down into two types: the riparian community and the desert-shrub community.

The riparian community exists within the influence of the river's water table and is confined to areas along the river bank. The width of the riparian community varies and is dependent on the river bank gradient; a gentle river bank having a wider riparian community than a steeper bank. Those plant species influenced by the river's water table usually require their root mass to be at or near the water table. Some, but not all, are phreatophytes.

The desert shrub community begins where the river bank is high enough so that plants are no longer influenced by the river's water table. This community is not, however, the subject of discussion since it is not directly influenced by the Escalante.

METHODS

Escalante Canyon is a roadless area with few access points. Foot travel is the only viable method of traversing through the study area. Access was gained through Harris Wash and through Coyote Wash. All sampling and camping equipment was backpacked and hand carried.

Riparian Community:

Sampling techniques for investigating the riparian community were modified from West et al., 1974. Macroplots were located, transects were set up within macroplots, and microplots were observed along each transect. Plant species were identified and measurements were taken to determine plant cover and density.

From preliminary observations, at which time presence-absence transects were taken, it was decided that a macroplot would be located every 3 km. along the river. Macroplot size was 50 m. long by 20 m. wide, the length parallelling the river. Approximate locations of the macroplots were determined from 7.5 and 15 minute maps upon which kilometer markings had been laid out. Tossing a stone located the beginning of the macroplot with the length running downstream from that point. Stream direction, side of bank sampled, rock formation, and stream gradient were recorded at this time. Also, estimations of various percent covers on the macroplot were taken at this time.

Transects were set up as follows: Previous to reaching the macroplot, three numbers spaced between increments of 17 were taken from 1-50. A measuring tape was laid out from the beginning of the macroplot so that 0 and 50 meters were exactly 10 meters from the river edge. The three numbers were then located along the tape and staked. These points were the midpoints of the three transects. Next, the tape was laid perpendicular to the previously measured line for 20 meters and staked so that the 10 meter mark was exactly at the mid point. This was the transect line for the microplots. The low and medium flood marks were recorded for distance in from the river edge and height above the river.

Microplots were laid side by side and measured 1 m. long by 2 m. wide. Microplots were always taken on the downstream side of the transect. Tree, shrub, and forb data were taken within this plot. Grass data was taken in a plot 50 cm. by 20 cm. on the right side adjacent to the baseline. A point-frame was used to measure ground cover at each meter mark; on the transect baseline and one-half meter from the transect.

Cover measurements were estimated with the aid of a frame that represented 5 and 10% of the microplot. Density measurements were taken by counting individual stems above the ground except bunch grasses which were counted by the bunch. Along with this information, plant species were collected each time a new one was encountered and measured.

Aquatic Community:

Sampling was conducted on two trips through the study area. Trip 1 (July 2-8) consisted of fish and plant sampling. Originally every other km was to be a sampling station, but longitudinal variation was small so stations were set further apart. Every other km was used to km 12, every third thereafter. The weather was clear and hot and the river was clear. Fish were sampled with a 30'x4'x1/4" seine, only species composition was noted. Fish were easily seen throughout the trip allowing for presence data to be obtained in deep holes or areas otherwise unsuited to seining.

Trip 2 (July 19-23) consisted of quantitative fish sampling in 14 sites. The weather was cloudy, rainy and the river was extremely turbid. Flash flooding occurred several times. Each site was seined several times to estimate population composition and size. An additional 12'x10'x3/8" seine was used for deep holes. Species and total length of fish were noted. The Escalante River is composed of three major habitat types, deep pool, riffle and shallow sand run. Each was sampled throughout the study area to determine changes in populations longitudinally in the stream. The data did not lend itself to formal population estimates so the number caught in the first three seine hauls at each site was used as a population index. These figures were considered good estimates because fish numbers

were generally small and the three seine hauls usually caught most of the fish present. Also information gathered during Trip 1 led credence to this index.

RESULTS

Riparian Community:

A discussion of results related to the riparian community will be treated in two parts. The first is floristic listings of the plant species found in the lower Escalante River Canyon. Second, is a discussion of the possible relationships of plant species to the riparian community subtypes. These relationships, however, are still not clearly understood and further investigation is required before they can be completely defined.

