United States
Environmental Protection
Agency

Environmental Research
Laboratory
Duluth MN 55804

Research and Development

EPA-600/S3-82-071 Oct. 1982

EPA

Project Summary

Spring and Springbrook Fauna of the Piceance Basin, Colorado

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The aquatic macroinvertebrates of Willow Creek, Piceance Creek, Stewart Gulch, and of spring sources surrounding Tract C-b (see map, Figure 2) in the Piceance Basin were sampled from July 1978 through August 1980 as part of a baseline monitoring program prior to oil-shale development. The spring sources exhibited a somewhat different and more constant physical and chemical environment than the streams. The more constant conditions in the springs allowed a generally greater density and biomass of macroinvertebrates than did the other study streams. Species compositions were also different. Differences in the macroinvertebrate community structure at each of the sites in the streams, were apparently caused by differences in flow patterns, substrate type, and influence of spring sources. The spring sources had distinct communities despite generally similar environmental conditions. Different slopes of the springs were the eminent cause of macroinvertebrate differences between springs. A discussion of major potential impacts resulting from development of oil-shale upon aquatic macroinvertebrates in springs and springbrooks surrounding mining Tract C-b is presented.

This Project Summary was developed by EPA's Environmental Research Laboratory, Duluth, MN, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The objectives of this study were:

1. To determine the macroinvertebrate community structure of spring sources and spring brooks surrounding Oil-Shale Tract C-b.
2. To provide baseline data from the above habitats prior to oil-shale development.
3. To continue monitoring Piceance Creek above and below Tract C-b.

The Piceance Basin is located in northwestern Colorado, northwest of the city of Rifle, and southwest of the city of Meeker (Figure 1). The basin is characterized by north to northeast-trending ridges and valleys. Elevations in the study area range from 1900 to 2100 m with local reliefs of over 100 m. The area is semi-arid; total annual precipitation ranges from 30 to 51 cm. The temperatures range from -40°C to +40°C.

Natural vegetation of the valleys and slopes consists primarily of big sage brush (*Artemesia tridentata*), which forms associations with grasses, forbs, or other shrubs. The ridges and north-facing slopes are dominated by a pinyon (*Pinus edulis*) — juniper (*Juniperus osteosperma* and *Juniperus scopulorum*) woodland. Although hay is grown on irrigated land in the stream valleys, plant coverage for the entire basin averages only 25% of the land's surface.

