

AN ABSTRACT OF THE THESIS OF

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Structure and Organization

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Abstract approved:

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The goal of this study was to better understand stream communities through a perspective that might make their structure, organization, and development more understandable. This goal was approached through the following objectives:

1. To determine the assemblages of stream organisms and define subsystems within a stream community.
2. To explain the structure and organization of the subsystems by means of habitat, life history, trophic, and environmental relationships.
3. To explain how the community as a whole and the subsystems develop and persist through immigration, colonization, and subsystem interactions.

An organismic perspective of stream communities is utilized in addressing the development and maintenance of stream community structure and organization. The conceptual framework of Warren et al.

(1979) provides a perspective which emphasizes the importance of species interrelationships and interdependencies within a community. This perspective is organismic in that it takes the view that communities exhibit organismic properties. It is not organismic in the Clementsian sense that communities are metaphorical organisms.

A hierarchical scheme of stream community subsystems is presented. Habitat organization is used to define 2° and 3° subsystems. Trophic organization defines 4° subsystems, and other aspects of life history organization define 5° subsystems.

Two model streams were employed in this study of stream community structure and organization. The 2° subsystems, shallow riffles, deep riffles, and pools, were sampled for one year following initiation of the experiment. Community organization and development are described in terms of biomass and taxa numbers. Macroinvertebrate biomass and taxa number tended to be greater in riffle habitats than in pool habitats. Biomass in 2° and 3° subsystems generally increased with time. Taxa number increased until early winter when it declined slightly. Changes in biomass and taxa number in 4° trophic subsystems and 5° species population subsystems are also discussed.

Species pool, life history, and colonization determination of stream community structure and organization are addressed. The potential capacity of the stream community resides in the species pool. The pattern of kinds and abundances of species in space and time is partially determined by the life history patterns of the species. Colonizing ability of species populations affects the development and organization of stream communities. Downstream drift and aerial sources of colonists contributed to the colonization of the experimental streams in this study, although the relative importance of the two sources changed through time.

Stream habitat and environment play important roles in stream community development and organization by providing shelter or cover and supplying needed resources. As the environment provided by a stream system impinges upon the stream community, there must be

concordance between the community and its environment. The climatic parameters light and temperature and autochthonous and allochthonous inputs such as litter fall are discussed as environmental parameters that impinge on the model stream communities.

The Development and Maintenance of Stream
Community Structure and Organization

by

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The Development and Maintenance of Stream
Community Structure and Organization

INTRODUCTION

Structure and organization are aspects of biological communities frequently addressed in the ecological literature. These concepts are not always defined and interpreted in the same manner. Here, community structure will be defined as the spatial and temporal distribution and abundance of species populations along with resultant superficial appearances. Structure is a dynamic performance of communities that is more or less observable. It is amenable to empirical examination. Organization is more nearly a theoretical construct, "written onto" a system, which arranges interdependent parts into a coherent whole. Applied to a community, organization implies "organs," or subsystems, at different hierarchical levels, suggests kinds of relationships among these subsystems, and indicates what their functional roles might be within the community.

Changes in community structure and organization through time constitute community development. Development occurs on different time scales, ranging from seasonal succession through the succession of seral stages to changes through geologic time. Maintenance refers to the persistence of the community through time. The goal of this study was to better understand stream communities through a community perspective that might make their structure, organization, and development more understandable.

Plant ecology has contributed at least two important community perspectives: Clements' "metaphorical organism" view and Gleason's "individualistic population" view. Clements (1916) recognized a community as a distinct entity extending in time as well as in space. Such a community system developed, reached maturity, and replicated with some fidelity. Overemphasis on these "organismic" properties helped to encourage the "individualistic dissent." But

Clements' view gave plant community ecology needed dynamic objects of understanding, which it now sometimes seems to lack. This organismic view of communities addresses succession. It recognized the importance of dynamic interrelationships and interdependencies contributing to community structure and organization. This is a dynamic view of communities.

In contrast, Gleason's (1926) individualistic concept of communities places emphasis on population level performances and does not address community specific performances. To the extent communities exist at all, they are little more than probabilistic aggregations of species populations colonizing a common location because of similar requirements. The continuum concept of Curtis and McIntosh (1951) and the gradient analysis approach of Whittaker (1967) are extensions of the individualistic perspective. Spatial patterns of plants are explained by their distribution along continuous environmental gradients of abiotic factors, such as temperature and moisture. Temporal distribution of species populations, or succession, is hardly addressed.

The organismic and individualistic perspectives are reflected in approaches subsequently taken in the study of streams. Shelford and Eddy (1929) were among the first to consider the existence of permanent stream communities. They hypothesized that streams experience successional development and are capable of reaching and maintaining stable conditions. Elton and Miller (1954) described communities as entities having organization, integration, and comparative independence from other communities and ecosystems. They applied this view to aquatic communities, where habitat structure was used as a basis for community classification.

Often, streams and rivers have been studied, not from a community perspective, but as ecosystems containing systems of populations. It has been presumed that stream-inhabiting organisms, being subject to random, destructive perturbations such as high discharge and streambed scouring, have little opportunity to form

persistent communities. This view is reflected in Dansereau's (1957) longitudinal profile of a stream ecosystem. Headwater reaches, which are subject to erosion, contain young, "unevolved" communities, exemplified by populations of encrusted or free algae. Downstream reaches harbor more "evolved" communities containing diverse assemblages of many forms of vegetation. Hence, Dansereau is referring to the "evolution" of the community as a whole, not the evolution of its constituent species populations.

As a result of the downstream movement of water in streams, biomass is removed from the upper reaches and transported to lower reaches of the stream system. Because of this phenomenon, Margalef (1960) states that small headwater streams have little control over external events. They have little chance to maintain some semblance of community structure and organization because biomass, the "keeper of organization," is much reduced in headwater streams. There is not enough information, in the form of stored biomass, to anticipate and compensate for the random variability of destructive events (Margalef, 1963). But transport of "information" and biomass downstream allows more highly developed or "mature" communities there. If succession occurs at all, it is not temporal but in space downstream.

For these same reasons, Odum (1969) would perhaps also conclude that it would be difficult for a headwater stream community to mature. In his view of community succession, the headwaters of a stream system might be likened to "young" communities, and the lower reaches, with greater accumulations of biomass, likened to "mature" communities. Shelford and Eddy (1929) similarly believed that larger, slower streams are nearer climax.

It might be mentioned that in these discussions of stream community maturity, strict definitions of biomass are not given, although biomass of living primary producers is inferred. But one could include in "biomass" the sometimes large amounts of wood and woody debris found in some headwater streams. This biomass might

enhance maturation of headwater stream communities through increasing habitat stability.

Succession in streams is usually considered only in a geologic time frame. Stream succession is thought to occur as water and local topography interact to form watersheds and stream channels through the process of erosion. Moon (1939) employed this in his stream classification scheme in which streams were categorized as erosional or depositional. And Hoffman (1978) discusses the controlling factors governing benthic community development over geological time.

More recently, ecosystem level and population level studies have been emphasized in stream ecology. Vannote et al. (1980) addressed the concepts of the downstream movement of allochthonous and autochthonous materials and their successive processing by organisms. Their river continuum hypothesis proposes a longitudinal or spatial variation of population systems in running water, in an ecosystem perspective. This view is reflected in Cummins' (1974) approach to classification of stream macroinvertebrates. His functional groups are systems of populations categorized by method of food acquisition. The role of macroinvertebrate functional groups in the decomposition of various detrital materials is emphasized. The relative proportions of functional groups change with distance downstream, this reflecting a continuum in space (Cummins, 1975). Haefner and Wallace (1981) describe changes in functional feeding groups in a stream over a period of nine years. They conclude that the recovery of a stream community from watershed disturbance is governed by the recovery rate of the surrounding riparian vegetation. This, then, would be an example of stream succession in the more classic temporal sense.

An organismic view of stream communities may facilitate study and understanding of stream community structure and organization and thus of any stream community development. This view emphasizes the importance of species interrelationships and interdependencies within a community that contribute to its structure and

organization. Competition, predation, and mutualism are examples of biotic interactions that have been found to be important in determining the distributions and abundances of organisms in many communities (Connell, 1961; Paine, 1966; King et al., 1975). These relationships are in all probability important in stream communities, as is suggested by Peckarsky and Dodson (1980), although they have not been investigated as intensively as have the effects of abiotic factors on stream organisms. Recognition of stream community succession, in other than a geological time frame, would make it possible to better understand watershed-stream community interactions, such as recovery of a stream community following watershed perturbation.

As stated earlier, the goal of this study was to better understand stream communities through a community perspective that might make their structure, organization, and development more understandable. This goal was approached through the following operational objectives:

1. To determine the assemblages of stream organisms and define subsystems within a stream community.
2. To explain the structure and organization of the subsystems by means of habitat, life history, trophic, and environmental relationships.
3. To explain how the community as a whole and the subsystems develop and persist through immigration, colonization, and subsystem interactions.

CONCEPTUAL MODELS

The manner in which we view biological systems determines our approaches to their study. When our views emphasize isolated aspects of stream communities, only partial appreciation and understanding can result. Even parts or aspects of communities can be better understood when unified through an organismic system perspective.

The conceptual framework of Warren et al. (1979) provides an organismic perspective on biological systems. In this conceptual framework, a community can be viewed as an organismic system incorporating a number of interpenetrating subsystems and their environments. The organismic system and each of its subsystems have their own level specific capacities, environments, and performances. There is a concordance, or harmonious and rule-like relation, between any organismic system or subsystem and its environment. Incorporation, concordance, and interpenetration of subsystems are taken to be universal properties of organismic systems. A community, viewed as an organismic system, incorporates a number of interpenetrating subsystems and their environments. Thus, subsystems are combined and unified into higher level systems.

The following models are proposed to enhance understanding of stream community structure and organization. They are conceptual models intended to symbolize, partially articulate, and provide a perspective on total experience relevant to stream communities. They should not be taken to directly represent specific stream communities or to be simply verifiable or falsifiable.

A stream system can be taken to be incorporated in a natural-cultural system. Natural-cultural systems can be thought of as functional components of the ecosphere (Gregor, 1982). The natural-cultural system model of Warren (1979) conceptually unifies the natural and cultural domains within the ecosphere. Figure 1 illustrates the interrelations of the primary components of such a

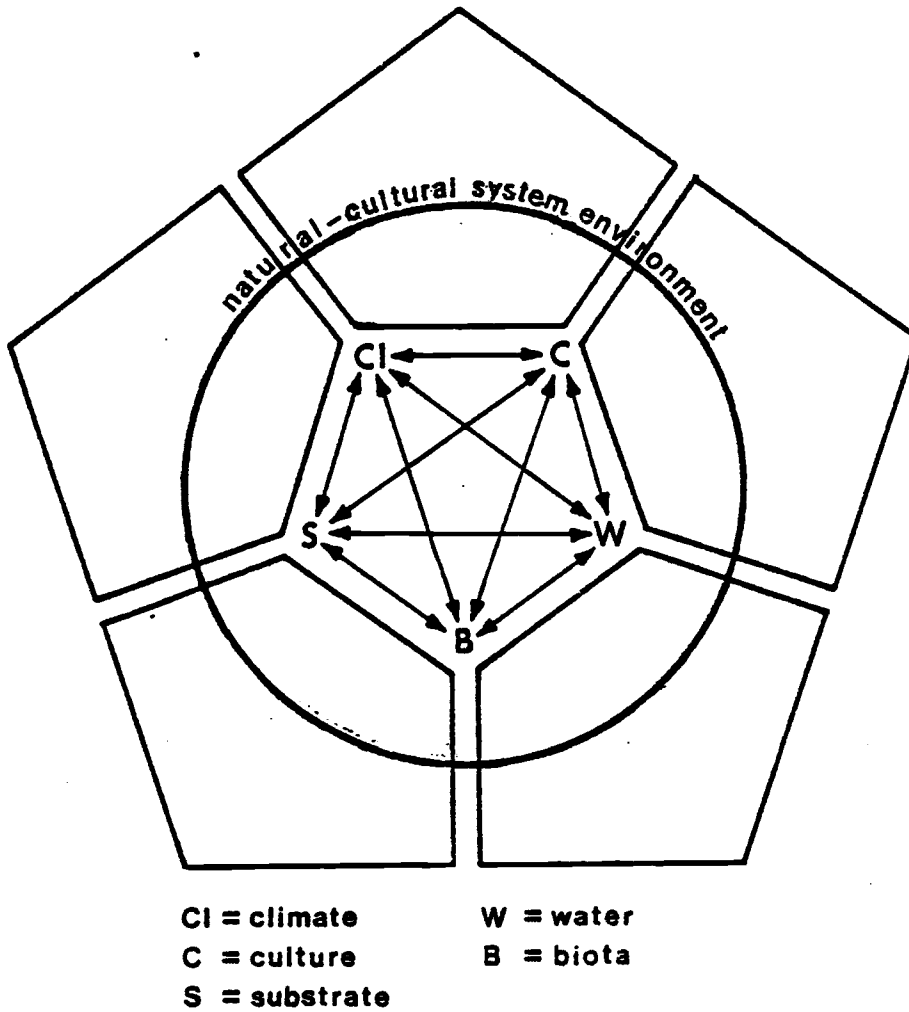


FIGURE 1. Diagrammatic representation of a natural-cultural system and its coextensive environment.

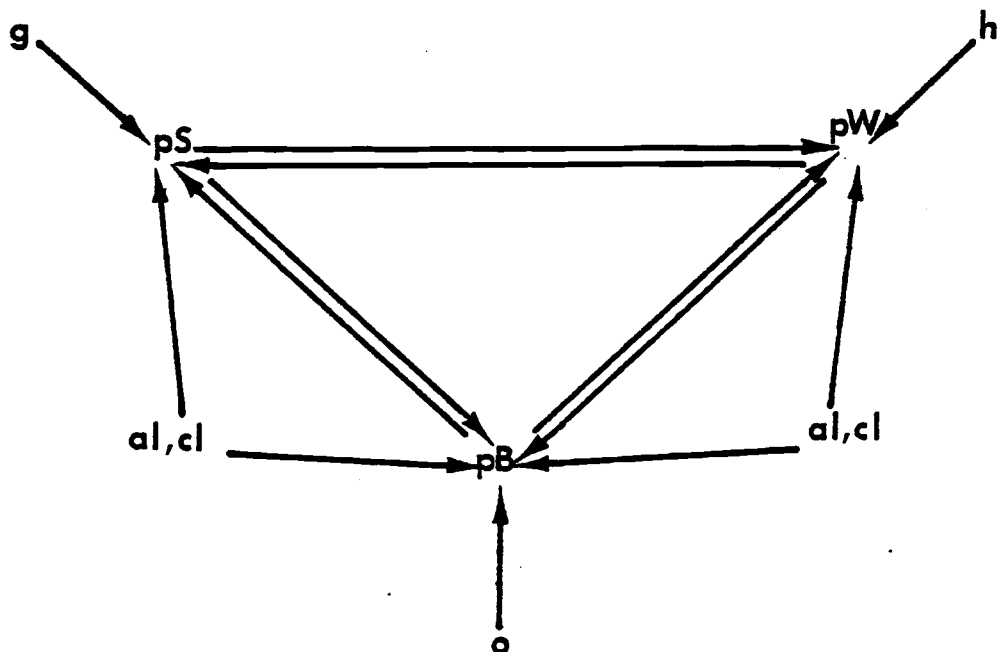
natural-cultural system. Climate (Cl), substrate (S), biota (B), water (W), and culture (C) are the primary components of the natural-cultural system, which is impinged upon by the natural-cultural system environment, represented by adjacent pentagons. A natural-cultural system can be expressed as a function of the capacities of the system and its environment.

$$\begin{aligned} \text{NCS} &= f(\text{NCS}_{\text{cap}}, \text{Environment}_{\text{cap}}) \\ &= f[(\text{Cl}_{\text{cap}}, \text{S}_{\text{cap}}, \text{B}_{\text{cap}}, \text{W}_{\text{cap}}, \text{C}_{\text{cap}})(\text{Environment}_{\text{cap}})] \end{aligned}$$

A stream system can be abstracted from the model of the natural-cultural system. Figure 2 is a kinetic diagram of a generalized stream system. Stream substrate (pS), stream water (pW), and stream biota (pB) are parts of the natural-cultural system substrate, water, and biota. Environmental parameters or performances that impinge directly upon all primary components of a stream system include allochthonous and autochthonous inputs (al) and climate (cl). Geologic (g), hydrologic (h), and organismic (o) environmental parameters impinge specifically on stream system substrate, water, and biota, respectively. These five environmental parameters may be viewed as performances of the natural-cultural system or its environment that impinge upon the stream system. Such a stream system can be expressed as a function of its primary subsystems and its environment. Capacity of both the stream system components and the stream system environment is inferred, although not specified, in the equations.

$$\begin{aligned} \text{SS} &= f[(\text{pS}, \text{pW}, \text{pB})(\text{Environment})] \\ &= f[(\text{pS}, \text{pW}, \text{pB})(\text{al}, \text{cl}, \text{g}, \text{h}, \text{o})] \end{aligned}$$

A stream system can be further decomposed in a hierarchical fashion to create stream community subsystems. The way in which



PRIMARY SUBSYSTEMS:

pS = stream substrate
 pW = stream water
 pB = stream biota

PRIMARY ENVIRONMENTAL PARAMETERS:

g = geologic environment
 h = hydrologic environment
 o = organismic environment
 al = allochthonous and autochthonous inputs
 cl = climate

FIGURE 2. Kinetic diagram of a stream system.

these subsystems are organized is determined by one's views of community structure and organization. In this view of community organization, it is important to distinguish between theoretical and empirical organization. Theoretical organization of communities entails incorporation, concordance, and interpenetration of the capacities, environments, and performances of community subsystems. Such a theoretical view should not be reduced to empirical definition and experience, but rather should provide perspective on our experience. But we need empirical views as well. Here, empirically, we will take habitat organization, life history organization, and trophic organization to be more or less apparent aspects of community organization.

