GEOMORPHIC AND AQUATIC CONDITIONS INFLUENCING SALMONIDS AND STREAM CLASSIFICATION
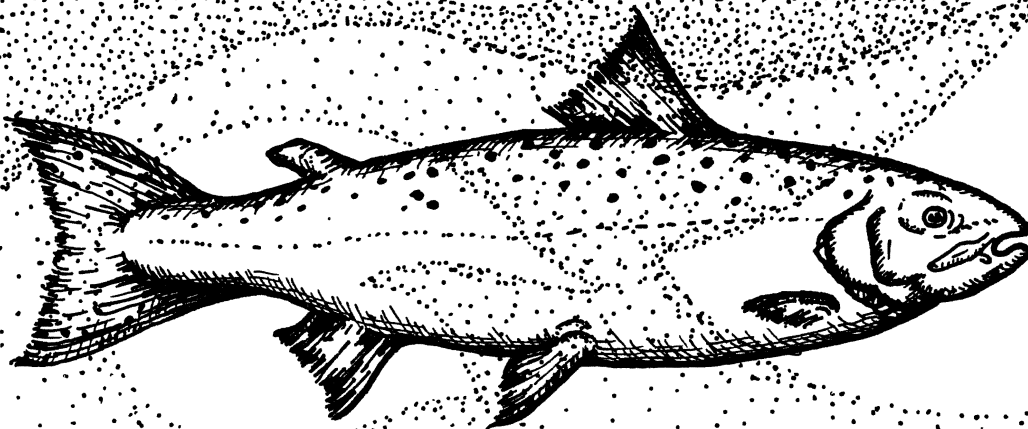
WITH APPLICATION TO ECOSYSTEM CLASSIFICATION

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ABSTRACT

GEOMORPHIC AND AQUATIC CONDITIONS INFLUENCING

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by

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Investigations were conducted from July 1970 through Sep-
tember 1972 of (1) the physical structure of aquatic environments
in granitic, mountainous lands in Idaho, (2) the relationship be-
tween physical stream structure and fish populations, (3) the in-
fluence of geomorphic process of aquatic ecosystems, (4) the
relation of order within landforms in relation to uniformity in
aquatic environments, and (5) the potential for classifying aquatic
environments from land classification systems. A 397 square mile
area in the upper south fork of the Salmon River watershed was
stratified into four geologic process groups and 12 geomorphic
types. Within that area, 38 streams were studied by analyzing 2,482
transects for physical aquatic and streambank environments, while
291 areas were investigated as to fish populations.

The streams had distinguishing structural features that had
resulted from the influences of geomorphic processes. In other
words, streams that drained similar lands had been formed by simi-
lar processes. Such streams will therefore be relatively uniform
in structure. The results of the two-year study allow classification

of aquatic environments within the granitic areas of the Idaho
Batholith to the geologic process group level. Some specific
environments can now be classified to the geomorphic type level.

Some areas of each stream studied had been dominated by one
type of external variable such as glaciation. Multivariate control
from geomorphic processes, however, exercised the most influence
on general stream conditions. Spatial differences in dissolved
and suspended substances in the streams appeared to depend on
the degree of decomposition of bedrock and possibly on the eleva-
tion of the channel. Time, as related to streamflow movement
through the drainage, had little influence.

In turn, certain aquatic structural characteristics controlled
the density of fish populations and the composition of fish species.
Stream depth, width, and the elevation of the stream channel were
the most important such characteristics, with salmonids apparently
adapted to almost all streams in these high elevation granitic
lands. Variations in water chemistry did not seem correlated with
the density of fish populations.

The fish population total density decreased or increased in
a uniform manner as certain variables in the aquatic structure
changed. Some individual fish species, however, responded in an
opposite manner and certain species showed no correlation. The
variables that described the structure of the study streams often
proved to be directly related. If one changing variable were
identified, most other structural variables responded in a pre-
dictable manner.

Multidisciplinary teams have attempted to develop ecosystem classification as in "ECOCLASS." ECOCLASS is an unpublished attempt by the U.S. Forest Service to develop a way to classify ecosystems in the Pacific Northwest. This system was to be a prototype for a national classification. A major weakness in the ECOCLASS system has been having to work the aquatic phase of classification in with the terrestrial phase at the same levels of generalization.