In the first two trips down the river, general observations were made and the presence-absence transects were taken every 3 km. From this was compiled a complete species list of plants encountered in the riparian community of the lower Escalante. This was further supplemented on the third trip at which time sampling was made on plant cover and density.

The first floristic listing is all plants encountered in the riparian community. Most of these species are not confined to the riparian community and are found elsewhere. However, these plants obtain maximum growth and development within the riparian community. The second listing is of species that are endemic to the riparian community and can not survive outside the influence of the river's water table. Within each listing, vegetation is clustered into three major divisions; trees

and shrubs and grasses including Carex and Juncus and forbs

Trees and Shrubs

Salix exigua
S. amygdaloides
Tamarix pentandra
Populus fremontii
Quercus gambelii
Baccharis emoryi
Chrysothamnus nauseosus

Grasses

Poaceae

Distichlis stricta
Muhlenburgia asperifolia
Ploypogon monospleniensis
Agrostis semiverticillata
A. paulustris
Panicum virgatum
Hordeum jubatum
Bromus tectorum
Elymus canadensis
Echinochloa crusgalli
Cenchrus pauciflorus
Orizopsis hymenoides
Sporobolus contractus

Juncaceae

Juncus torreyi
Juncus bufonius
Juncus tracyi

Equisetaceae

Equisetum arvense
Equisetum laevigatum

Typhaceae

Typha latifolia

Cyperaceae

Scirpus americanus

Forbs

Melilotus officinalis
Melilotus alba
Fraxinus anomala
Franseria acanthicarpa
Conyza canadensis
Ranunculus cymbalaria
Plantago major
Polygonum lapithifolium
Kochia scoparia
Lepidum montanum
Corispermum hyssopifolium
Apocynum cannabinum
Medicago lupulina
Medicago sativa
Cleome lutea
Plantago purshii
Euphorbia parryi
Castilleja linariaefolia
Veronica anagalis
Heliotropium convolvulaceum
Epilobium adenocaulon
Rorripa nasturtium
Gnaphalium palustre
Eriogonum inflatum
Xanthium officinales
Taraxacum officinales
Axcelepias speciosa
Salsola kali
Dicoria canescens
Petalostemum flavescens
Mentzelia pumila
Oenothera hookeri
Ranunculus cymbalaria
Castilleja linariaefolia
Veronica anagalis
Eriogonum inflatum
Oenothera hookeri

Those species endemic to the riparian community are grouped as follows:

Trees and shrubs:

Salix exigua
Salix amygdaloides
Tamarix penotandra
Populus fremontii - in shrub form
Baccaris emoryi

Grasses

Junacaceae

Juncus torreyi

Juncus bufonicus

Juncus tracyi

Equisetaceae

Equisetum arvense

Equisetum laevigatum

Cyperaceae

Scirpus americanus

Forbs

No forbs were found that were strictly confined to the riparian community; however, Melilotus alba and Franseria acanthicarpa thrive best within this community.

Those species confined to the riparian community are of principle concern and probably constitute the most ecologically important species within the riparian community. It is these species with which subsequent analysis deals.

The next step in the analysis of data was to cluster by Ecudidian distance using methods derived from Ward and described by Pyott (1972). Clustering was done, on presence-absence data, on a weighted group basis starting with the two individual species having the lowest index value of similarity. Table 1 is a dendogram of microplots clustered on the basis of plant species.

The groups can be delineated with an index of similarity of 16 from the dendogram based on vegetation similarities.

1. Immature Salix and Tamarix
2. Mature Populus and Tamarix
3. Adolescent Salix, Populus, and Tamarix
4. Immature Tamarix, Franseria, and Melilotus alba

5. Mature Melilotus alba with understory of Muhlenburgia asperifolia.
6. rock walls, water, or clay slicks.
7. Mature Salix and Chrysothamnus nauseosus with understory of Distichlis stricta.
8. Adolescent and mature Salix and Tamarix with understory of immature Franseria.
9. Immature, adolescent, and mature Tamarix and Baccharis.
10. Immature and adolescent Salix with understory of Scirpus and Equisetum.