A hierarchical scheme of stream community subsystems is shown in Table 1. Habitat organization is initially used to construct subsystems. The primary habitat types of margins, riffles, and pools (2° subsystems) are broken down into subhabitats in terms of vertical placement within the water column and substrate type (3° subsystems). Trophic organization is used to form subsystems on the next lower level (4° subsystems). Trophic subsystems are further decomposed into species population subsystems (5° subsystems). Life history phenomena such as dispersal, colonization, phenology, and interspecific and intraspecific interactions contribute to life history organization of communities at this level, although there is interpenetration of population phenomena between levels as well as between subsystems on a given level.

Table 2 further elaborates on the trophic categories and their corresponding resource bases in this scheme. The trophic subsystems listed in Table 2 are intended to include, in a generalized way, all trophic categories encountered in a biological community. Slightly more emphasis is placed on detritus as a resource base due to its relative importance in small stream communities. Subdivision of the detritus food base is from the classification of Cummins and Klug (1979).

TABLE 1. Hierarchical scheme of stream subsystems.

1° Subsystems		
pS (stream substrate)	pW (stream water)	pB (stream biota)

2° Subsystems		
pS (margin)	pW (margin)	pB (margin)
pS (riffle)	pW (riffle)	pB (riffle)
pS (pool)	pW (pool)	pB (pool)

3° Subsystems		
pS (riffle, bedrock)	pW (riffle, surface)	pB (riffle, water surface)
pS (riffle, cobble)	pW (riffle, water column)	pB (riffle, water column)
pS (riffle, gravel)	pW (riffle, bottom)	pB (riffle, bottom, bedrock)
pS (riffle, litter)*	pW (pool, surface)	pB (riffle, bottom, cobble)
pS (riffle, vegetation)†	pW (pool, water column)	pB (riffle, bottom, gravel)
pS (pool, bedrock)	pW (pool, bottom)	pB (riffle, bottom, litter)
pS (pool, cobble)	pW (margin, surface)	pB (riffle, bottom, vegetation)
pS (pool, gravel)	pW (margin, water column)	pB (pool, water surface)
pS (pool, sand)	PW (margin, bottom)	pB (pool, water column)
pS (pool, silt)		pB (pool, bottom, bedrock)
pS (pool, litter)		pB (pool, bottom, cobble)
pS (pool, vegetation)		pB (pool, bottom, gravel)
pS (margin, bedrock)		pB (pool, bottom, sand)
pS (margin, cobble)		pB (pool, bottom, silt)
pS (margin, gravel)		pB (pool, bottom, litter)
pS (margin, sand)		pB (pool, bottom, vegetation)
pS (margin, silt)		pB (margin, water surface)
pS (margin, litter)		pB (margin, water column)
pS (margin, vegetation)		pB (margin, bottom, bedrock)
		pB (margin, bottom, cobble)
		pB (margin, bottom, gravel)
		pB (margin, bottom, sand)
		pB (margin, bottom, silt)
		pB (margin, bottom, litter)
		pB (margin, bottom, vegetation)

4° Subsystems		
Trophic Subsystems	<ol style="list-style-type: none"> 1. Autotrophs 2. Microphyte Herbivores 3. Macrophyte Herbivores 4. Decomposers (not treated in this study) 5. Coarse-particle Detritivores 6. Fine-particle Detritivores 7. Carnivores 	

5° Subsystems		
Populations by species		

* litter includes woody and leafy debris

† vegetation includes vascular plants and algae

TABLE 2. Trophic organization.

<u>Trophic Subsystems</u>	<u>Energy or Food Base</u>
1. Autotrophs	1. Solar radiation or reduced inorganic compounds
2. Aufwuchs and phytoplankton feeders	2. Microphytes and associated microbial film and detritus
3. Macrophyte herbivores (plant parasites included)	3. Macrophytes (vascular plants and macroalgae)
4. Decomposers (microbiota, e.g., fungi, bacteria)	4. Dead particulate and dissolved organic matter
5. Detritivores	5. Coarse particle detritus (dead organic matter and associated microbiota)
6. Detritivores	6. Fine particle detritus (dead organic matter and associated microbiota)
7. Carnivores (parasites and parasitoids included)	7. Animals and live animal tissue

Although individual organisms are placed in a specific trophic category, it should be recognized that organisms usually derive their energy and material needs from more than one category. In his discussion of the food habits of species of an estuarine community, Darnell (1961) writes:

Individual species do not appear to conform to specific trophic levels on the basis of the following considerations:

1. Omnivory on the part of most, if not all, of the major consumer species,
2. Nutritional opportunism among the consumers,
3. Ontogenetic change in the food habits of the consumers,
4. Importance of organic detritus in the nutrition of the consumer species,
5. Complex nature of the origin of detritus.

Many stream invertebrates also exhibit these tendencies. Darnell (1961) presented a model which describes the trophic relations of the estuarine community. In it, the food of each species is represented in the form of a spectrum. Darnell states:

... the ability of a given species to utilize alternate foods (often from different 'trophic levels') appears to be one of the main buffering factors which tend to stabilize population levels in complex natural communities.

Figure 3 represents theoretically the utilization of different food bases by stream invertebrate trophic subsystems (decomposers are excluded). This diagram illustrates what Darnell (1968) refers to as the "multivoracity" of aquatic animals. For example, a microphyte herbivore consumes primarily microphytes during its stream life, but it also consumes a large amount of fine particulate detritus and some coarse particulate detritus. Cummins (1973) suggests that many aquatic insects may select food on the basis of particle size, not on the basis of food type or origin. Thus the hypothetical curves in Figure 3 may better represent the trophic spectra of

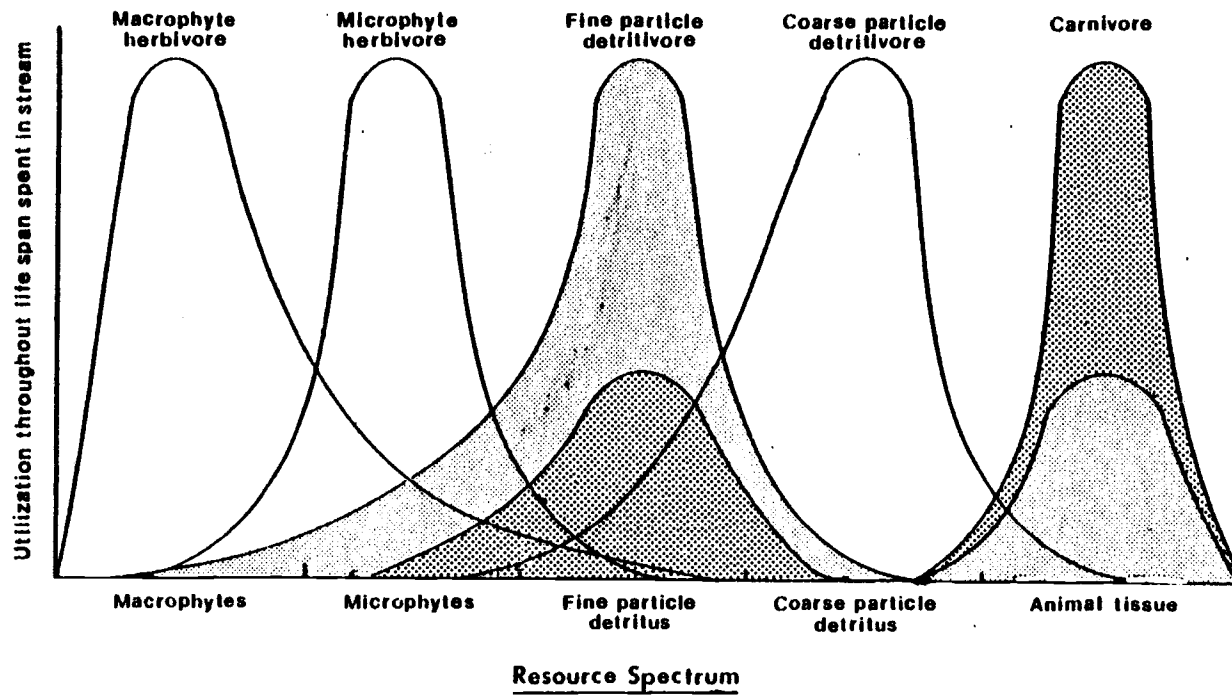


FIGURE 3. Theoretical utilization of different food categories by stream invertebrate trophic subsystems.

food types utilized by aquatic invertebrates than do narrow categories. But, for simplicity in our discussion of stream communities, it will be convenient to identify an organism by the predominant food category consumed during its stream life.

SPECIFIC METHODS

Model streams, such as were employed in this study, can facilitate understanding of stream communities by providing somewhat simpler and more controllable systems than those found in nature. Environmental parameters can be more easily regulated and assessed, and habitat types can be clearly defined. Colonization by aquatic organisms and their establishment in stream systems can be monitored more easily. Since they are controlled, communities in model streams lack some of the environmental variability experienced by those in natural streams. The controlled flow regime in the experimental streams did not provide an increase in water discharge during the winter months, when nearby natural streams were subject to freshets.

Research was conducted in two outdoor model streams located at the Oak Creek Laboratory of Biology, Oregon State University, near Corvallis, Oregon, from May 1978 through February 1980. Each stream is composed of two wooden channels elevated above the ground and having inner walls of plexiglass (Figs. 4 and 5). Water from a nearby spring-fed stream was continuously piped into each stream at a rate of 1.8 liters per minute. The channels had a slope of approximately 1.7 percent and were connected at each end with large irrigation pipe. A 2.0 hp pump maintained recirculation of water in each model stream.

Riffle areas were built up with hollow concrete blocks and the resulting shallow riffle-deep riffle-pool contour was overlaid with natural stream substrate. Cobble and gravel were the predominant particles in the riffles while the pool substrate consisted mostly of gravel with fine sediments. Alder wood from nearby Oak Creek was air-dried for a few weeks and then added to each deep riffle and pool. Alder (Alnus spp.) and apple (Malus sp.) trees growing beside the stream channels provided partial shade and litter fall into the streams.

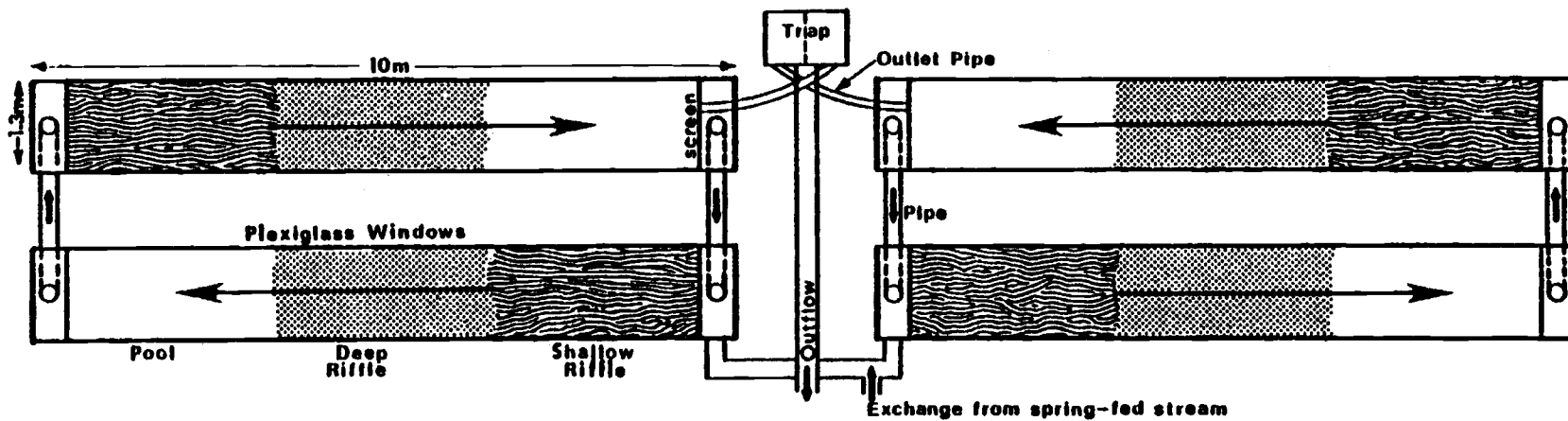


FIGURE 4. Overhead view of model streams showing recirculation patterns.

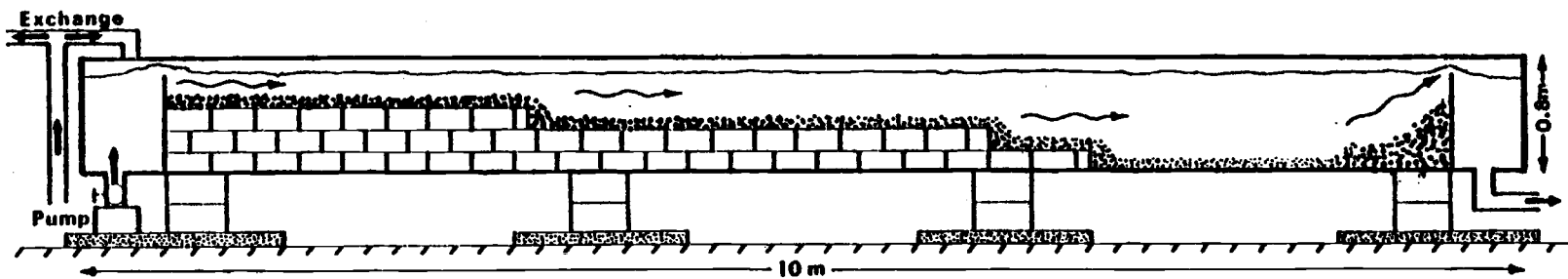


FIGURE 5. Longitudinal sectional view of a model stream channel. Arrows indicate direction of water flow.

Light was one of the environmental factors measured. A Belfort pyrliometer was placed above and between the two streams to measure daylength and relative light intensity from June 1979 through February 1980. Temperature was recorded continuously in each stream with spring-driven thermographs (Partlow Model RFT). Temperatures taken from the records were weekly minimum and maximum temperatures.

Current velocity measurements were taken at three points across each stream channel approximately every 0.5 meters. Current was measured at the bottom and at 0.6 of the water depth with a TSI flowmeter (Model 1630-U) after flow patterns in the stream channels became stabilized. Current velocity measurements are given in Appendix I.

Organic and inorganic materials entering the stream through the water supply in a 24-hour period were measured weekly until 13 July 1979 and biweekly thereafter. A small plankton net made of 300 μ mesh was placed under the exchange flow pipe to capture incoming materials. Organisms were sorted live and preserved in 70 percent ethanol. Sediments and debris were dried in a 60°C oven and combusted in a 550°C muffle furnace to obtain dry weight and ash-free dry weight measurements of nonliving materials.

Litter fall into the streams was sampled once a week by removing litter that accumulated against the downstream screen in each stream. Litter was dried at 60°C and then sorted. Dry weights of leaves, twigs, flowers and fruits, moss, algae, and miscellaneous litter were measured.

Benthic samples were taken triweekly in each shallow riffle, each deep riffle, and each pool. Each of these three habitats was divided by a grid, each section of a grid corresponding to a site where samples were collected and current velocity readings were taken. A specific grid section within a habitat was not resampled until six months had elapsed.