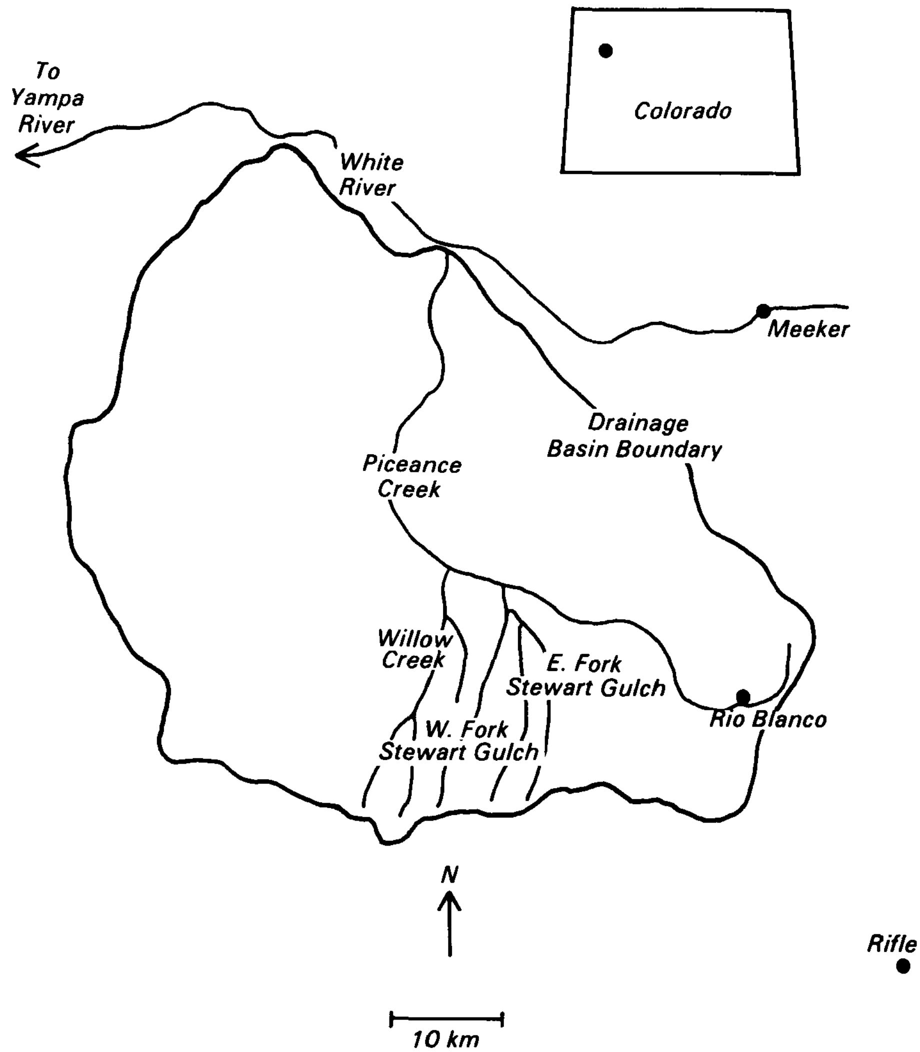

Figure 1. *Location and boundaries of the Piceance Basin.*

The largest known oil resource in the world lies in the oil-shale deposits of the Green River Formation in Colorado, Wyoming and Utah. This resource has stimulated governmental and industrial interest in developing oil-shale extraction technology. In 1974, the U.S. Department of the Interior leased two tracts of public land in the Piceance Basin to stimulate oil-shale development (Tracts C-a and C-b). The present study was concerned only with springs and streams near Tract C-b. Numerous studies of the macroinvertebrate fauna in aquatic habitats near Tract C-b have been carried out, but very little work has been done in springbrook habitats near the tract.

The effect of area springs in providing important water quality characteristics to streams is recognized. The water flowing from these springs is provided by two main aquifers which are separated by a 30-m confining layer termed the Mahogony Zone. The upper aquifer is primarily within the Unit Formation (sandstones and malstones), which forms the surface rock. The aquifer is located in the Parachute Creek Member of the Green River Formation. The lower aquifer is highly saline (up to 30,000 mg L^{-1} T.D.S.) principally due to nahcolite ($NaHCO_3$). The Mahogony Zone separates the upper and lower aquifers both chemically and hydraulically, except in recharge and discharge areas. Recharge areas are generally above an altitude of 2130 m; water discharges from the upper aquifer to the alluvium of the valley floors and through springs along the valley walls.

The springs and springbrooks provide excellent locations to monitor groundwater quality as oil-shale development proceeds. The development plan at Tract C-b was changed from the Tosco II process to a modified *in-situ* extraction method. The new technique involves mining 10 to 30% of the shale to create retort chambers. The remaining shale above the chambers is then fractured and retorted in place. This process is to be carried out in the Mahogony Zone.

The locations of the sampling sites of this study are shown in Figure 2. WC-2 was approximately 1-m wide, 10-cm deep, and had a rubble substratum. WC-1 was similar in depth; however, it was wider and had a sand-silt substratum. There were some emergent macrophytes at WC-1 (*Rorippa nasturtium-aquaticum* and *Veronica salina*), but WC-2 was limited to a small amount of submerged macrophytes (*Zannichiellia palustris*).

SP-1 was approximately 1.5-m wide; depth was variable (2 to 15 cm) depending upon the amount of emergent macrophyte growth. The substrate was primarily rubble. SP-2 formed a small pool below the emergence area due to low gradient. The entire channel became choked with macrophytes during the summer, and the low gradient allowed an accumulation of silt except at the emergence area. The macrophytes influenced water depth to a greater degree than at SP-1 In contrast, the substrate of SP-3 was rubble-boulder. Width near the multiple sources was approximately 5 m; depth was not influenced by macrophytes, though macrophyte growth was heavy during the summer.

PC-1 and PC-2 were approximately 4 to 5-m wide. PC-1 had a cobble substrate and little algal growth. PC-2 had a predominantly rubble-boulder substrate which supported large mats of algae (mainly *Cladophora*) during the summer.

SG-1 was located approximately 100 m below the springs which provided year-around flow to Stewart Gulch. The site was about 0.5-m wide and supported fairly dense growths of emergent macrophytes. The substrate was primarily silt-gravel.

The variability of physico-chemical factors at or near a spring source is compared to the lotic environment some distance from the source. Springs are generally rich in carbon dioxide due to the breakdown of subterranean organic matter by microorganisms, and have a low pH as the excess carbon dioxide forms a weak acid. Dissolved oxygen is also usually low at spring sources.