For ease in interpretation four major categories based on the ten above can be derived with an index of similarity equal to 28. Percent cover for important species in each community subtype are shown in Table 2.

Groups 1-4 can be collapsed to yield community subtype A. Adolescent and mature Salix, Populus, and Tamarix with an understory of Salix, Tamarix, Franseria, and Melilotus.

Groups 5 and 7 collapse into community subtype B: mature Salix, Chrysotamnus nauseosus, and Melilotus with an understory of Muhlenburgia asperifolia and Distichlis stricta.

Groups 8 and 9 collapse into community subtype C: immature, adolescent, and mature Salix, Tamarix, and Baccharis with an understory of Franseria, Melilotus, and Conyza.

Community subtype D is composed of group 10: immature and adolescent Salix with understory of Scirpus and Equisetum.

In order to understand the relationships of each community subtype one must resort to investigating the environmental gradients surrounding each community subtype. From combining the information in Tables 1 and 2 with environmental gradients of geology, hydrologic flow, and stream bank gradients each community subtype can be understood.

COMMUNITY SUBTYPE

Species	A	B	C	D
I <u>Salix exigua</u>	.46	.05	.30	<u>15.28</u>
A <u>S. exigua</u>	.81	.14	<u>3.98</u>	<u>4.24</u>
M <u>S. exigua</u>	<u>1.68</u>	<u>8.94</u>	<u>6.20</u>	.36
I <u>Populus fremontii</u>	.09	.13	.08	.75
A <u>P. fremontii</u>	<u>1.04</u>	.17	.40	.17
M <u>P. fremontii</u>	<u>1.85</u>	.25	.30	.00
I <u>Tamarix pentandra</u>	.22	.26	<u>1.8</u>	.46
A <u>T. pentandra</u>	<u>1.69</u>	.30	.46	.46
M <u>T. pentandra</u>	.98	<u>1.40</u>	<u>.86</u>	.05
<u>Baccharis emoryi</u>	.00	.00	<u>2.21</u>	.05
<u>Chrysothamnus naseosus</u>	.14	<u>2.58</u>	.54	.02
<u>Scirpus americanus</u>	.10	.00	.13	<u>6.47</u>
<u>Equisetum arvense</u>	.13	.00	.05	<u>2.36</u>
<u>Distichlis stricta</u>	.05	<u>3.37</u>	.32	.01
<u>Muhlenbergia asperfolia</u>	.10	<u>2.11</u>	.19	.10
<u>Melilotus alba</u>	<u>6.01</u>	<u>8.07</u>	<u>.87</u>	.33
<u>Franseria acanthicarpa</u>	<u>5.43</u>	<u>4.43</u>	<u>1.01</u>	.27

Table 2. Mean Percent Cover for Plant Species Occurring in More Than 20% of the Microplots by Community Subtype Cover is on Basis of 1x2 Meter Microplot.

The first of these delineations is the apparent correlation of the rock strata to the vegetation. Those formations composed of sandstone (Navajo, Kayenta and Windgate) seem to have a different influences than the Chinle formation which is composed mainly of limestone. Within these formations, community subtypes A, D, and B occur.

In the Navajo and Kayenta Formations, Salix exigua and Populus fremontii seem to be the most abundant. Species of each exist from seedlings through maturity. Baccharis emoryi essentially does not exist and Tamarix pentandra is not very abundant. Tamarix pentandra occurs only in mature forms. Scirpus americanus and Equisetum arvense as every abundant peripheral to the river edge, as in community subtype D.