Riffles were sampled with a modified Hess box sampler with a sampling area of 507 cm^2 . The upstream side of the box had a wall of 300μ mesh allowing water flow through the device to wash organisms and debris into two nets attached to the downstream side of the sampler. One net of 300μ mesh was fastened inside another net of 64μ mesh to prevent clogging of the fine net. Large substrate particles, mostly cobble and gravel, were scrubbed with soft brushes inside the sampling box to remove organisms and were then removed for substrate analysis. Contents of the nets were transferred to plastic bags and preserved in formalin. Pool samples were taken by pushing a 15 cm aluminum pipe (area of 175 cm^2) into the substrate. Large particles were removed by hand, after scrubbing, and the remaining material was siphoned through a 64μ mesh net by means of a Guzzler "500" hand pump. Water and very fine particles passing through the net were collected in a plastic bucket. Organisms and debris caught in the net were preserved in formalin.

Substrate analysis procedures followed those of Cummins (1962). All mineral substrate materials were dried and sieved through Tyler U.S.A. Standard Testing sieves. Each size class was weighed and the geometric mean particle size and standard deviation for each sample was computed (Shirazi and Seim, 1979). Dry weight and ash-free dry weight of silt and clay particles in the pool water samples were measured using the hydrometer technique (Black, 1965). Substrate particle size classes used in this study are modified from those of Wentworth (1922). Classes are designated as follows:

Particle name:	Cobble	Gravel	Sand	Silt	Clay
Particle size range in mm:	256-32	32-2	2-.063	.063-.004	.004-.00045

Benthic organic matter from each sample was dried at 60°C and weighed.

Stream drift was sampled every two weeks. Drift nets of 300μ mesh were placed at the end of each deep riffle for 24 hours, a cross-sectional area of stream water of 711 cm^2 being filtered.

Drift samples were preserved in formalin. Each preserved benthic sample and each preserved drift sample was divided into ten equal subsamples by means of a sample splitter. Three subsamples were combined and analyzed for each sample. Organisms were sorted under 12X magnification and preserved in 70 percent ethanol.

Monthly sampling of specific microhabitats was conducted to gain information about aquatic organisms not obtained by the routine sampling procedures. Organisms residing in or on moss, macroalgae, leafy litter, and wood were hand-picked from the substrate and preserved in 70 percent ethanol. Observation of adults and occasional sampling by netting as well as by taking exuvia samples from the streams provided life history information on many insects and facilitated species identification.

All macroinvertebrates were identified, counted, and measured to the nearest 0.5 millimeter under 25X magnification. Biomass estimates of macroinvertebrates were obtained from length and frequency measurements by using regression equations and single factor relationships provided by Mike Crouse (U.S. Environmental Protection Agency, Corvallis, Oregon). Biomass estimates were not obtained for the Hydroida, Acarina, Isopoda, Collembola, Hemiptera, nonelmid Coleoptera, Blephariceridae, Chaoboridae, Empididae, and all adult insects.

Trophic habits of organisms were ascertained from the literature (Grafius and Anderson, 1973; Merritt and Cummins, 1978; Chapman and Demory, 1963).

Benthic algae and macrophytes were sampled every two weeks. Visible amounts of vegetation were mapped. Samples were then taken at selected sites in riffles and pools. A 25 cm² area of substrate was gently scrubbed with a brush and the algae and macrophytes washed into a beaker. Half of the sample was dried at 60°C to obtain a dry weight estimate. The remaining half of the sample was preserved with Lugol's solution for species identification. The percent species composition of each algae sample was determined by identification of one hundred cells.

A Scientific Information Retrieval (SIR) database was used to store and organize data from this study. This system also generated reports and scattergram plots of the data. An overall description of the database, a listing of the schema, and reports generated are presented in Appendix II.

RESULTS AND INTERPRETATION

Stream Community Organization

It will be recalled from the introduction that the goal of this study was to better understand stream communities through a community perspective that might make their structure, organization, and development more understandable. In a very fundamental sense, then, the primary objective of this study becomes the provision of a perspective making community understanding possible. But a perspective is, as it were, transparent and can be known only through the simplicity, order, and unity it brings--or perhaps fails to bring--to experience. I must employ, then, in this thesis the perspective articulated in the introduction and conceptual model section to order experience, some of which is general and some of which is the particular model stream experience of this study.

Beyond advancing a perspective, this study thus becomes a sort of "demonstration" of that perspective, first through the order it may bring to observations on communities in two experimental streams, and second through the ordering and relating of other relevant community experience. The two experimental streams described in the methods section were designed, constructed, and operated so that in terms of energy, material, and colonizing species inputs they were essentially alike. They were also made alike in terms of the physical habitat they provided for the development and organization of stream communities. Given similar community habitats and the same species pool from which colonization occurred, the development and organization of the communities in the two experimental streams should be alike in the perspective here advanced, or of the same kind in all fundamental respects. In what follows, I will be primarily concerned with how adequately experience with two replicate stream communities is simplified, ordered, and unified, even though

these communities must differ somewhat in their particular performances. My concern is thus the demonstration of order provided by a perspective, not primarily description, estimation, and their statistical significance.

One final point must be made. We are concerned here with stream communities and thus with community level capacities and performances and, insofar as it is possible, with analysis of these performances. Community level performances are taken to be community structure, community habitat, trophic, and life history organization, and community development. These then will be decomposed or analyzed into community subsystems based on physical habitat, trophic group, and species populations. But we do not have very satisfactory common denominators for representation. Energy transfer has received much attention, but the theoretical and empirical problems of its application have not yet been resolved. Turnover ratio, the ratio of production to standing crop, is useful in illustrating the rapid replacement of invertebrate biomass. However, biomass and taxa numbers will be resorted to primarily as they are additive and offer some other advantages. But it must be acknowledged that they leave one with the feeling that there is so much more to picture.

Stream community organization is represented empirically in two-dimensional graphs utilizing relationships between the primary stream system components shown in Figure 2. Community and community subsystem biomasses and species numbers, performances of the stream biota p_B , are presented as functions of geometric mean particle size and current velocity, performances of the substrate p_S and the water p_W . Stream community organization is shown first for only one point in time, in August 1979, when there was a peak in the number of taxa in the experimental streams.

In this presentation of stream community organization and in the subsequent presentation of community development, only data from benthic samples are used. Biomass of stream organisms

utilizing water surface subhabitats is not included as it was very small, so small that it was detectable only during the summer months when gerrids were present. Biomasses of organisms utilizing water column subhabitats are also not included. Organisms occupying these subhabitats are fish, which are not addressed in this study, planktonic crustaceans which do not contribute greatly to the total biomass of the community, and drifting benthic invertebrates which use the water column only as a transportation channel during drift and emergence.

According to the classification scheme of generalized stream systems (Table 1), the 2° subsystems presented here should be margins, riffles and pools. True margins do not occur in the experimental streams. Hence, two kinds of riffles, a shallow riffle and a deep riffle, and pools are taken to be 2° subsystems. Macroinvertebrate biomass in riffles, where geometric mean particle size and current velocity were greatest, was higher than biomass in pools. Macroinvertebrate biomass was slightly greater in shallow riffles than in deep riffles. The number of taxa in shallow riffles, which ranged from 16 to 26, was slightly higher than the number of taxa in deep riffles, which ranged from 12 to 20. Pools generally contained fewer taxa than riffles, the number ranging from 9 to 15.

The 2° and 3° subsystems, defined by habitat substrate type, are displayed in Figure 6. In addition to riffle and pool subhabitats defined by substrate particle size, vegetation and litter subhabitats are represented. Macroinvertebrate biomass per unit area was greater in cobble and litter subhabitats than in vegetation, gravel, or sand subhabitats. Biomass of macroinvertebrates in cobble subhabitats tended to increase as geometric mean particle size and current velocity at 0.6 total depth increased. While macroinvertebrate biomass in vegetation subhabitats was not great, it should be mentioned that numbers of macroinvertebrates were high. Early instar nemourid stonefly nymphs and chironomid midge larvae were abundant in moss. Taxa number was highest in cobble

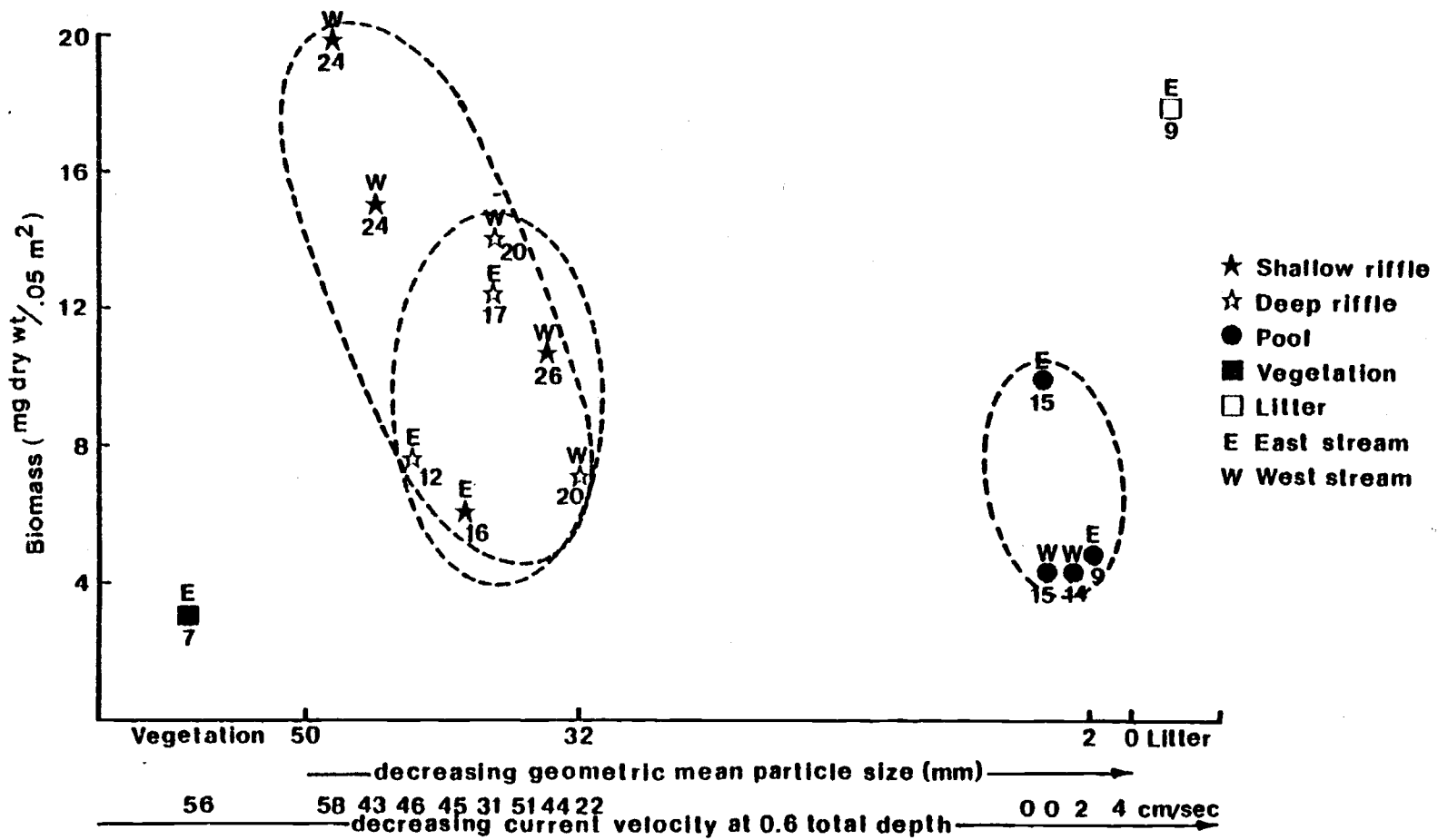


FIGURE 6. Organization of 2° and 3° subsystems. Data are from August 1979. Numbers indicate number of taxa in each 3° subsystem.

subhabitats, and the number of taxa tended to increase as geometric mean particle size and current velocity increased. Generally, taxa number tended to increase with biomass with the exception of the litter subhabitat. Here, biomass tended to be relatively high, while taxa number was low.

Figure 7 presents the biomass and number of taxa within each trophic subsystem present in each subhabitat. Autotroph biomass per unit area is nearly undetectable except in shallow riffles and pools where the particle size is in the gravel range. Macrophyte herbivore biomass was also low throughout all stream subhabitats. Microphyte herbivore biomass was high in vegetation, shallow-riffle cobble, and litter subhabitats. The abundance of these herbivores was most likely partially responsible for the low biomass of autotrophs in these subhabitats (Sumner and McIntire, 1982). Biomass of fine-particle detritivores was low in vegetation and litter subhabitats, moderate in shallow-riffle cobble and sandy pool subhabitats, and greatest in gravel subhabitats of deep riffles and pools. Coarse-particle detritivore biomass was much greater in litter subhabitats than in other subhabitats, as might be expected. Carnivore biomass was extremely low in most subhabitats, it being noticeable only in shallow-riffle cobble and deep-riffle and pool gravel subhabitats.

Each trophic subsystem includes one or more species populations, a population in this perspective being a 5° subsystem. The number of taxa (species, when possible) in each trophic subsystem is shown in Figure 7. The greatest number of taxa was in the fine particle detritivore trophic subsystem in the cobble subhabitat, where biomass was relatively low. The number of taxa in each trophic subsystem generally did not vary with biomass. In other words, a high biomass was not necessarily due to a great number of taxa.

Figure 8 shows the habitat spectrum of some species populations from different trophic subsystems within the community: Melosira varians, Hydroptila, Baetis tricaudatus, Eukiefferiella species,

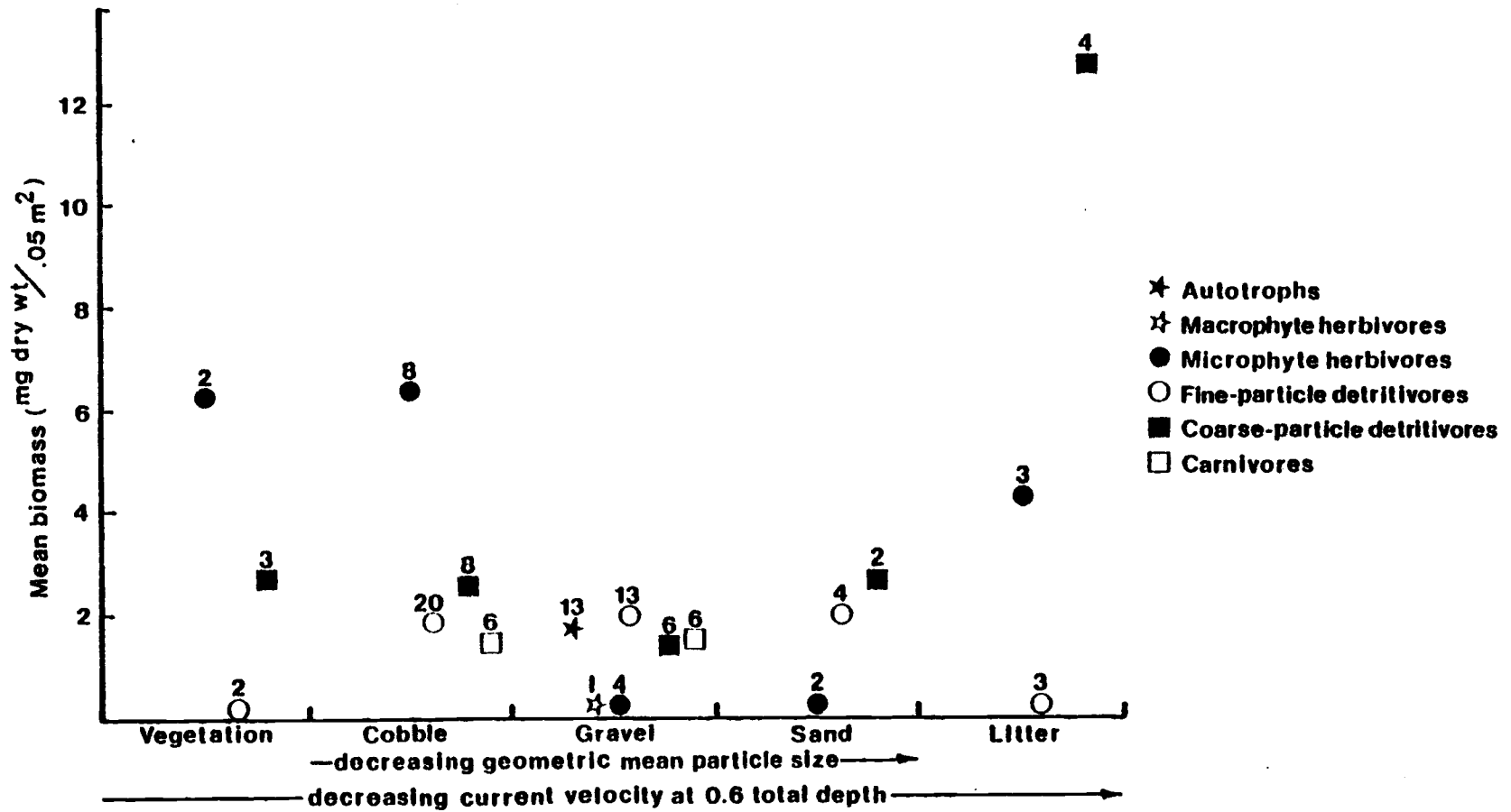


FIGURE 7. Organization of 4° and 5° subsystems. Data are from August 1979. Numbers indicate the number of taxa in each 4° trophic subsystem.