Spring sources generally, contain fewer species of macroinvertebrates

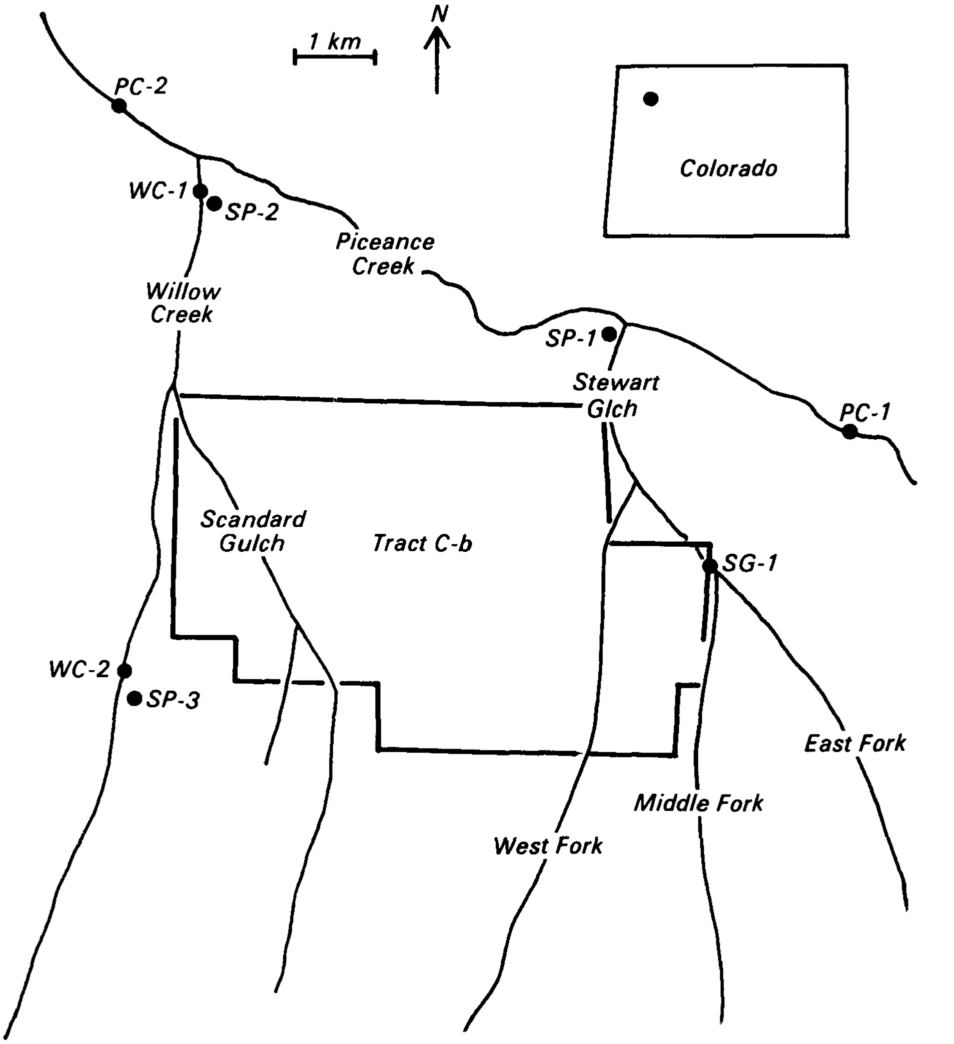

Figure 2. *Locations of the sampling stations surrounding Tract C-b, in the Piceance Basin, Colorado.*

compared to downstream areas that have greater physico-chemical variability. This may be due to temperature, dissolved oxygen, or other parameters, which, being relatively constant, fail to provide cues necessary for initiation or completion of the life cycles in some species. Species able to withstand the unique conditions of a spring are likely to have reduced competition and may exhibit greater density and biomass than at areas farther downstream. The diversity and number of organisms inhabiting spring communities resemble communities located in areas of organic enrichment, a situation also reported below hypoliminal release reservoirs (which in some ways resemble springs).

Physical and chemical variables were tabulated over a two-year period. Dissolved oxygen, free CO_2, pH, temperature, and stream width and depth were measured in the field. Samples for analysis of bound CO_2, dissolved and suspended solids, nitrate-oxygen, and other ions were transported to the laboratory on ice. Organisms from each spring and stream source were preserved in the field with 5% formaline and later transferred to 80% ethanol. Biomass was determined and species diversity values were calculated using the Shannon-Weaver Index.

Conclusions and Recommendations

1. The spring sources exhibited more constant physical and chemical conditions and generally supported greater numbers and biomass of macroinvertebrates than sites in Piceance Creek, Stewart Gulch, and Willow Creek. The spring sources had less dissolved and suspended substances, and had less dissolved O_2 and lower pH than other locations sampled.
2. The sites in Willow Creek, Piceance Creek, and Stewart Gulch had quite different physico-chemical conditions resulting in different macroinvertebrate communities. The major regulating variables appear to be flow patterns, substrate type, and proximity to spring sources.
3. The three study springs were similar in most physical and chemical variables measured, yet contained distinct macroinvertebrate communities. Differing gradients allowed the development of such communities.
4. Monitoring of springbrook macroinvertebrates and physico-chemical variables (especially dissolved salts and flow) should be continued as oil-shale development proceeds.
5. Additional research is necessary concerning substances contained in spent oil-shale from the modified *in-situ* process and their effects upon aquatic macroinvertebrates.

☆ U.S. GOVERNMENT PRINTING OFFICE. 1982-559-017/0846

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The complete report, entitled "Spring and Springbrook Fauna of the Piceance Basin, Colorado," (Order No. PB 82-240 193; Cost: $7.50, subject to change) will be available only from:

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