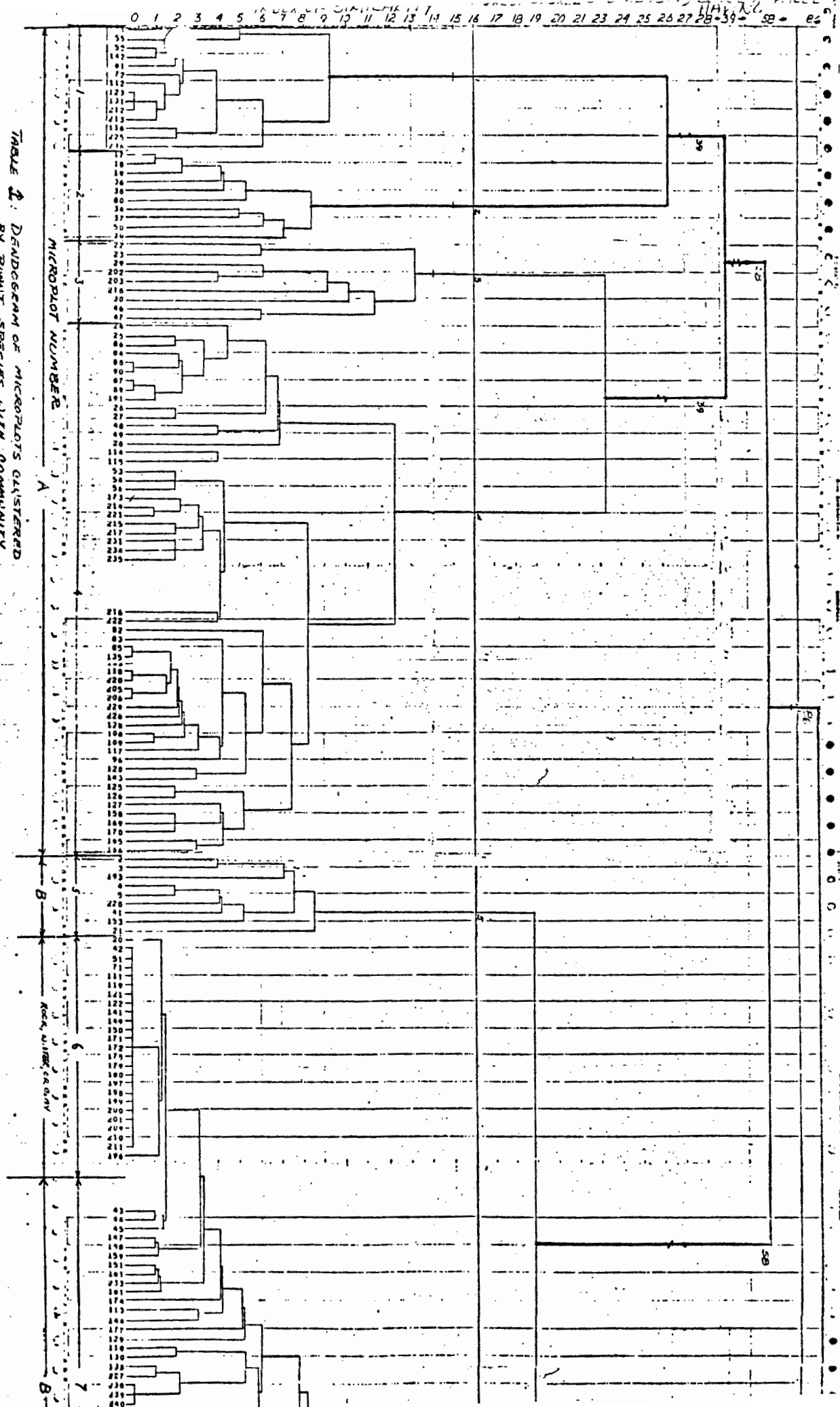
In the Windgate formation species composition remains approximately the same. However, Tamarix pentandra is no longer present. Baccharis emoryi still does not exist.