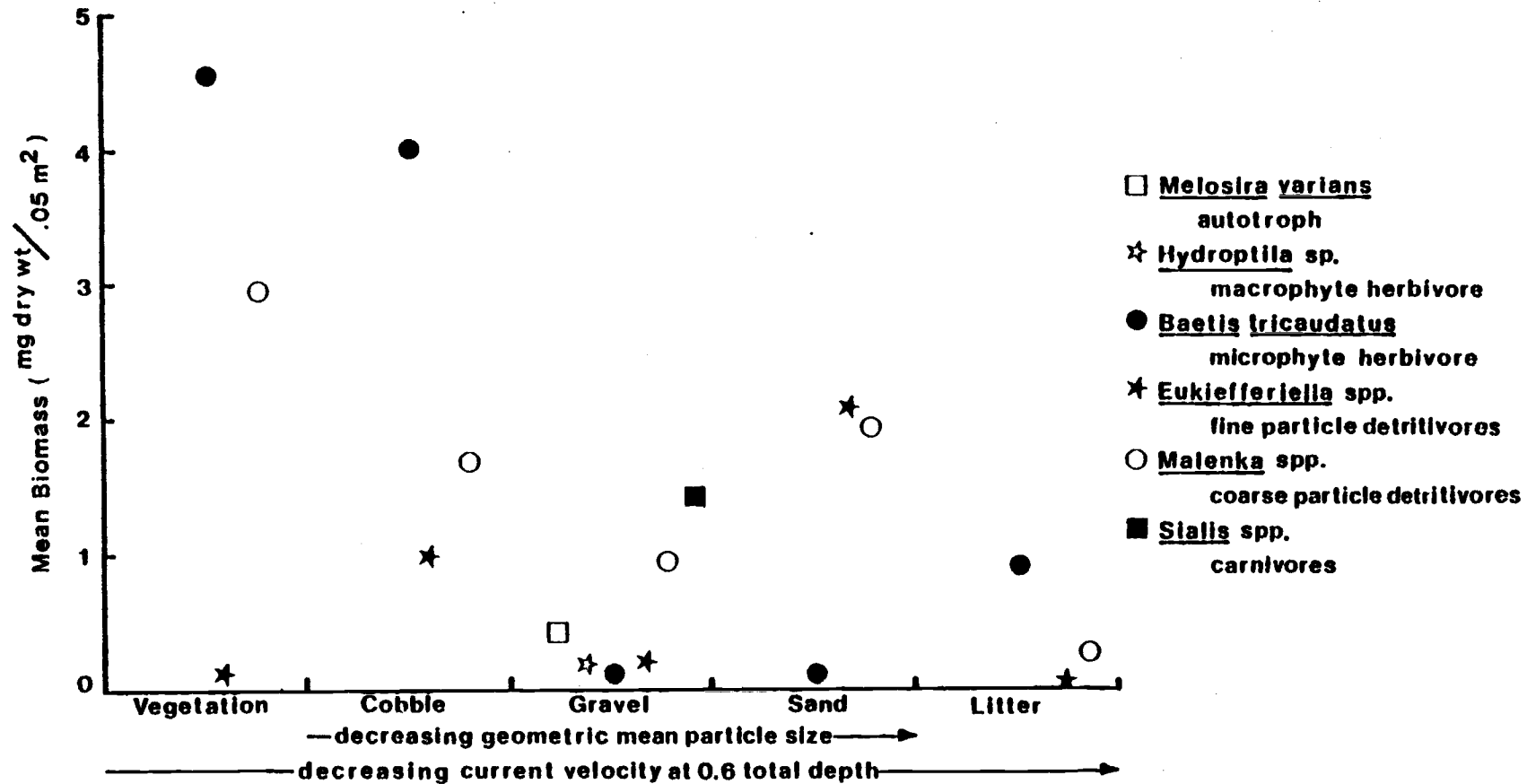


FIGURE 8. Habitat organization of selected species. Data are from August 1979.

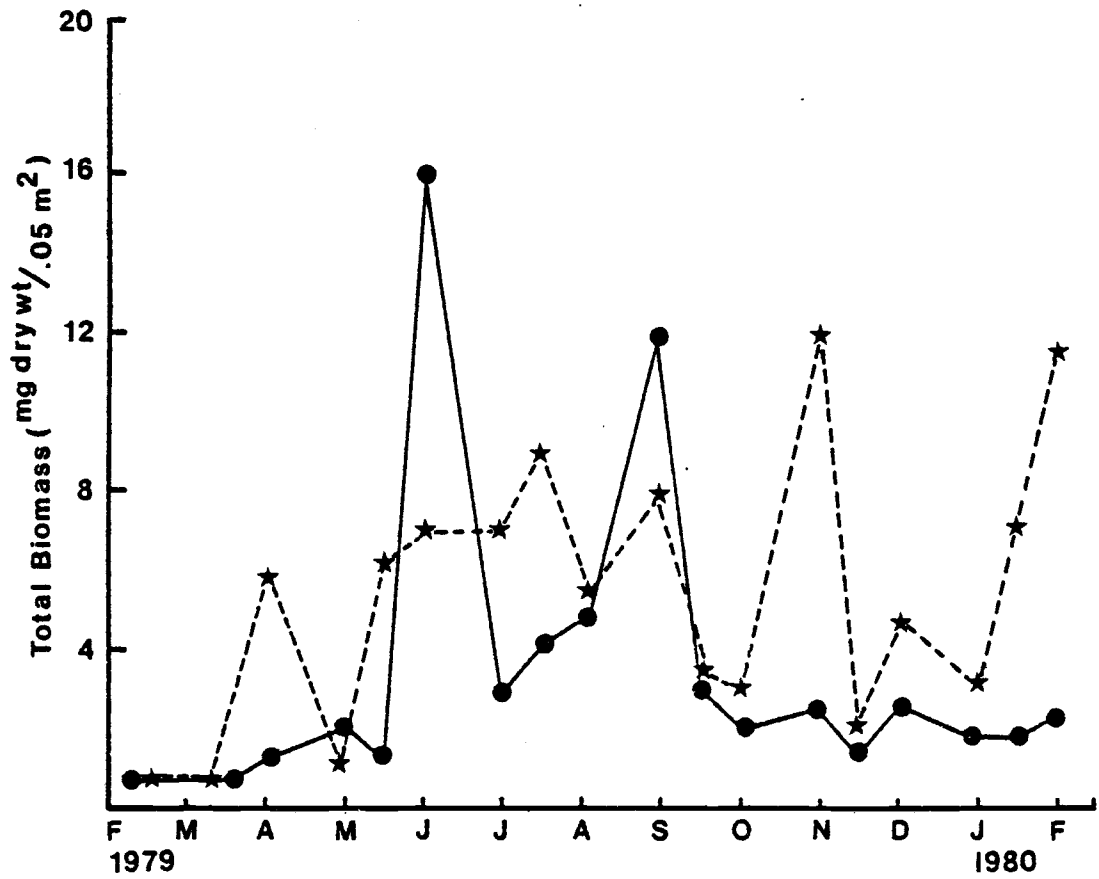


FIGURE 9. Benthic biomass in the experimental streams. Total biomass of macroinvertebrates in benthic samples are from east (★) and west (●) streams.

Malenka, and Sialis species. Now it should be remembered that species such as these, which have been classified as different kinds of autotrophs, herbivores, detritivores, or carnivores, generally utilize a spectrum of trophic resources, not just one category according to their class (Fig. 3). These species serve in this way to unify the different trophic subsystems which are not clearly distinguished. Similarly, species populations utilize a spectrum of habitat types and thus become the "girders" that Elton (1966) believed to unify the habitat subsystems into a community. But species differ in the degree to which they function in this way, as is apparent in Figure 8. Melosira varians, Hydroptila, and Sialis species were found in only single subhabitats; Baetis tricaudatus, Eukiefferiella, and Malenka were found in more than one subhabitat. The presence of species in several subhabitats can be thought of as linking the subhabitats, uniting them into a higher level system.

Stream Community Development

We can begin our discussion of stream community development by considering the change in biomass and taxa numbers for the entire community in each of the two model streams. Then these total changes can be analyzed or partitioned into the community subsystems as these changed through time. Finally, in the next two sections of this thesis, some explanation for community development and organization will be given. Changes in biomass were much more erratic in the east stream than in the west stream. From a very low level in February 1979, the biomass of macroinvertebrates in the east stream increased until early summer and then fluctuated precipitously to end at a very high level by January 1980 (Figure 9). Biomasses in the west stream were generally lower and less variable, except for high levels in late spring and late summer.

In view of the striking differences in macroinvertebrate biomass within and between streams, the increases in taxa numbers

through colonization of the two streams were remarkably similar, both in numbers and in pattern through time (Figure 10). Taxa number in both streams increased from about 8 in February 1979 to about 46 by July and August. Taxa numbers then declined into winter, this being followed by an apparent increase in January and February 1980.

Stream community development can be defined as change in stream community organization through time. Figure 11 shows biomass and taxa number development of 2° and 3° subsystems, based on vegetation, litter, and particle size. Three weeks after the experiment was begun, only very low levels of macroinvertebrate biomass were found in the riffles and pools, which I have called 2° subsystems. Biomass values per 0.05 m² ranged from a mean of 0.1 milligram dry weight in deep riffles to 0.9 milligram dry weight in shallow riffles. Twelve weeks later, in May, mean macroinvertebrate biomasses had increased greatly in the riffle habitats, but remained low in the pools. By August, mean biomass of macroinvertebrates in the pools had increased by an order of magnitude while riffle biomasses differed only slightly from those twelve weeks earlier. In early November, mean biomass of macroinvertebrates in the pools is very similar to that in August, but we see a dramatic increase in mean biomass in the shallow riffles (31.1 milligrams dry weight per 0.05 m²) and a decrease in mean biomass in deep riffles to one-half of what it was in August. A general trend seen here is that habitats with greater substrate particle size and greater current velocity at 0.6 of the total depth have consistently increased in biomass of macroinvertebrates through time.

The number of taxa in each habitat changed similarly through time. In February taxa numbers were consistently low in shallow and deep riffles and pools. By May, taxa numbers had increased in all three 2° subsystems, but remained relatively low in pools. Number of taxa was highest in August, where shallow riffles contained 16 to 26 taxa, deep riffles had 12 to 20 taxa, and pools had 9 to 15 taxa. By early November, the number of taxa had declined somewhat.

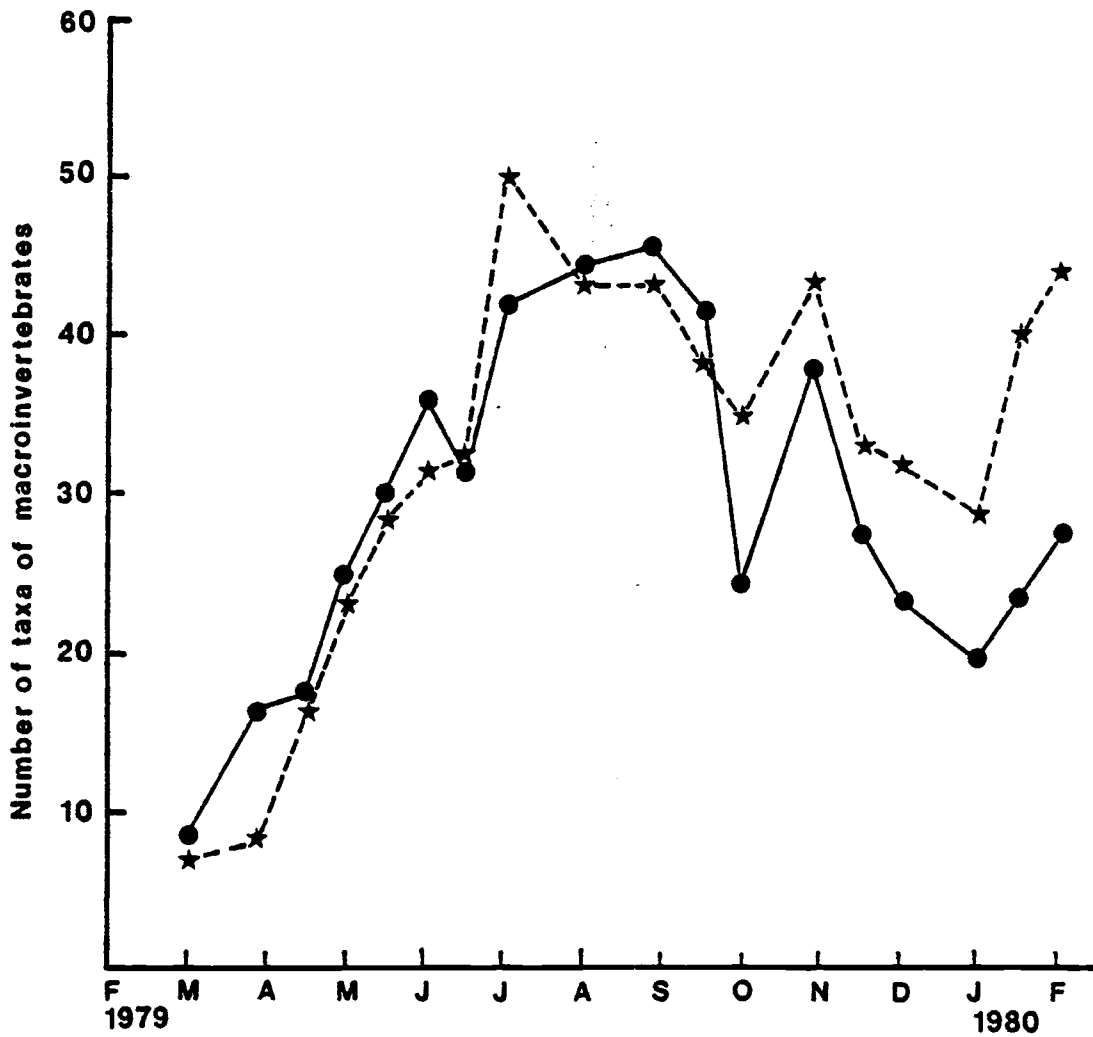


FIGURE 10. Species colonization of the experimental streams. The number of macroinvertebrate taxa in benthic samples from east (★) and west (●) model streams is shown.

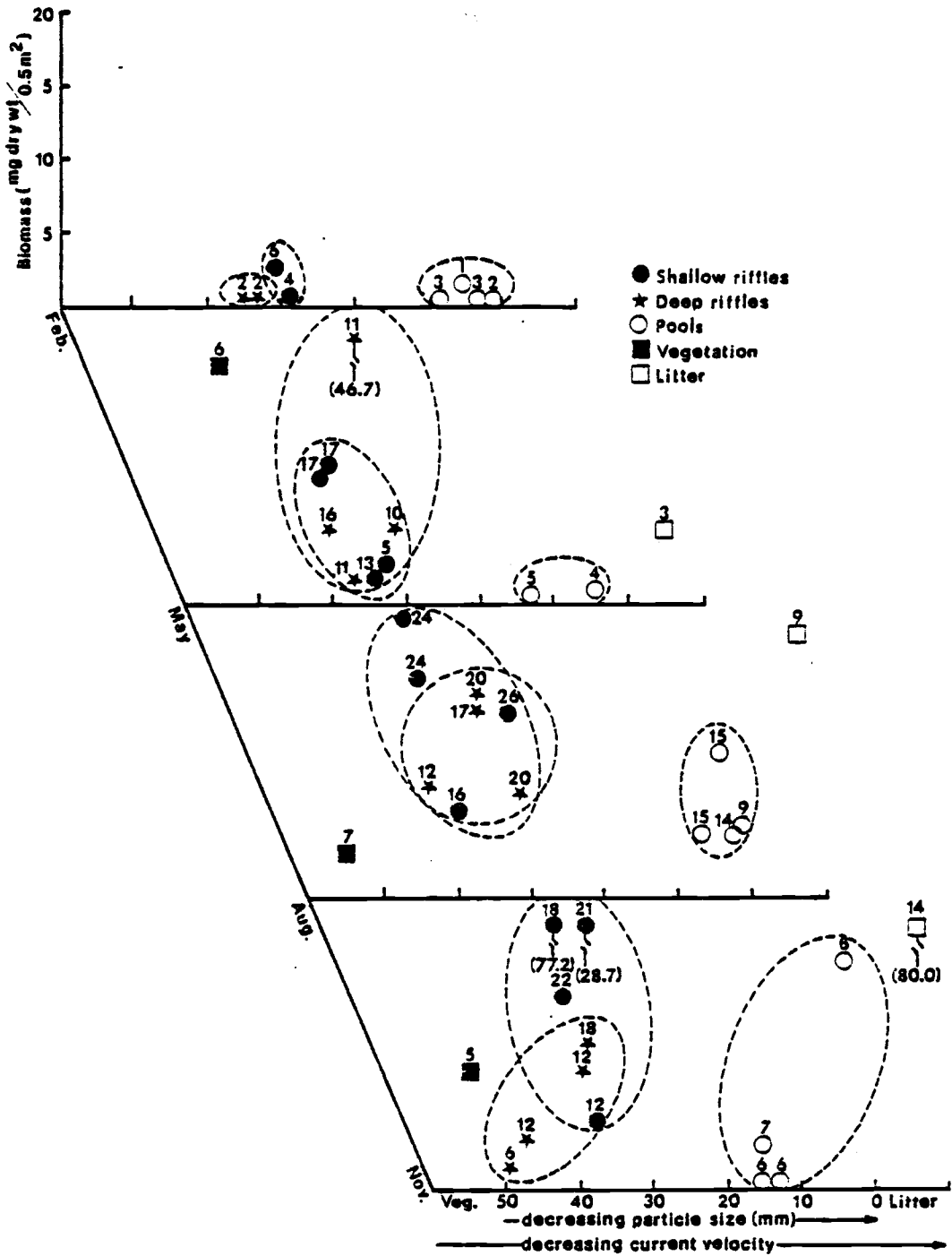


FIGURE 11. Development of 2° and 3° subsystems. Number of taxa in each 3° subsystem is shown. Vegetation and litter samples were not taken in February.