The work reported here provides a solution to current difficulties. It is based on the idea that once ecosystems can be classified, they become identified units that can be meshed into land management programs (Figure I). Aquatic resources merely need to be described and classified so they can be processed as workable units in land and water management. This is especially important in SEAM (Surface Environment and Mining) programs, as mining and milling constitute an especially difficult land use to fit into proper comprehensive land use planning.

This study provides information from mountainous aquatic environments that can be used to examine further the relationship of order and control in specific geologic and geomorphic settings. In my work, I quantitatively analyzed the relationship of geomorphic order to the existing condition of stream environments. Effects of stream condition on fish populations were also described so that the effects of geomorphic process on fish populations could be evaluated.
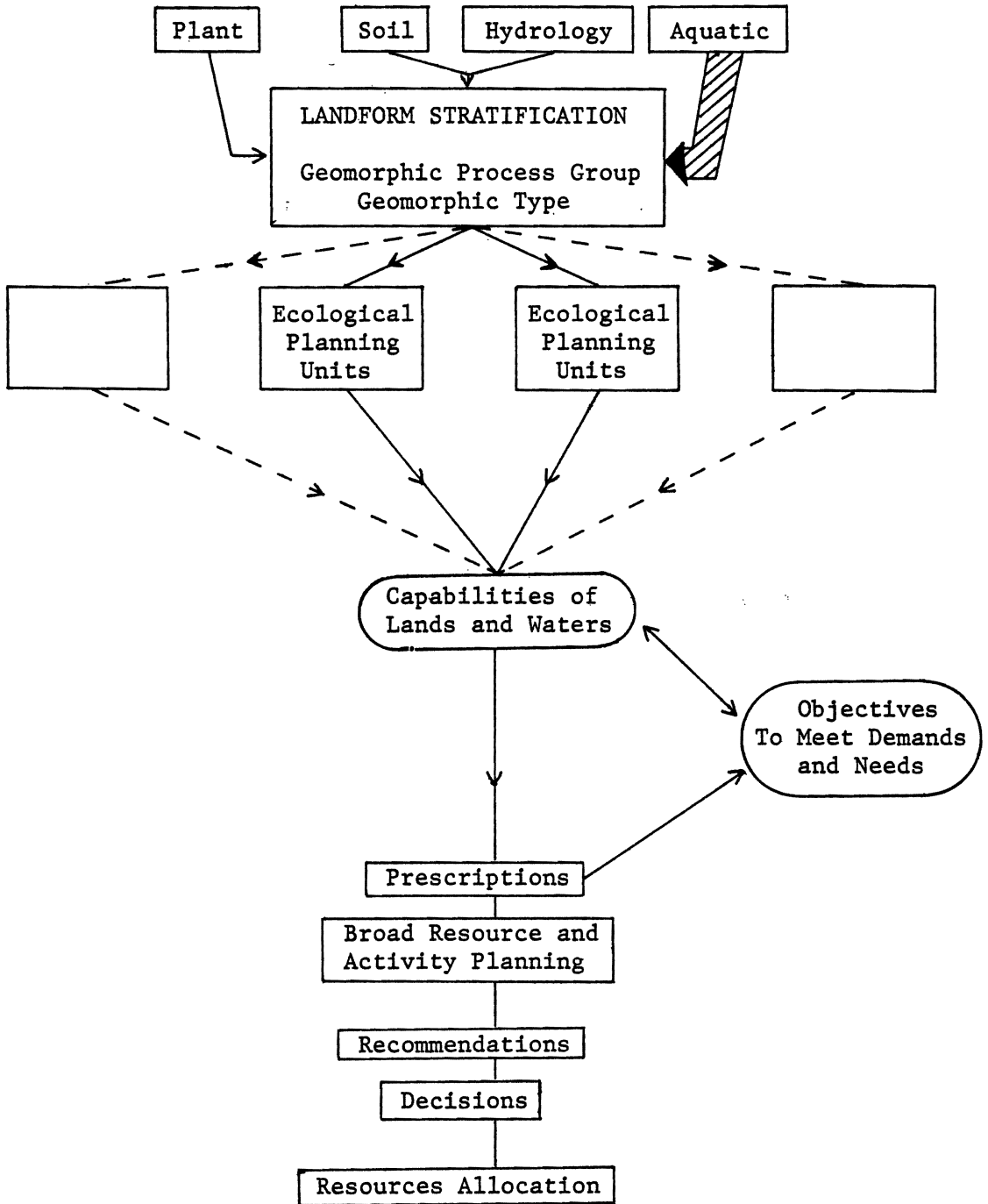
Figure 1. Flow chart of environmental management with phase of this study represented by shaded line linkage.