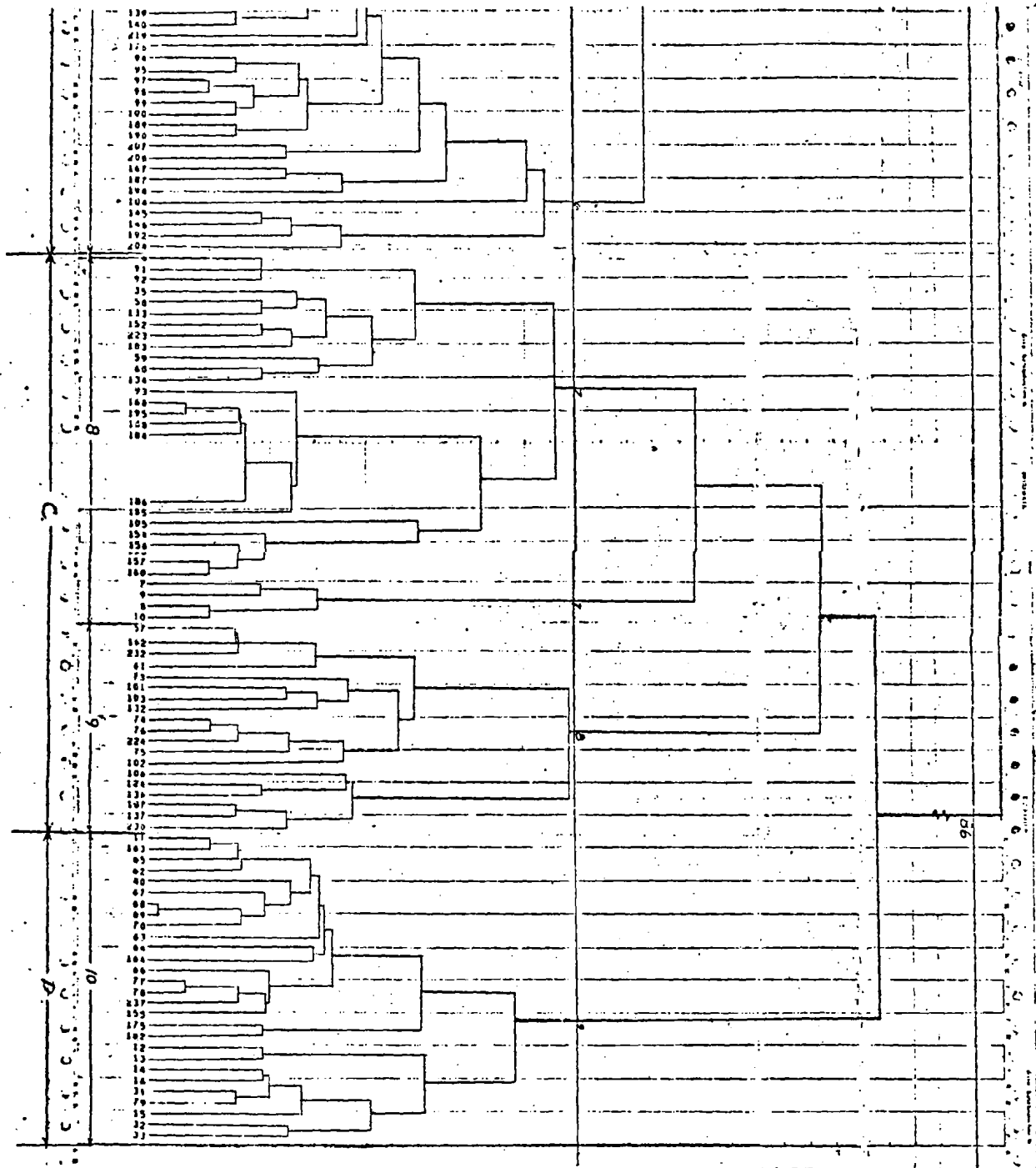
In the Chinle formation, species composition changes and community subtype C appears. Populus fremontii is essentially nonexistent. Baccharis emoryi occurs for the first time and through this section. It along with Salix and Tamarix becomes the dominant plant species. Tamarix pentandra increases in abundance as compared to previous sections.

When the river returns into the Windgate formation, species composition returns to that prior to the Chinle formation. Baccharis emoryi decreases in abundance until it is nonexistent. Tamarix also appears to decrease in abundance, but occurs with greater frequency than in the previous sandstone formations.