The greatest number of taxa was found in the shallow riffles, the lowest number in the pools.

February biomasses of macroinvertebrates in 3° subsystems were low, detectable amounts appearing in one sample from shallow-riffle cobble and in one sample from pool gravel. Benthic biomasses increased by May, especially in a deep-riffle cobble subhabitat. A high macroinvertebrate biomass of 16.2 milligrams dry weight per 0.05 m^2 occurred in the vegetation subhabitat. By August, biomasses were similar in the various subhabitats. Macroinvertebrate biomass in vegetation subhabitats had decreased somewhat while biomass in litter subhabitats had increased. In November, macroinvertebrate biomass was very high in a single shallow-riffle cobble subhabitat and in the litter subhabitat (Fig. 11). The number of taxa was generally higher in subhabitats of mineral substrate. Vegetation and litter subhabitats harbored fewer taxa with the exception of the litter subhabitat in early November, which had 14 taxa.

Development of the trophic subsystems in each subhabitat is shown in Figure 12. In February, autotrophic biomass per unit area was higher than that of other trophic subsystems, but only slightly. A very low macrophyte herbivore biomass of 0.5 milligram dry weight per 0.05 m^2 occurred in pools of gravel substrate. By May there had been an increase in autotroph biomass and noticeable increases in microphyte herbivore biomasses in vegetation, shallow-riffle cobble, and litter subhabitats. Fine-particle detritivore biomass had increased in shallow-riffle cobble and in litter subhabitats, but is greatest in vegetation subhabitats. Coarse-particle detritivore biomass had increased in all subhabitats, but most conspicuously in litter, by August. Biomass of autotrophs declined after May, but there is only a slight decrease in microphyte herbivore biomass. Biomass of fine-particle detritivores had decreased somewhat in vegetation subhabitats by August, but increased slightly in all other subhabitats. Carnivore biomass, which had been consistently low in earlier samples, was not perceptible in shallow riffle and

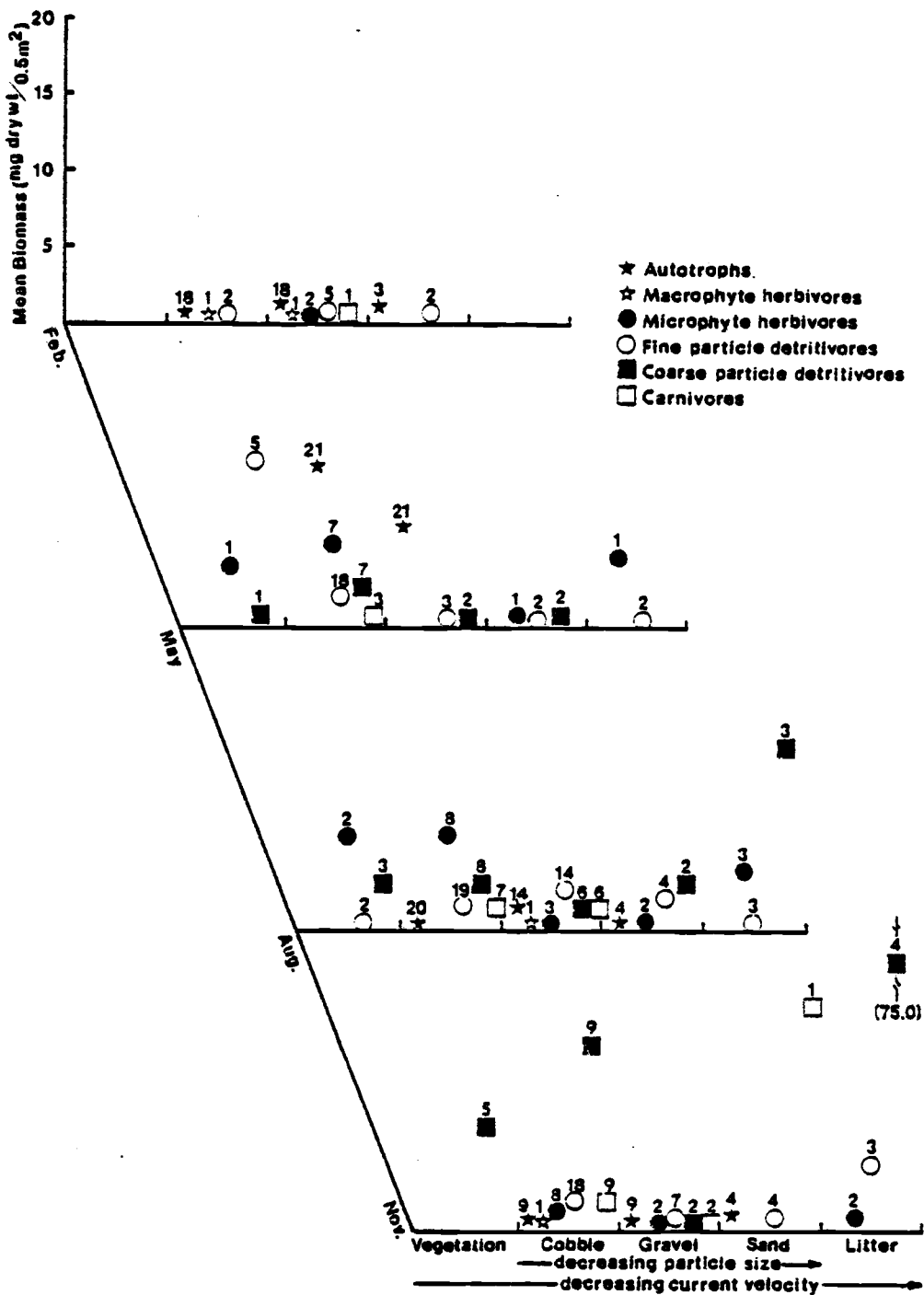


FIGURE 12. Development of 4° and 5° subsystems. Number of taxa in each 4° trophic subsystem is shown. Vegetation and litter samples were not taken in February.

pool subhabitats. November samples show low biomass of most trophic subsystems. But coarse-particle detritivore biomass had increased, dramatically in litter microhabitats which contained 75.0 milligrams dry weight of macroinvertebrates per 25 grams dry weight of leafy litter. Also apparent by November was a slight increase in carnivore biomass throughout riffle and pool subhabitats having cobble and other mineral substrates (Fig. 12).

Change in taxa number within each trophic subsystem is also shown in Figure 12. Many taxa of autotrophs were present in the stream community early in the study. As many as 18 taxa were common in cobble and gravel riffles in February. By May, taxa number had changed little, but a decrease in number occurred by August, where 4 to 20 taxa were common. In November, only 4 to 9 taxa of autotrophs were common enough to be detected. Generally, greater numbers of autotroph taxa were found in subhabitats of greater particle size and current velocity at 0.6 total depth. A single taxa of macrophyte herbivore was present in the streams during the study. It was found in pools having gravel substrate. The number of microphyte herbivore taxa remained low throughout the year. The greatest number of taxa, 8, was found in riffles of cobble substrate. The number of fine-particle detritivore taxa increased slightly over time, most markedly in riffle cobble subhabitats. Here, taxa number increased from 2 in February to 18 in May. The number of coarse-particle detritivore taxa also increased only slightly over time, with the greatest number of taxa in cobble subhabitats. The number of taxa of carnivores increased from 1, at the beginning of the study, to 9 in early November. Once again, the greatest number of taxa occurred in the riffle subhabitats of cobble substrate. Generally, these subhabitats had the greatest total number of taxa within the community.

Habitat utilization through time of selected species populations is shown in Figure 13. Hydroptila was the only macrophyte herbivore present in the streams in February. Its biomass varied

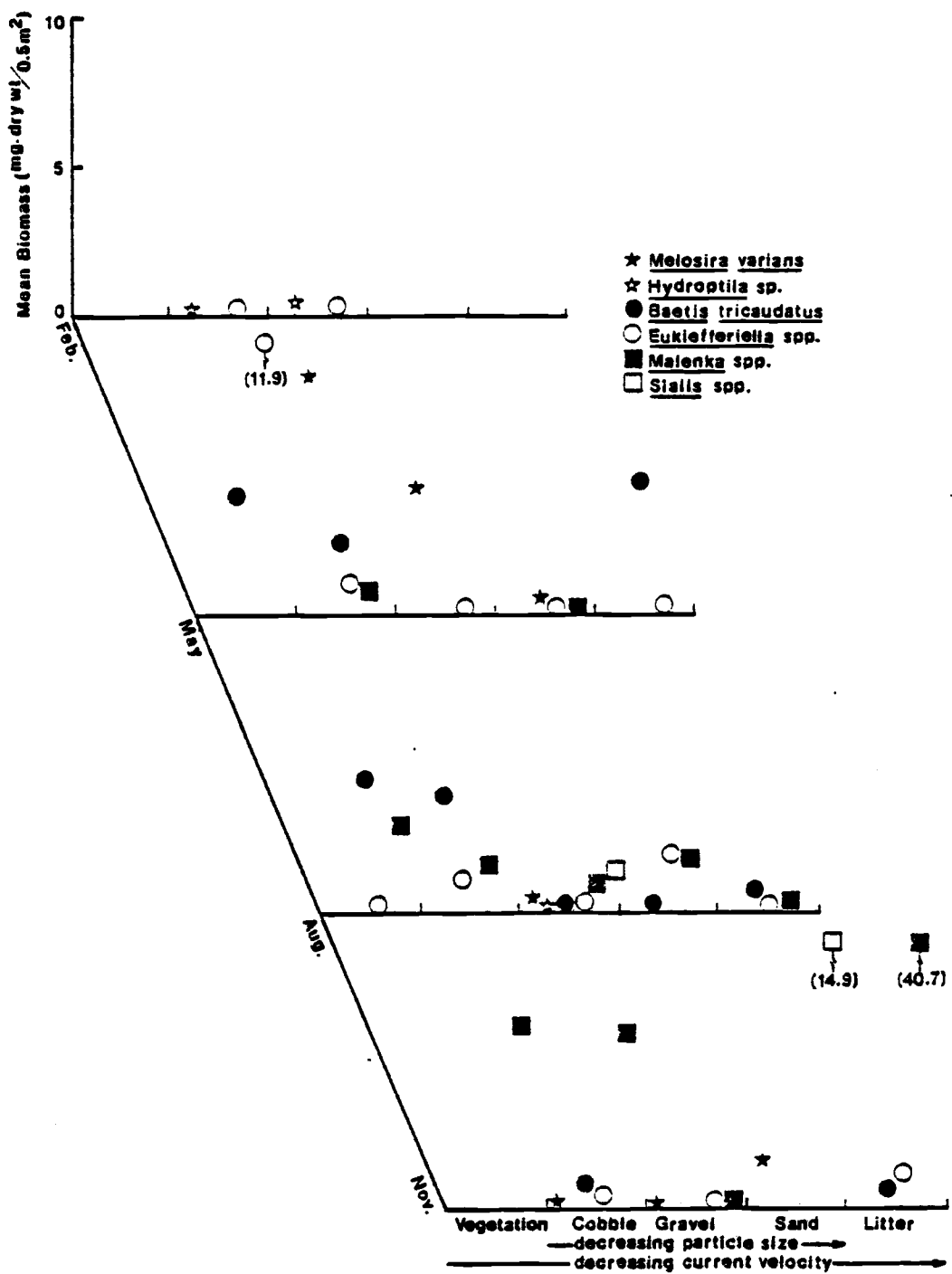


FIGURE 13. Development of selected 5° subsystems.

throughout the stream subhabitats as did macrophyte herbivore biomass. Shallow and deep-riffle cobble and pool gravel subhabitats contained low biomasses of Eukiefferiella species. Melosira varians was most abundant in all subhabitats in May. Hydroptila was absent from samples in May and August. Baetis tricaudatus biomass ranged from 0.5 milligram dry weight per unit area of sandy pool subhabitat to 4.6 milligrams dry weight per unit area of litter. Eukiefferiella species biomass had risen sharply in vegetation subhabitats and slightly in shallow-riffle cobble and litter subhabitats. August samples show an increase in Baetis tricaudatus biomass in vegetation and shallow-riffle cobble subhabitats and a decrease in biomass in litter. Eukiefferiella species biomass rose slightly in sandy pool subhabitats. Malenka biomass increased little in vegetation, shallow-riffle cobble, and sandy pool subhabitats. In November, Malenka and Sialis species show the sharpest changes in biomass. Increase in Malenka biomass is apparent in vegetation, shallow-riffle cobble, and litter subhabitats. In the latter subhabitat, Malenka constitutes almost one-half of the total coarse-particle detritivore biomass. Sandy pool samples had an average of 14.9 milligrams dry weight of Sialis species per 0.05 m^2 .

Species Pool, Life History, and Colonization Determination of Development and Organization

The potential capacity of a stream community resides, in a sense, in the species pool. The development and organization of a stream community in a given habitat will depend on the colonizing species, which came from the "pool" of species in surrounding habitats. The species pool of the experimental streams consisted of aquatic organisms from Oak Creek and its local tributaries. Stream water fed into the model streams from a nearby spring seep stream provided some species. The number of taxa entering the experimental

streams in a 24-hour period via the water supply ranged from 4 in December to 34 in April. Other sources of species, Oak Creek and its tributaries, contributed adult forms that colonized the experimental streams directly or via oviposition. Appendix III lists the taxa found in the experimental streams and the trophic codes assigned to them.

Through their life history capacities, species shape community structure, organization, and development. The pattern of kinds and abundances of species in space and time is determined partially by life history patterns of species. The phenology of a species helps determine its ability to survive and reproduce in a particular habitat. Hynes (1961) describes generalized life cycle patterns of stream invertebrates. Nonseasonal cycles are exhibited by species having life cycles extending for more than one year. Seasonal life cycles are shown by species having one or more cohorts within a year. This category is further subdivided into "slow" and "fast" seasonal cycles. Hynes saw species in a stream system as being organized by these life history patterns, as did Minshall (1968), who used a variation of Hynes' classification.

Species appearing early in community development in the experimental streams were characterized by "fast" life cycles, such as many species of the Chironomidae, which produce several generations each year. This conforms with Hynes' (1961) observation that streams recovering from disturbance often have short life cycle organisms appearing first. The frequent generation of dispersal forms provides individuals ready to colonize new habitats as they appear. Univoltine species and species having life cycles requiring more than one year are less likely to be the first to colonize new habitats. Of course, environmental conditions must be conducive to dispersal and favorable for colonization for it to be successful.

Other life-history phenomena are responsible for changes in community structure and organization. The emergence of many microphyte herbivores in late summer resulted in lower biomass of this

trophic subsystem in the fall and winter (Fig. 12). Trophic organization of a community, an aspect of its life history organization, is important in determining community development as well as overall organization. Ulfstrand (1968) discusses the relationship between food habits and life cycles, and he cites examples of species with life-cycle phases timed to correspond with the availability of their predominant food source. He concludes that there is "a general correlation between the life cycle, especially the periods of intense growth, and food availability." In the model streams, Baetis tricaudatus nymphs reached peak abundances in biomass in May (Fig. 13), when the greatest abundance of algae occurred (Fig. 14). Grazing pressure by microphyte herbivores surely contributed to the radical decrease in standing crop of algae during the summer.