Geomorphic Process

Each geomorphic process develops its own characteristic assemblage of landforms as it shapes the landscape and its streams. Ninety-five percent of all landforms are sculptured by streams (Strahler 1974); landform and stream development inevitably occur together. Thus, the distinguishing features of streams should be dependent on the geologic and geomorphic process responsible for their development. Brush (1961) presented evidence that order is exhibited by the hydraulic environment of stream channels, but few data have been available for use in determining how this order varies in relation to the geologic setting.

Because running water is constantly changing the landscape, valleys are geologically young and it is generally accepted that little of the earth's topography is older than Pleistocene. Ashley (1931) made a strong case for the youthfulness of the world's topography and stressed that nearly all landform details have evolved since the emergence of man. In contrast, members of the Salmonidae family have been present since the Miocene, 28 million years B.P. (before present) (Berg, 1947). Consequently, salmonids have adapted their life cycle to erosion processes that continually change the landscape and create and maintain stream habitat.

Watershed-Stream Relationship

Streams are controlled by the watershed they help build, and each one reflects the geology, geomorphology, biology, climate, and

hydrology of its drainage basin. The watershed exercises its control over the streams by dictating or influencing physical and chemical conditions,which in turn help determine the character of the aquatic environment. Watershed and stream variables can be described, measured, and quantified. These variables thus allow identification and description of both the stream and its surroundings.

Describing and quantifying a stream condition and comparing it with the surrounding and influencing geologic process group or geomorphic type provides a way to evaluate the degree to which geomorphic controls affect or control the stream environment. With an understanding of the stream and its surroundings, we have the possibility of describing and classifying types of habitat in a stream from known geomorphic processes. Land classification maps, already completed by other disciplines, are then useful in classifying and better understanding fluvial aquatic environments. By combining the various classifications we can ultimately classify total ecosystems.

Classification

In the first part of this report, I describe specific aquatic environments in Idaho and compare them with other aquatic environments and their surroundings. Then these aquatic habitats are classified or described based on their inherent variables and variables from their influencing geologic process groups and geo-[1]morphic types. The study area along the south fork of the Salmon River is young as measured by surface changes and has been subject to well-defined geomorphic processes. This provides circumstances

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[1] Geomorphic types are referred to in recent literature (Wertz and Arnold 1972) as landtypes and geologic process groups as landtype associations.

conducive to determining if fluvial aquatic environments can
be classified or at least better understood on the basis of their
surrounding land classification systems. The bedrock within the
study area is almost entirely granitic, which minimizes the bias
of mixed parent (bedrock) materials.

The study area was recently landtyped by soil scientists
(Anonymous 1969) and is one of the first land areas to be strati-
fied using mainly geomorphic processes (Figure 2). The aquatic
environments thus can readily be compared with the different
geologic process groups and geomorphic types in which they lie.

History

The aquatic environments of the south fork of the Salmon River
and some of its tributaries have deteriorated in quality during the
past several years because of increased sediment loads due mainly
to logging and road construction (Figures 3 and 4). By 1965,
15 percent of the lands within the study area had been included in
logging sale boundaries, and had yielded 325 million board feet of
timber. Seventy-eight percent of the logging and 69 percent of
the road construction were on fluvial lands, which are the least
stable of all the lands in the drainage (Arnold and Lundeen 1968).
Erosion rates were accelerated tremendously on disturbed areas,
particularly on logging roads (Megahan and Kidd 1972), causing
increased amounts of sediment to alter stream structure (Figures
5 and 6). Most of stream degradation occurred between 1962 and
1965; prior to 1952 the streams were in good condition (Platts
1968, 1970 and 1972). Following the elimination of logging and
road construction in 1965, the streams have steadily improved.

Steelhead trout[2], chinook salmon, and resident game fish popu-
lations have steadily declined in the area since 1957 and there have
been closures on the anadromous fishery. The decline of summer chi-
nook salmon numbers and the deterioration of the salmon's upstream
environment within the study area caused concern at local and na-
tional levels. The concerned public and the resource managing
agencies, provided the money needed to initiate aquatic-fishery
studies to identify the initial causes of the environmental
degradation and to determine solutions. The initial studies showed
how little is known about aquatic environments in mountainous lands.

Problem

If aquatic environments are to be managed in conjunction with
our present deficiency of money, manpower, and data, some practi-
cable way must be devised to understand, inventory, and classify
the abiotic and biotic aspects of these aquatic environments.
Comparisons of aquatic environment information with soil, hydro-
logical, and geomorphic information can provide resource managers
with the information they need in the form of a description and
classification system.