The next major stratification is an apparent age-class structure of plant species within macroplots. No age-class structure has yet been determined but estimates were made on a visual bases. This stratification

TABLE 1. DENDROGRAM OF MICROPLOTS CLUSTERED BY PLANT SPECIES WITH COMMUNITY SUBTYPES DELINEATED.





seems to exist throughout the canyon but is more pronounced in the narrower sections of the Canyon. Reasons for these stratifications are not yet clearly understood but are probably related to periodic flooding. Further investigations should define this relationship.

The first zone occurs along the river edge and is represented best by community subtype D and in part community subtype A. This zone is dominated with Scirpus americanus and seedlings of Salix exigua, Tamarix pentandra and Populus fremontii. Baccharis emoryi seedlings were also found in the limestone section of the canyon. Equisetum species, Typha latifolia and Juncus species were primarily confined to this zone.

The second zone represented by community subtype A was predominantly made up of adolescent plants of fairly young age. All riparian and other species occur in this zone and are generally more mature than the vegetation in the previous zone.

The last zone moving away from the river is represented by community subtype B consisted of all species growing in a mature state. Populus, Tamarix and Salix are all in a shrub form with one major stem and many suckers. In this zone, Melilotus officinales and Melilotus alba occur in the mature form, as does Franseria acanthicarpa. Chrysothamnus nauseosus invades this zone from the desert shrub community and reaches maximum development.

Aquatic Community

Ten species of fish were collected in Escalante Canyon. Only four of these are native; flannelmouth sucker - Catostomus latipinnis, bluehead sucker - C. disocobolus, roundtail chub - Gila robusta robusta and speckled dace - Rhinichthys osculus. The flannelmouth sucker was the

most common indigenous species, whereas the introduced red shiner - Notropis lutrensis was the most abundant species in the study area (Table 3).

Distribution of native and introduced species different. Native forms were most abundant in the upper part of the study area, introduced fishes in the lower part (Table 3). The diversity of species also varied by being higher (more species) in the upper part. All four native species were relatively abundant in the upper area whereas the red shiner dominated the lower area.

Species Accounts

Roundtail Chub - *Gila robusta robusta* Baird and Girard. Roundtail chubs were common to abundant in the upper part of the study area (Table 3). Few were collected or seen below km 30. Three size classes were noted, 30-50 mm, 70-120 mm and 160+ mm. The juveniles (30-120 mm) were most abundant in sand or sand and rock runs, whereas adults (160+ mm) were almost exclusively in deep pools. The 70-120 mm size class was the most abundant, sampling gear probably sampled this group most effectively.

Speckled Dace - *Rhinichthys osculus*. Speckled dace were found throughout the study area but were most common in the upper 30 km. They were collected in all habitat types. Two size classes were found, juveniles 30-50 mm and adults 55-80 mm. Juveniles were usually found in slower water; sand runs and edges of pools. Adults were typically found in riffles. Few juveniles were found below km 30 although adults were common throughout the study area.

Flannelmouth Sucker - *Catostomus latipinnis*. Flannelmouth suckers were found throughout the study area but were most abundant above km 30 where they dominated the stream, especially in biomass. Three size classes

Station	Km	Roundtail Chub			Speckled Dace		Flannelmouth Sucker			Bluehead Sucker			Red Shiner	Fathead Minnow	Carp	Channel Catfish	
		30-50	70-120	160+	30-50	55-80	30-100	140-215	220+	30-50	65-100	100+	all	all	all	all	
1	1	1	20	26	1	2	19	2	1	4	5		4	1			Hal
2	6		1		1	1	5	1				1	8	1			Sar
3	9		3	1		4	6	1	1		4	3	1				Gr
4	9		6	62.2	5	4	8	11		3	5		20	1		3	Rif
5	14					2	1						4				Dee
6	28		1		2		1	1		1			9				Poc
7	30		18		2	1	11	4	1				14				Rif
8	31				1	1		2	2	2	1		7			2	San
9	50						1						1				Roc
10	51				3	2				1		1	13	1		1	Dee
11	52							1					5				San
12	52		3			5							46		1	4	Gr
13	70					1				1			91	1			Rif
14	72					2		1	1				3	1		1	Dee

Table 3. Fish population size and composition at 14 locations in the Escalante River, Utah. Numbers are those collected the first three seine hauls.

were noted, 30-100 mm, 140-215 mm and 220+ mm. The last size class undoubtedly encompasses several age groups. Adults were found throughout the study area in nearly equal abundance (Table 3), but both smaller size classes were almost exclusively living in the upper 30 km.