Colonization ability of species populations also affects the organization and development of stream communities. Colonization is an important mechanism in maintaining community organization in an environment that is subject to periodic loss of organisms, such as during winter spates. Williams and Hynes (1976) and Williams (1977) discuss recolonization mechanisms in stream benthic communities. They examined the relative contributions of four sources of colonists in the reestablishment of benthic communities. In their view, downstream drift is the most important source of recolonizing macroinvertebrates for permanent streams, followed by aerial sources being second in importance. Upstream migration and movement up from within the substrate also contribute to recolonization, but not as greatly. Downstream drift and aerial forms contributed to colonization of the model streams. The importance of downstream drift in the establishment of macroinvertebrates in the model streams decreased throughout the year, most markedly in the east stream. This might be expected, as with time relatively fewer new or not yet established forms were present in the incoming drift. Also, many of the species in the incoming drift were different from those in the benthic samples. Many species found in the incoming drift

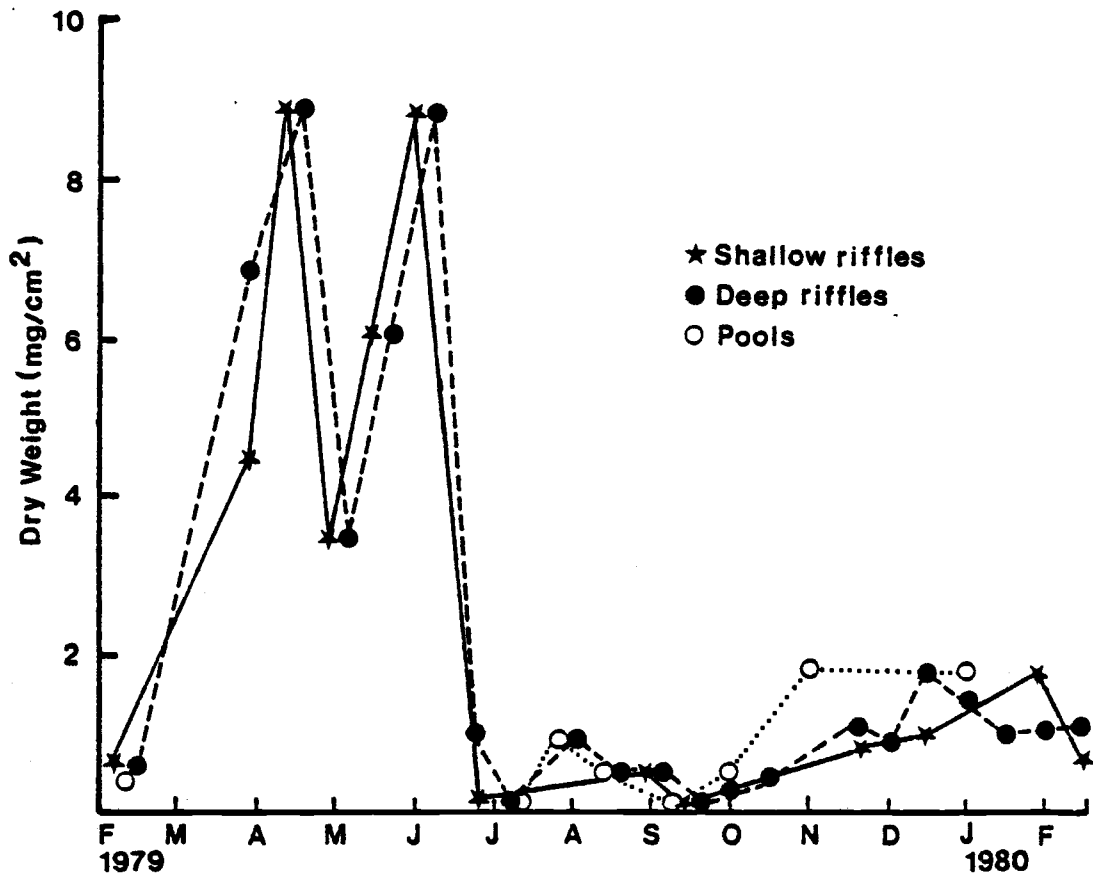


FIGURE 14. Algal biomass in model stream habitats. Mean values for each habitat are shown.

(e.g., Nerophilus, pelecypods, Dugesia, the isopod Ligidium gracilis) did not become established in the model stream communities. These species tend to be those found in ponds and spring seeps, the latter being the source of the incoming water, and the model stream environment apparently was not suitable for their establishment. This suggests that aerial forms of macroinvertebrates became more important in colonization as the stream communities developed.

Habitat and Environmental Determination of Development and Organization

Williams and Hynes (1976) have stated that "successful colonization by a species is not only dependent on a satisfactory dispersal mechanism, but also on the suitability of the habitat invaded." Habitat and environment play an important role in community development and organization by providing shelter or cover and supplying needed resources and otherwise suitable conditions.

In the present hierarchical scheme of community organization, habitat organization defines the 2° and 3° subsystems of a stream community. Stream substrate and stream water (pS and pW in Fig. 2) together form habitats for stream organisms (pB). Vertical placement within the water column, as used by Elton and Miller (1954), and substrate type subdivide the major habitat types--margins, riffles, and pools. Ulfstrand (1968) considered substrate to be an important determinant of the distribution of benthic invertebrates, through its direct effects on the life conditions of stream organisms. He believed that current velocity has a lesser role, affecting benthic invertebrates indirectly. He noted, however, that substrate and current velocity in streams generally "vary in a parallel fashion." In describing stream community organization and development, both substrate and current velocity were used to define the habitat types of stream organisms. In Figures 11, 12, and 13 it is apparent that habitats having greater substrate

particle sizes and faster current velocities generally have higher macroinvertebrate biomasses.

The relative importance of specific habitats may change seasonally. A species may use different habitats during different life stages. For example, Figure 13 shows higher biomasses of Malenka in vegetation subhabitats than in litter subhabitats in August. The reverse is true in November, when biomasses are much greater in litter subhabitats. Moss appeared to provide the proper cover and food resources for early instar Malenka nymphs. Moss provides a somewhat stable habitat in stream riffles and fine particulate detritus trapped in the moss serves as food for the small nymphs.

As the environment provided by a stream system impinges upon the stream community, there must be concordance between the community and its environment. In the kinetic diagram of a stream system (Fig. 2), the environmental parameter climate impinges upon all the primary components of a stream system. Thus, it has an effect on stream community organization and development, though not necessarily directly. Performances of climate such as light and temperature affect the seasonal development of a stream community in a variety of ways.

Light and temperature control the "rhythm of the life histories" of many aquatic organisms (Hynes, 1970). Hynes states that low winter temperatures tend to slow down growth rates of aquatic insects. Also, difference in emergence dates of insects can be explained by temperature differences. The seasonal temperature profile of a stream system can determine what species will be able to inhabit it. If the warm season is too short for a species to complete its life cycle, it will not occur there. The seasonal temperature ranges of the experimental streams are shown in Figure 15.

Hynes (1970) also reviews work that describes preferences of macroinvertebrates for shaded or lighted reaches of streams. He mentions that Wormaldia prefers shade while species of Baetis have been found to prefer open, well-lighted areas. Wormaldia did not

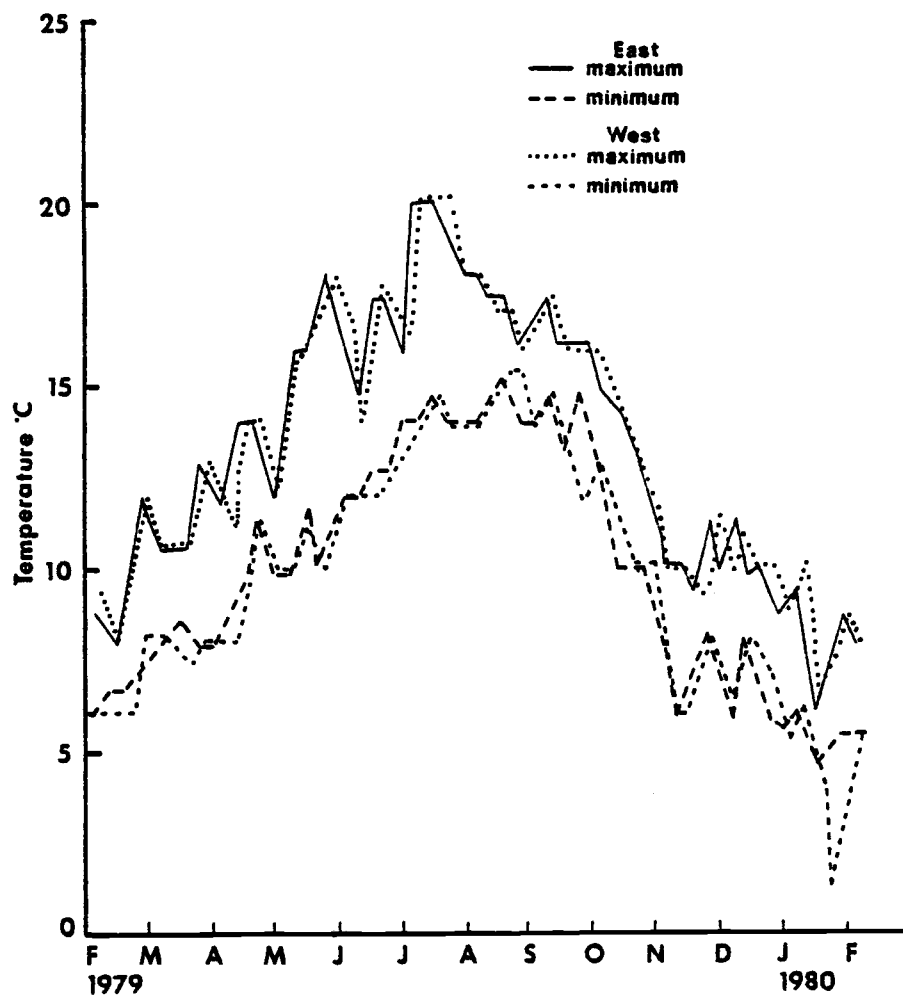


FIGURE 15. Weekly mean maximum and minimum temperatures in the model streams.

become well-established in the experimental stream communities, although it was often found in the incoming drift samples. Baetis tricaudatus was abundant in the experimental streams during months of maximum day length and light intensity during the year (Figs. 13 and 16).

These seasonal and habitat preferences of species are likely to be correlated with food resources. Well-lighted areas would presumably have more algae than shaded areas. Baetis species, which feed heavily on microphytes, would be found in well-lit areas, but Wormaldia, which feed primarily on fine particle detritus, could be found elsewhere. Thus climatic parameters may influence the distributions and abundances of species within a community indirectly, through food resources.

Allochthonous and autochthonous inputs are also parameters that affect all primary components of a stream system. Allochthonous inputs have been shown to be very important in determining the structure of trophic subsystems within a community (Cummins, 1974). Such a relationship between allochthonous inputs and species in the model streams is most dramatically exemplified by the rapid increase in coarse-particle detritivores during the time of greatest litter fall. Figure 17 shows that maximum litter input, which was primarily leafy litter, occurred in the fall, particularly in late October and early November. Figure 12 illustrates the development of the macro-invertebrate trophic subsystems in the model streams. Coarse-particle detritivore biomass reached 50.5 milligrams dry weight in November, during the time of maximum litter input. Approximately 80 percent of the biomass was due to Malenka, alone. Thus, seasonal variation in allochthonous and autochthonous inputs can affect seasonal development and the ultimate organization of stream communities and their subsystems.

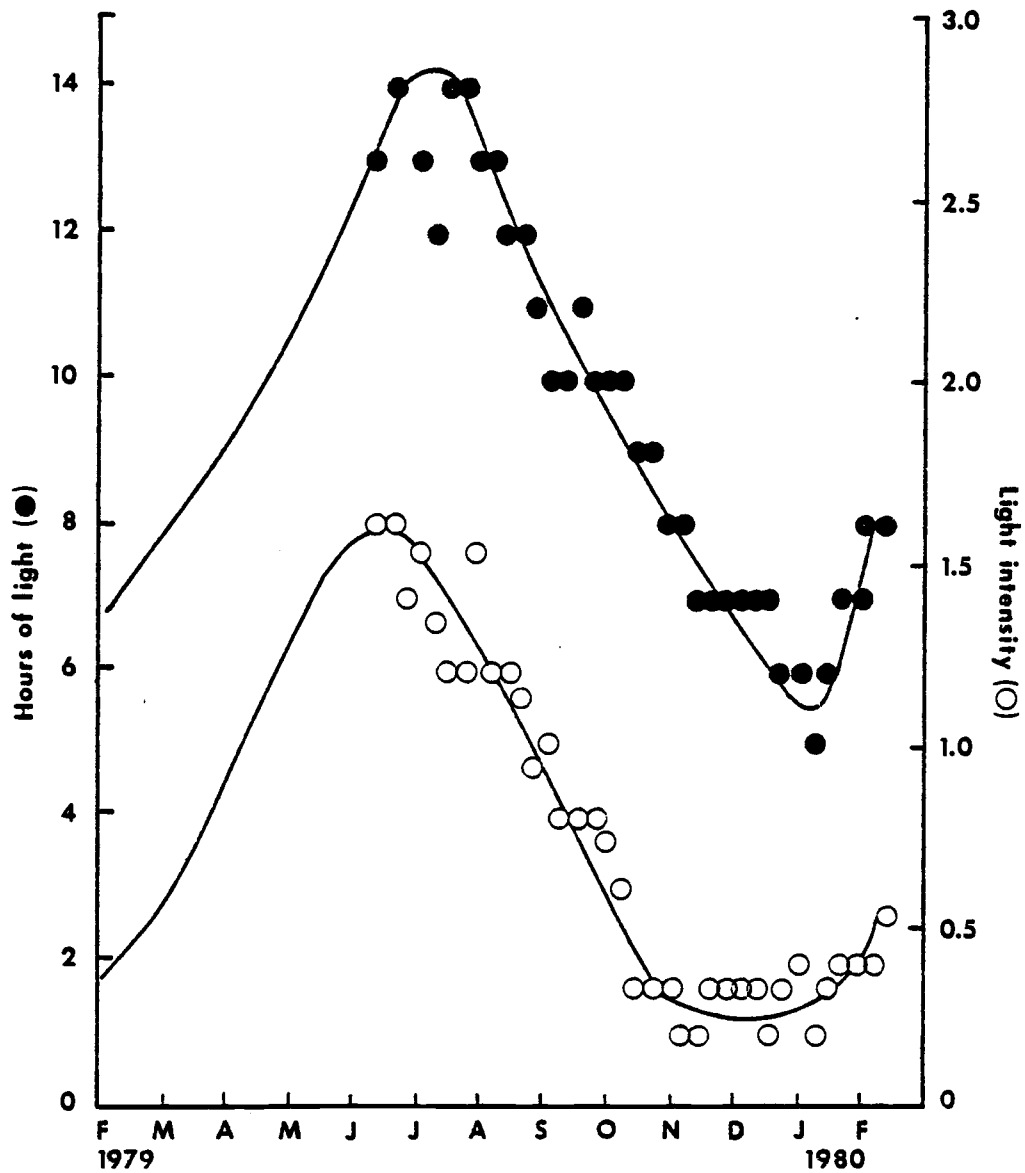


FIGURE 16. Day length and light intensity at the model streams. Light intensity is expressed as numerical values on a relative scale of 0.0 to 3.0.