Resource allocation that is compatible with conservation and
maintenance of desirable stream environments can then be identified
after the complete ecosystem is classified.

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[2] Refer to Appendix A, Table 5 for scientific names of fishes as listed
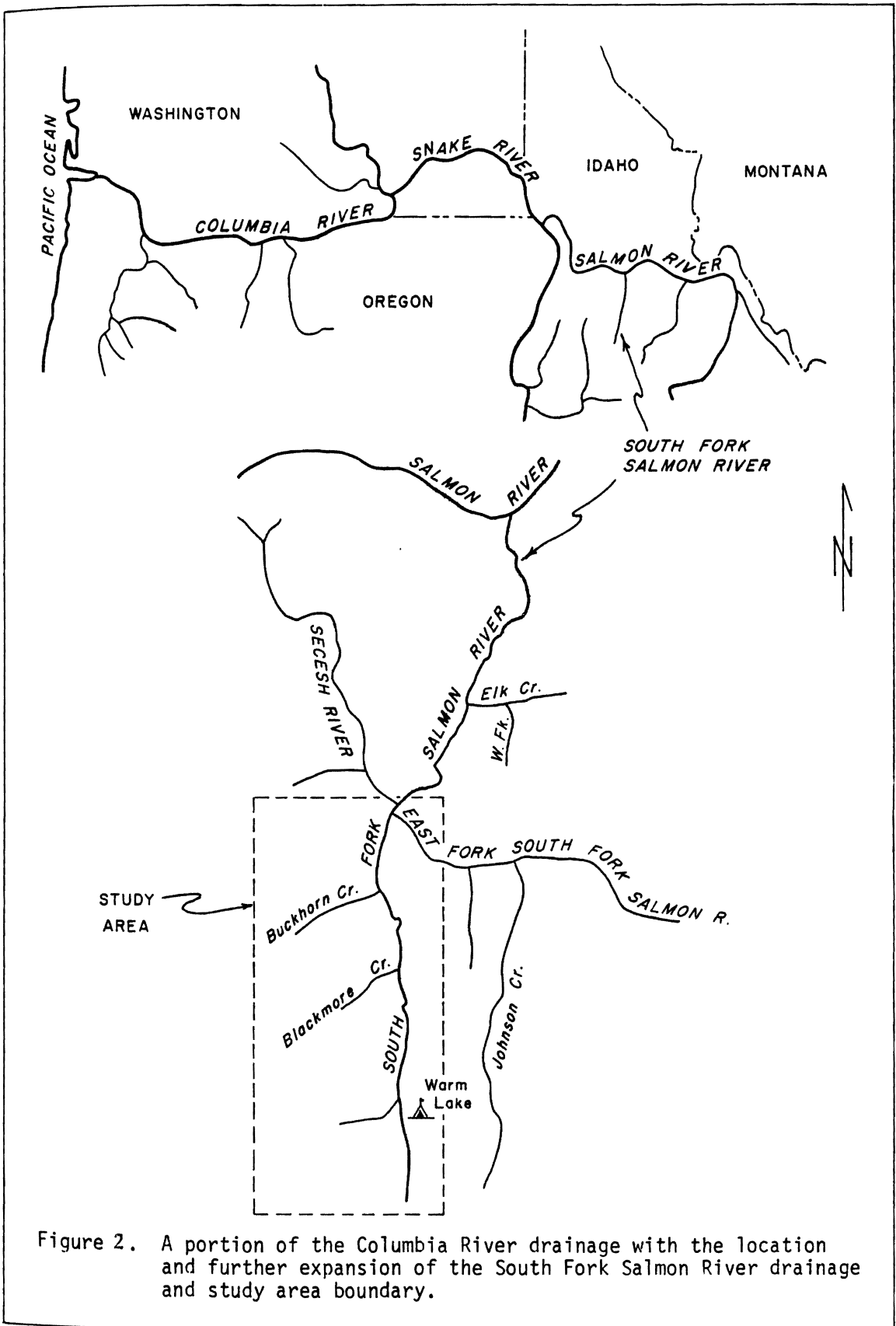in the American Fisheries Society list of common and scientific
names of fishes - 1970.

Figure 2. A portion of the Columbia River drainage with the location and further expansion of the South Fork Salmon River drainage and study area boundary.

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