Bluehead Sucker - Catostomus discobolus. The bluehead sucker was the least common of the four native fishes. Again it was mainly restricted to the upper part of the study area. Three size classes were evident, 30-50 mm, 65-100 mm and 100+ mm. No distributional difference was noted between size classes. Blueheads were primarily taken over gravel or sand and gravel bottoms, in riffles or deep (0.5-1.0 m) runs.

Red Shiner - Notropis lutrensis. Red shiners were collected at all 14 sites in Trip 2. They almost totally dominated the lower part of the study area. When they were abundant above km 30, the native species also were abundant. But native fishes became scarce below km 30 and red shiner numbers rose. Only two size classes were evident, 35-40 mm, probably yearlings, and 41-69 mm, undoubtedly several age groups but no finer breakdown could be made. Red shiners were abundant in all habitat types, they were most common over sand and rock bottoms with a relatively slow current.

Fathead Minnow - Pimephales promelas. Fathead minnows were rarely taken in the main river (Table 3). They were extremely abundant in a silty, dammed pool in Harris Wash and in stagnant pools near the mouth of Stephens Wash. In the river they were usually found in small backwashes of still water adjacent to pools or the channel.

Carp - Cyprinus carpio. Adult carp were seen occasionally on Trip 1, but only one juvenile was caught during Trip 2. No more than two seen in an area. They were in pools or slow length of the study area.

Channel Catfish - Ictalurus punctatus. Adult channel seen occasionally during Trip 1, usually lying near the bottom pools. They were more common in the lower part of the study area. Yearling catfish (30-56 mm) and one juvenile (158 mm) were along with one adult (390 mm) in Trip 2. The small catfish in slow water areas; pools, sand runs and edges of riffles

Largemouth Bass - Micropterus salmoides. Largemouth Bass approximately 150-300 mm were seen occasionally in deep pools in the study area during Trip 1. None were collected in Trip 2. They were in pairs, a few large pools contained several.

Green Sunfish - Lepomis cyanellus. One green sunfish in the river on Trip 1. None were collected there in Trip 2. Abundant in stagnant pools near the mouth of Stephens Wash. Age classes represented, suggesting reproduction there.

DISCUSSION

Riparian Plants

Among the more important results obtained in the appraisal of geologic strata with vegetation. The sandstone formation and limestone formation exert different controls as shown in the increase in Tamarix and the introduction of Baccharis in the limestone formation. Whether this correlation is a nutrient-based effect or pure phenomenon due to the geologic differences should be determined.

The stratification of species to an age-size class structure appears very important in maintaining an equilibrium in the successional dynamics of the riparian plant community. The stratification seems to be related to the frequency and intensity of the flash flood cycle. Little vegetation becomes permanently established close to the river where flash flooding occurs most frequently. Further away from the bank, flooding becomes less intense and the vegetation is able to persist longer until the area of permanent vegetation and no or very few floods is reached.

Both the intensity of flooding and the geology of the area appear to maintain an equilibrium between Salix, Populus and Tamarix. Further analysis of the data pool and additional field work is needed to explain this phenomenon. Undoubtedly if flash flooding was reduced or alleviated, alterations in the riparian community would be expected. Vegetation would grow into a dense jungle of mature Salix, Populus and Tamarix. Evapotransporative losses would be expected to increase. The canyon would no longer be as easily hiked as the open beaches become filled. Much of Escalante's charm as a natural area would be lost.