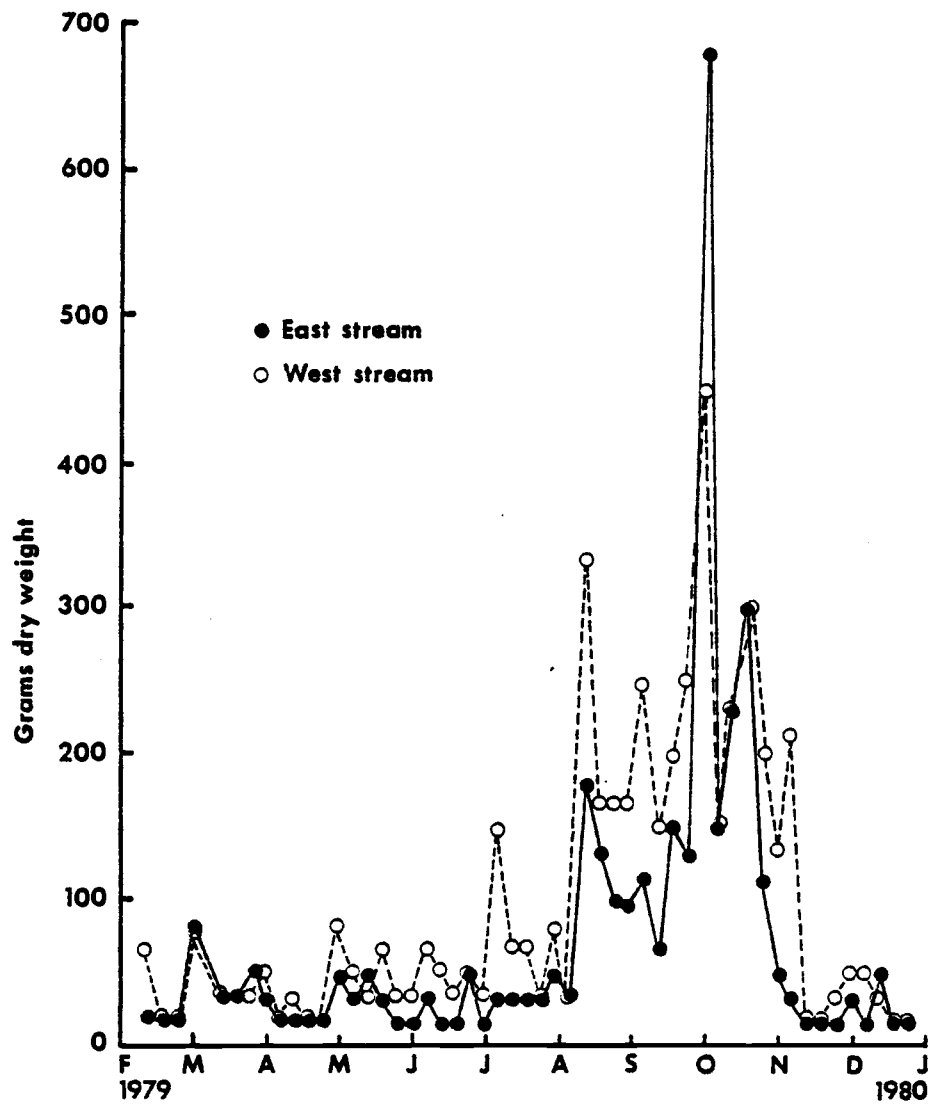


FIGURE 17. Total litter retention in the model streams.

DISCUSSION

The goal of this study was to better understand stream communities through a community perspective that might make their structure, organization, and development more understandable. Understanding natural systems entails perceiving them as being essentially simple, ordered, unified, and harmonious in their roles in more subsuming systems, however they may be in reality. Our actual experience of natural systems often is in agreement with such a way of understanding.

I believe a theory or a model is primarily a perspective we take in viewing a system. Ideally, a perspective provides simplicity, order, unity, and harmonious roles in our experience of natural systems. As such, a perspective is not strictly falsifiable or verifiable. It should be judged on the basis of its ability to order our experience of natural systems.

The perspective developed in this thesis is partial, as is any view. I am taking an organismic perspective, but not in the Clementsian sense of communities being metaphorical organisms. While Clements proposed that communities are organisms, I am taking the view that communities exhibit properties that can be considered to be organismic. These organismic properties can be taken to be co-extension with environment, the possession of capacities as well as performances, or states, the incorporation of systems, subsystems, and their environments, and the interpenetration and concordance of these (Warren et al., 1979).

As well as exhibiting organismic properties, stream communities also exhibit continuum aspects downstream. The organismic perspective does not necessarily preclude the continuum view. Through the notion of interpenetration of organismic communities, species populations can extend between communities. The two views need not be mutually exclusive. They both provide valuable perspectives

on natural systems and both views reflect characteristics of stream communities.

In my presentation of stream community structure, organization, and development, I am utilizing a systems approach in applying organismic properties to stream systems. I am viewing a stream system as incorporating a number of interconnected stream subsystems and their coextensive environments in an organized way. Habitat, life history, and trophic organization are more or less apparent aspects of stream community organization. Development I have taken to be change in stream system structure and organization through time. Development is determined by the capacity of the stream system, the capacities of its subsystems, and the coextensive environments of the stream system and subsystems.

Stream system development occurs on different time scales. It is important to make a distinction between annual changes in community structure and organization and long-term successional changes. Stream community structure shows marked changes throughout the year. Incorporated into the phenology of species populations are adaptations to annual habitat or environmental fluctuations such as winter floods. I view long-term successional changes of a stream community as being driven by the successional changes in the surrounding terrestrial and geological systems. Thus the stream seral stage is a reflection of the surrounding terrestrial seral stage.

The perspective I am taking has affinities with the polyclimax concept of communities in plant ecology (Tansley, 1920). This concept postulates that a landscape pattern is composed of a mosaic of different kinds of communities, each in a different stage of development owing to local perturbation, all tending toward the climaxes of their kinds, some being at such climaxes or steady states. These different climax stages are relatively stable communities containing reproductively persistent species populations under climax conditions. In viewing a system of streams as a polyclimax mosaic, different reaches of streams can be thought of

as different habitats. The vegetation and soil changes experienced by these habitats through successional time lead to a mosaic of different kinds of stream communities.

Evidence for this polyclimax view of stream communities is given by Molles (1982). In his study, Molles looked for long-term changes in the structure of stream invertebrate communities that coincided with terrestrial plant succession. Frequent disturbance by fire created "patches of early successional forest," which produced habitat changes in adjacent streams and in their communities.

In taking the view that stream communities experience succession, I am taking primarily an organismic view. However, I have attempted to unify both the organismic and individualistic perspectives as this approach would seem to be the most fruitful. And as Richardson (1980) has stated, the "polarizing nature of Clements' and Gleason's arguments has left room for more moderate views acknowledging both concepts." Richardson feels that communities differ from one another in their degree of integration. Some communities are more organismic than others. Between the two extremes of organismic communities and very individualistic communities are communities that exhibit both characteristics. Apparently Richardson believes streams exhibit some organismic properties. He cites the complex set of relationships between functional feeding groups in stream communities as evidence of "multispecies group mutualism--associations that demonstrate integrated interdependency basic to the organismic concept." Winterbourn et al. (1981) do not take this view. They feel neither the organismic viewpoint of Richardson nor the river continuum concept of Vannote et al. (1980) truly represent their experience of New Zealand streams.

In this thesis, I chose to take understanding to be a way of seeing things as being simple, ordered, unified, and harmonious in their relation to other components of a natural system, however it may be in reality, so long as the understanding provided by the perspective is in agreement with our stream experience. In

doing this, I have found the organismic system properties of coexistence, capacity, organization, development, and interpenetration to provide just such a perspective.

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APPENDICES

APPENDIX I

Current velocities in the model streams.
Paired numbers refer to measurements
at the bottom and at 0.6 total depth.

Stream	Channel	Habitat	Grid:	Current Velocity (cm/sec)			
				x	y	z	
East	1	Shallow riffle	1	36,36	20,20	31,31	
			2	41,41	58,58	42,42	
			3	46,46	24,24	46,46	
			4	54,54	60,60	49,49	
		Deep riffle	5	46,46	54,54	20,20	
			6	*	45,45	50,50	
			7	*	28,31	34,35	
			8	0,2	21,29	27,29	
		Pool	9	2,5	24,25	27,30	
			10	1,8	13,33	18,28	
			11	0,0	0,7	2,11	
			12	0,0	0,0	0,6	
		11	Shallow riffle	13	0,0	0,15	2,13
				14	0,2	9,6	6,8
	15			34,34	42,42	34,34	
	16			38,38	45,45	31,31	
	17			29,29	31,31	50,50	
	18			52,52	47,47	34,34	
	19			57,57	39,39	48,48	
	20			*	56,56	66,66	
	Deep riffle		21	*	30,46	32,30	
			22	0,0	18,18	25,28	
	Pool		23	0,1	10,14	26,35	
			24	0,2	10,14	17,28	
			25	0,1	0,2	10,26	
			26	0,0	0,4	0,20	
		27	0,0	0,1	2,12		
		28	0,0	9,8	5,14		

Stream	Channel	Habitat	Grid:	Current Velocity (cm/sec)			
				x	y	z	
West	1	Deep riffle	6	41,62	33,55	*	
			7	38,47	49,51	*	
			8	38,46	35,38	0,3	
			9	24,36	28,34	5,5	
		Pool	10	13,27	9,24	0,0	
			11	13,21	8,14	0,0	
			12	10,20	2,2	0,6	
			13	9,15	3,10	1,2	
		11	Shallow riffle	14	12,16	8,13	4,6
				15	51,51,	32,32	34,34
				16	37,37	44,44	49,49
				17	42,42	41,41	65,65
				18	49,49	32,32	48,48
				19	38,38	56,56	68,68
	20			70,70	40,40	66,66	
	21			39,51	22,22	*	
	Pool		22	43,47	25,32	0,10	
			23	26,33	28,35	6,7	
			24	20,38	19,28	0,0	
			25	12,22	6,15	0,0	
			26	4,16	0,0	0,0	
			27	0,15	4,13	0,0	
	28	9,14	7,8	0,1			

* Current velocity measurements not taken due to a log occupying the grid.

APPENDIX II

Development of the Fisheries Database

The Scientific Information Retrieval (SIR) database management system is being used to store and organize data from the fisheries study. The SIR system also allows the generation of reports and plots from the data.

The data has been organized into a number of different "case types." Case types are shown below. Each case type is identified by a two-letter code.

<u>Case Types</u>		<u>Record Types</u>	
<u>Description</u>	<u>Code</u>	<u>Description</u>	<u>Number</u>
Sample 1 - Benthic Data	S1	Grid Data	1
Sample 2 - Drift Data	S2	Taxa Data	2
Sample 3 - Microhabitat Data	S3	Taxa Data	4
Sample 4 - Incoming Data	S4	Taxa Abundance	5
Stream and Light Data	ST	Taxa Data	6
Algae Data	AL	Organic Matter Data	7
Fish Data	FI	Taxa Data	8
Current Velocity Data	CV	Total Biomass Data	9
Taxa Codes	TA	Percent Biomass Data	10
Trophic Codes	TR		11
			12
			13
			14
			15

Within each case type are cases. A case is a collection of data belonging to a given case type, week number, and stream code combination. Week numbers range from 1 to 55 and stream codes are E for east and W for west. If the week or stream code does not have meaning for the case type, the week will have a value of zero and the stream will have the code M, for missing. Some data are present for each week of the study, some for every other week, some for every third week, and some are present on an irregular basis.

Within each case are the data records which are usually sorted according to one or more data elements that have been defined as "Sort Identifiers."

An example may illustrate this hierarchical relationship of the data more clearly. Assume one wishes to find out what taxa are present in the benthic data for week number 24 of the study in the west stream. Then the case type code is S1, the week number is 24 and the stream code is W. With these three values, an individual case may be selected from the database. The data records of interest belong to that case. Case type S1 has both Grid Data (record type 1) and Taxa Data (record type 2). The Sort Identifiers for record type 2 are Section, Habitat, Grid Number, Grid Letter, Taxa Code, and Life Stage Code. So, all the type 2 data records for the case may be retrieved, one at a time and will be ordered as dictated by the Sort Identifiers.

The SIR codebook listing should be referred to in order to determine the complete structure of the database. The codebook listing shows all data variables, their formats in the different record types, the textual name associated with each variable name, and the text (value label) to be associated with the particular values a variable might assume. When variables are listed in the codebook listing, they are tagged with a label of the form Vnnn or Cnnn. The letter V or C is used to designate a "record" variable or a variable that is common to the case containing the record. The "nnn" is the position of the variable within the record.

The taxa data in record types 2, 4, 6, and 8 are organized so that each record corresponds to a unique combination of the Sort Identifiers for the particular record type. There are a number of size/frequency combinations in each taxa data record where size is in millimeters and frequency is a count of the number or individuals observed in that particular size class. The size and frequency information was entered manually.

Other data contained in taxa records are total weight for all individuals in the taxa record and trophic codes. Total weight values for selected taxa records were computed in milligrams using the regression equation

$$W = \sum_{i=1}^n 10^A S_i^B F_i$$

where the (Si,Fi) are the size and frequency pairs for the taxa code in a given taxa record and A and B are the regression coefficients for selected taxa codes shown below. Additionally, weights for selected taxa records were computed using milligrams per individual values.

<u>Taxa Codes</u>		<u>Life Stage</u>	<u>Regression Coefficients</u>	
<u>From</u>	<u>To</u>		<u>A</u>	<u>B</u>
1200000	1201010	Not known	1.2368	1.3372
1400000	1400000	Not known	-.7313	2.6414
2100000	2102000	Not known	.3789	2.1210
3600000	3600000	Nymph	1.0942	2.2860
3601000	3601011	Nymph	1.3418	2.1060
3602000	3602021	Nymph	1.0942	2.2860
3603000	3603000	Nymph	1.7540	1.6226
3603010	3603011	Nymph	1.9174	1.8926
3603020	3603021	Nymph	1.4609	1.9139
3603030	3603041	Nymph	1.5710	2.0473
3604000	3604013	Nymph	1.4129	1.7153
3800000	3801011	Nymph	1.0811	2.7492
4000000	4001033	Nymph	1.1846	2.3471
4002000	4002010	Nymph	1.9427	1.0093
4003000	4004021	Nymph	1.1846	2.3471
4005000	4005011	Nymph	1.8269	1.8159
4006000	4006000	Nymph	.8949	3.0130
4006010	4006014	Nymph	1.7323	1.9189
4006020	4006030	Nymph	2.1013	2.4554
4007000	4007011	Nymph	1.1681	2.6217
4008000	4008010	Nymph	1.6462	1.9519
4400000	4401012	Larva	1.9288	1.7551
4604000	4604051	Larva	1.2696	2.1498
4800000	4800000	Larva	.8592	3.2349
4801000	4801010	Larva	1.0688	2.5697
4802000	4803030	Larva	1.0688	2.5697
4804000	4804013	Larva	1.2138	2.1523
4805000	4811011	Larva	.8592	3.2349
5001000	5002010	Larva	1.0125	2.5153
5005000	5008010	Larva	.6120	2.4791

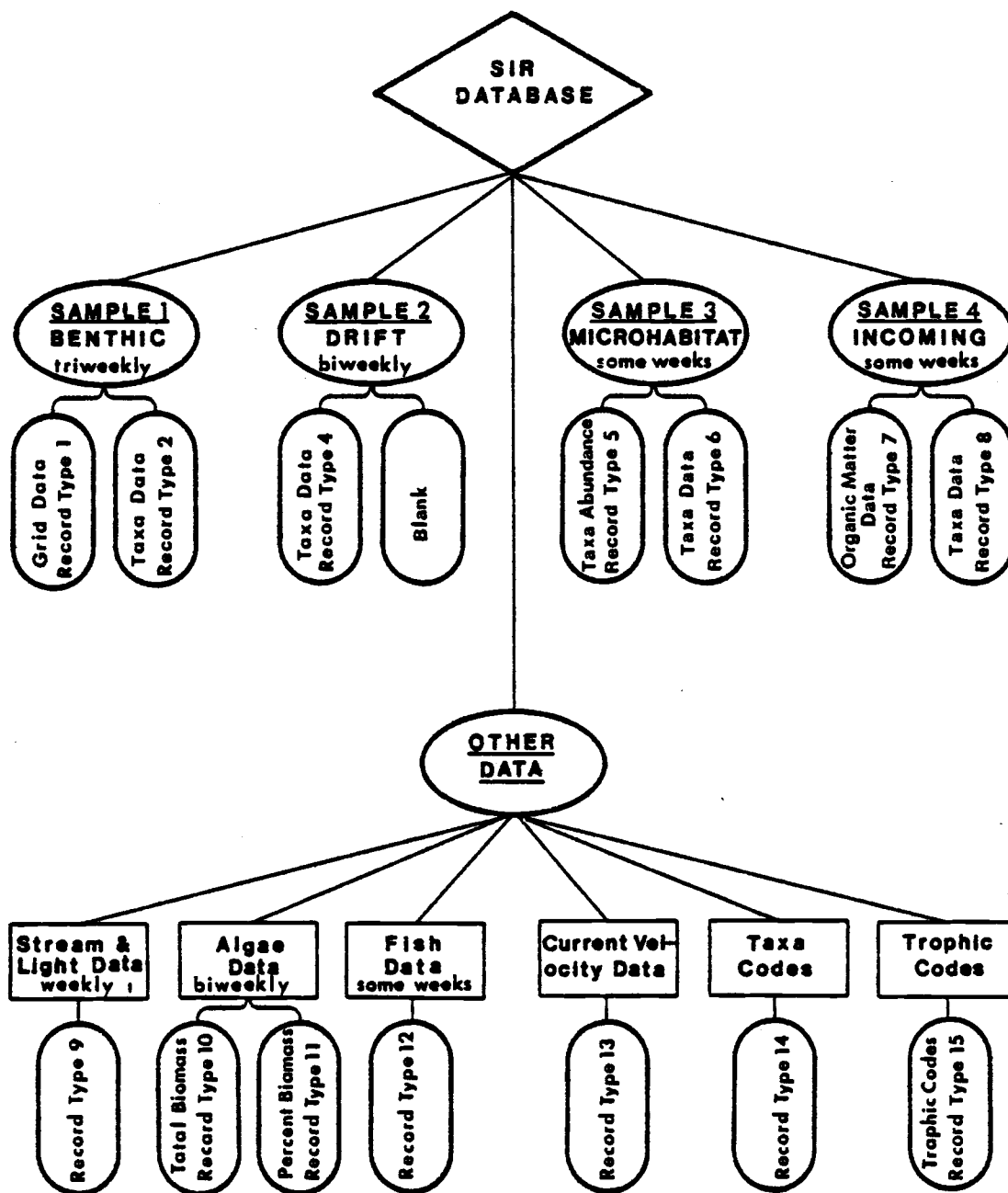
<u>Taxa Codes</u>		<u>Life Stage</u>	<u>Milligrams/Individual</u>
<u>From</u>	<u>To</u>		
1601000	1601010	Not known	6.000
1602000	1602010	Not known	0.300
1700000	1701012	Not known	6.300
2500000	2500000	Not known	0.005
2700000	2702021	Not known	0.003
2900000	2902000	Not known	0.004

Finally, to complete the information needed in the taxa records, the following trophic codes were entered manually. The trophic codes assigned to the taxa records were obtained from the trophic code information,

<u>Code</u>	<u>Meaning</u>
A	Autotroph
P	Macrophyte herbivore
H	Microphyte herbivore
F	Fine-particle detritivore
D	Coarse-particle detritivore
C	Carnivore
M	trophic code missing

stored in record type 15.