Fishes

The observed distribution of fishes in the Escalante River suggests that the red shiner has replaced many of the native species in the lower area. It is then important to determine why or how the shiner becomes established. The answer to this problem appears to be found in considering the diversity of the habitat, and the effect that diversity has on the competitive advantage of one species over another.

It seems safe to assume that species which are adapted for a given set of conditions usually compete favorably with generalist species in that habitat. But the generalist, especially if it is an aggressive competitor,

usually can outcompete the specialized species in other than prime habitat for the latter. This appears to be the case for the Escalante fishes. A distinct difference was noted in fish species, size classes and numbers above and below approximately km 30. This corresponds quite well to the area where the canyon bottom narrows and the river becomes entrenched in the Windgate formation. The upper meandering river has considerable riffles and sand and/or rock runs, intermixed with pools of various shapes and sizes. Diversity of the habitat is relatively high. Native fishes are abundant. The lower entrenched river has a rather monotonous string of sand runs and deep pools under large boulders, with a few riffles intermixed. Diversity there is low. Native fishes are scarce and an exotic species dominates. Therefore it appears that the upper area provides good habitat for the native species and the lower area is less than prime.

Aquatic invertebrates productivity appears to be the key to the importance of the upper areas. Riffles typically produce the bulk of stream invertebrates. The upper area had a greater percentage of riffles than the lower area and hence would be expected to have more invertebrates. This was noted to be true in the Escalante, although invertebrates were not quantitatively sampled. The carnivorous roundtail chub would be expected to be better adapted to the upper than lower area. The bluehead sucker, which typically feeds by scraping algae and invertebrates off rocks, would also be better adapted to the upper area. In the lower area a much less stable food supply exists. Here the omnivorous red shiner appears better adapted to utilize what food is available than either the chub or bluehead, and therefore

outcompetes them. The shiner does not outcompete adult flannelmouth sucker and speckled dace in the lower area, at least not to the point of replacement. These two omnivorous species are the generalists of the upper Colorado basin and hence can compete favorably with the shiner. Juveniles of these species do not fare as well though, they apparently are outcompeted by the shiner in the lower area. Juveniles of omnivorous species are generally more reliant on invertebrates than adults, and would be more susceptible to competition for this limited resource in the lower area. In the area of abundant, stable food, juveniles apparently compete favorably with the exotic shiner.

The redshiner appears to dominate the lower area by being omnivorous, aggressive and by the sheer weight of numbers. These tendencies were noted at a camp site near km 67. Literally hundreds of shiners swarmed around the shore when food was offered, and continued to follow us whenever we were near. Reminiscent of bears in Yellowstone or gray jays around a picnic basket, all fear of humans seemed lost. Competition for food scraps was fierce. The rapidity by which this species can and has increased in the Colorado basin is well documented (Hubbs, 1955; Stone et al., 1969; Holden, 1973).

Therefore, the upper area remains a stronghold for native fishes because of a diversity of habitat which provides adequate living space and abundant invertebrate food source. The lower area lacks the diversity of habitat and stable invertebrate food source which apparently gives the red shiner an advantage over the native species. Holden (1973) hypothesized competition between red shiners and native fishes to be a major cause of recent declines in the latter in the upper Colorado

basin. The data of this study lend considerable support to the hypothesis and indicate the areas of probably active competition.

If these conclusions are valid, any major reduction of water in the Escalante system would have disastrous effects on the native fishes. A lowering of the river volume would cause the upper area to become much less diverse than it is presently. Riffles would be made smaller and less productive. Silting would have disastrous effects in the riffles as flows may not be adequate to wash it away. The upper area would become much more homogenous, approaching the lower area in this respect. These changes would then provide conditions where the red shiner can apparently outcompete the native forms, and the natural river ecosystem would be lost.

RECOMMENDATIONS

The present study has shown that changes in the fluvial regime of Escalante Canyon could seriously alter the natural communities presently existing there. Additional studies should be made to quantify the effects caused by different levels of flow reduction. In this way future energy or water needs could be planned so as not to bring unalterable changes in the successional dynamics of the flora and fauna of this unique area. It is important such studies be undertaken immediately so as to gather baseline data before irreversible changes take place.