The database is currently stored on tape in SIR Version 1.1 format at the Oregon State University Computer Center.



S I R S Y S T E M 1 . 1
FILE ST RECORD 1 (BENTGRID) DETAILED LIST

-- RECORD TYPE 1 (BENTGRID)

MAXIMUM OF THIS RECORD TYPE PER CASE 400
NUMBER OF RECORDS OF THIS TYPE ON DATA FILE 216
NUMBER OF CARDS IN DATA RECORD 1

SORT IDENTIFIER 1 - SECTION
SORT IDENTIFIER 2 - HABITAT
SORT IDENTIFIER 3 - GRIDN
SORT IDENTIFIER 4 - GRIDL

C1. ID,
COLUMNS 3 - 7 TYPE (A)

V1. SECTION, SECTION
COLUMN 8 TYPE (I)

V2. HABITAT, HABITAT
COLUMN 9 TYPE (A)

A = SHALLOW RIFFLE B = DEEP RIFFLE
C = POOL

V3. GRIDN, GRID NUMBER
COLUMNS 10 - 11 TYPE (I)

V4. GRIDL, GRID LETTER
COLUMN 12 TYPE (A)

C2. CASETYPE, CASE TYPE IDENTIFIER
COLUMNS 3 - 4 TYPE (A)

C3. WEEK, WEEK NUMBER
COLUMNS 5 - 6 TYPE (I)

C4. STREAM, STREAM
COLUMN 7 TYPE (A)

E = EAST W = WEST

V5. MEANPS, MEAN PARTICLE SIZE
COLUMNS 13 - 17 TYPE (F5.1)

V6. STDPS, STANDARD DEVIATION PARTICLE SIZE
COLUMNS 18 - 21 TYPE (F4.1)

V7. PAFDWS, PERCENT ASH FREE DRY WEIGHT (SILT)
COLUMNS 22 - 23 TYPE (I)
MISSING= 99

V8. PAFDWC, PERCENT ASH FREE DRY WEIGHT (CLAY)
COLUMNS 24 - 25 TYPE (I)
MISSING= 99

V9. OMDW, ORGANIC MATTER DRY WEIGHT
COLUMNS 26 - 29 TYPE (F4.1)

S I R S Y S T E M 1 . 1
FILE ST RECORD 2 (BENTTAXA)

MAXIMUM OF THIS RECORD TYPE PER CASE 400
NUMBER OF RECORDS OF THIS TYPE ON DATA FILE 2338
NUMBER OF CARDS IN DATA RECORD 1

SORT IDENTIFIER 1 - SECTION
SORT IDENTIFIER 2 - HABITAT
SORT IDENTIFIER 3 - GRIDN
SORT IDENTIFIER 4 - GRIDL
SORT IDENTIFIER 5 - TAXACODE
SORT IDENTIFIER 6 - LIFESTA

-- RECORD TYPE 2 (BENTTAXA)

C1. ID, COLUMNS 3 - 7 TYPE (A)	V8. SIZE2, COLUMNS 27 - 29 TYPE (F3.1) MISSING= 99.9	V19. FREQ1, COLUMNS 24 - 26 TYPE (I)
V1. SECTION, SECTION COLUMN 8 TYPE (I)	V9. SIZE3, COLUMNS 33 - 35 TYPE (F3.1) MISSING= 99.9	V20. FREQ2, COLUMNS 30 - 32 TYPE (I)
V2. HABITAT, HABITAT COLUMN 9 TYPE (A)	V10. SIZE4, COLUMNS 39 - 41 TYPE (F3.1) MISSING= 99.9	V21. FREQ3, COLUMNS 36 - 38 TYPE (I)
A = SHALLOW RIPPLE B = DEEP RIPPLE C = POOL	V11. SIZE5, COLUMNS 45 - 47 TYPE (F3.1) MISSING= 99.9	V22. FREQ4, COLUMNS 42 - 44 TYPE (I)
V3. GRIDN, GRID NUMBER COLUMNS 10 - 11 TYPE (I)	V12. SIZE6, COLUMNS 51 - 53 TYPE (F3.1) MISSING= 99.9	V23. FREQ5, COLUMNS 48 - 50 TYPE (I)
V4. GRIDL, GRID LETTER COLUMN 12 TYPE (A)	V13. SIZE7, COLUMNS 57 - 59 TYPE (F3.1) MISSING= 99.9	V24. FREQ6, COLUMNS 54 - 56 TYPE (I)
V5. TAXACODE, TAXA CODE COLUMNS 13 - 19 TYPE (I)	V14. SIZE8, COLUMNS 63 - 65 TYPE (F3.1) MISSING= 99.9	V25. FREQ7, COLUMNS 60 - 62 TYPE (I)
V6. LIFESTA, LIFE STAGE COLUMN 20 TYPE (A)	V15. SIZE9, COLUMNS 69 - 71 TYPE (F3.1) MISSING= 99.9	V26. FREQ8, COLUMNS 66 - 68 TYPE (I)
0 = NOT KNOWN E = EGG N = NYMPH L = LARVA P = PUPA A = ADULT J = JUVENILE	V16. SIZE10, COLUMNS 75 - 77 TYPE (F3.1) MISSING= 99.9	V27. FREQ9, COLUMNS 72 - 74 TYPE (I)
C2. CASETYPE, CASE TYPE IDENTIFIER COLUMNS 3 - 4 TYPE (A)	V17. SIZE11, COLUMNS 81 - 83 TYPE (F3.1) MISSING= 99.9	V28. FREQ10, COLUMNS 78 - 80 TYPE (I)
C3. WEEK, WEEK NUMBER COLUMNS 5 - 6 TYPE (I)	V18. SIZE12, COLUMNS 87 - 89 TYPE (F3.1) MISSING= 99.9	V29. FREQ11, COLUMNS 84 - 86 TYPE (I)
C4. STREAM, STREAM COLUMN 7 TYPE (A)		V30. FREQ12, COLUMNS 90 - 92 TYPE (I)
E = EAST W = WEST		V31. WEIGHT, WEIGHT=0; TYPE (F) MISSING= 999999.
V7. SIZE1, COLUMNS 21 - 23 TYPE (F3.1) MISSING= 99.9		V32. TROPHCD, TROPHCD=' ' TYPE (A)

S I R S Y S T E M 1 . 1
FILE ST RECORD 4 (DRIFTAXA)

MAXIMUM OF THIS RECORD TYPE PER CASE 400
NUMBER OF RECORDS OF THIS TYPE ON DATA FILE 1017
NUMBER OF CARDS IN DATA RECORD 1

SORT IDENTIFIER 1 - SECTION
SORT IDENTIFIER 2 - TAXACODE
SORT IDENTIFIER 3 - LIFESTA

-- RECORD TYPE 4 (DRIFTAXA)

C1. ID, COLUMNS 3 - 7 TYPE (A)
V1. SECTION, SECTION
COLUMN 8 TYPE (I)
V2. TAXACODE, TAXA CODE
COLUMNS 13 - 19 TYPE (I)
V3. LIFESTA, LIFE STAGE
COLUMN 20 TYPE (A)
0 = NOT KNOWN E = EGG
N = NYMPH L = LARVA
P = PUPA A = ADULT
J = JUVENILE
C2. CASETYPE, CASE TYPE IDENTIFIER
COLUMNS 3 - 4 TYPE (A)
C3. WEEK, WEEK NUMBER
COLUMNS 5 - 6 TYPE (I)
C4. STREAM, STREAM
COLUMN 7 TYPE (A)
E = EAST W = WEST
V4. SIZE1,
COLUMNS 21 - 23 TYPE (F3.1)
MISSING= 99.9
V5. SIZE2,
COLUMNS 28 - 30 TYPE (F3.1)
MISSING= 99.9

V6. SIZE3,
COLUMNS 35 - 37 TYPE (F3.1)
MISSING= 99.9
V7. SIZE4,
COLUMNS 42 - 44 TYPE (F3.1)
MISSING= 99.9
V8. SIZE5,
COLUMNS 49 - 51 TYPE (F3.1)
MISSING= 99.9
V9. SIZE6,
COLUMNS 56 - 58 TYPE (F3.1)
MISSING= 99.9
V10. SIZE7,
COLUMNS 63 - 65 TYPE (F3.1)
MISSING= 99.9
V11. SIZE8,
COLUMNS 70 - 72 TYPE (F3.1)
MISSING= 99.9
V12. SIZE9,
COLUMNS 77 - 79 TYPE (F3.1)
MISSING= 99.9
V13. SIZE10,
COLUMNS 84 - 86 TYPE (F3.1)
MISSING= 99.9
V14. SIZE11,
COLUMNS 91 - 93 TYPE (F3.1)
MISSING= 99.9

V15. FREQ1,
COLUMNS 24 - 27 TYPE (I)
V16. FREQ2,
COLUMNS 31 - 34 TYPE (I)
V17. FREQ3,
COLUMNS 38 - 41 TYPE (I)
V18. FREQ4,
COLUMNS 45 - 48 TYPE (I)
V19. FREQ5,
COLUMNS 52 - 55 TYPE (I)
V20. FREQ6,
COLUMNS 59 - 62 TYPE (I)
V21. FREQ7,
COLUMNS 66 - 69 TYPE (I)
V22. FREQ8,
COLUMNS 73 - 76 TYPE (I)
V23. FREQ9,
COLUMNS 80 - 83 TYPE (I)
V24. FREQ10,
COLUMNS 87 - 90 TYPE (I)
V25. FREQ11,
COLUMNS 94 - 97 TYPE (I)
V26. WEIGHT,
WEIGHT=0;
TYPE (F)
MISSING= 999999.
V27. TROPHCD,
TROPHCD= ' '
TYPE (A)

S I R S Y S T E M 1 . 1
FILE ST RECORD 5 (MICRABUN) DETAILED LIST

-- RECORD TYPE 5 (MICRABUN)

MAXIMUM OF THIS RECORD TYPE PER CASE 400
NUMBER OF RECORDS OF THIS TYPE ON DATA FILE 2780
NUMBER OF CARDS IN DATA RECORD 1

SORT IDENTIFIER 1 - SECTION
SORT IDENTIFIER 2 - HABITAT
SORT IDENTIFIER 3 - GRIDN
SORT IDENTIFIER 4 - GRIDL
SORT IDENTIFIER 5 - MIHACOD
SORT IDENTIFIER 6 - TAXACODE
SORT IDENTIFIER 7 - LIFESTA

C1. ID,
 COLUMNS 3 - 7 TYPE (A)

V1. SECTION, SECTION
 COLUMN 8 TYPE (I)

V2. HABITAT, HABITAT
 COLUMN 9 TYPE (A)

 A = SHALLOW RIFFLE B = DEEP RIFFLE
 C = POOL

V3. GRIDN, GRID NUMBER
 COLUMNS 10 - 11 TYPE (I)

V4. GRIDL, GRID LETTER
 COLUMN 12 TYPE (A)

V5. MIHACOD, MICRO HABITAT CODE
 COLUMNS 13 - 14 TYPE (A)

AE = AERIAL AL = ALGAE
MO = MOSS LI = LITTER
WO = WOOD IN = INTERSTITIAL
SZ = SPLASH ZONE CO = COBBLE
SA = SAND FG = FISH GUT
SU = SURFACE

V6. TAXACODE, TAXA CODE
 COLUMNS 15 - 21 TYPE (I)

V7. LIFESTA, LIFE STAGE
 COLUMN 22 TYPE (A)

 O = NOT KNOWN E = EGG
 N = NYMPH L = LARVA
 P = PUPA A = ADULT
 J = JUVENILE

C2. CASETYPE, CASE TYPE IDENTIFIER
 COLUMNS 3 - 4 TYPE (A)

C3. WEEK, WEEK NUMBER
 COLUMNS 5 - 6 TYPE (I)

C4. STREAM, STREAM
 COLUMN 7 TYPE (A)

 E = EAST W = WEST

V8. REABCOD, RELATIVE ABUNDANCE CODE
 COLUMN 23 TYPE (A)

 R = RARE O = OCCASIONAL
 C = COMMON A = ABUNDANT

S I R S Y S T E M 1 . 1
FILE ST RECORD 6 (MICRTAXA)

MAXIMUM OF THIS RECORD TYPE PER CASE 400
NUMBER OF RECORDS OF THIS TYPE ON DATA FILE 331
NUMBER OF CARDS IN DATA RECORD 1

SORT IDENTIFIER 1 - SECTION
SORT IDENTIFIER 2 - HABITAT
SORT IDENTIFIER 3 - GRIDN
SORT IDENTIFIER 4 - GRIDL
SORT IDENTIFIER 5 - MIHACOD
SORT IDENTIFIER 6 - TAXACODE
SORT IDENTIFIER 7 - LIFESTA

-- RECORD TYPE 6 (MICRTAXA)

C1. ID, COLUMNS 3 - 7 TYPE (A)	C2. CASETYPE, CASE TYPE IDENTIFIER COLUMNS 3 - 4 TYPE (A)	V17. FREQ1, COLUMNS 26 - 28 TYPE (I)
V1. SECTION, SECTION COLUMN 8 TYPE (I)	C3. WEEK, WEEK NUMBER COLUMNS 5 - 6 TYPE (I)	V18. FREQ2, COLUMNS 32 - 34 TYPE (I)
V2. HABITAT, HABITAT COLUMN 9 TYPE (A)	C4. STREAM, STREAM COLUMN 7 TYPE (A)	V19. FREQ3, COLUMNS 38 - 40 TYPE (I)
A = SHALLOW RIFFLE C = POOL	B = DEEP RIFFLE M = MISSING	V20. FREQ4, COLUMNS 44 - 46 TYPE (I)
V3. GRIDN, GRID NUMBER COLUMNS 10 - 11 TYPE (I)	E = EAST W = WEST	V21. FREQ5, COLUMNS 50 - 52 TYPE (I)
V4. GRIDL, GRID LETTER COLUMN 12 TYPE (A)	V8. SIZE1, COLUMNS 23 - 25 TYPE (F3.1)	V22. FREQ6, COLUMNS 56 - 58 TYPE (I)
V5. MIHACOD, MICRO HABITAT CODE COLUMNS 13 - 14 TYPE (A)	V9. SIZE2, COLUMNS 29 - 31 TYPE (F3.1)	V23. FREQ7, COLUMNS 62 - 64 TYPE (I)
AE = AERIAL MO = MOSS WO = WOOD SZ = SPLASH ZONE SA = SAND SU = SURFACE	AL = ALGAE LI = LITTER IN = INTERSTITIAL CO = COBBLE FG = FISH GUT	V24. FREQ8, COLUMNS 68 - 70 TYPE (I)
V6. TAXACODE, TAXA CODE COLUMNS 15 - 21 TYPE (I)	V10. SIZE3, COLUMNS 35 - 37 TYPE (F3.1)	V25. FREQ9, COLUMNS 74 - 76 TYPE (I)
V7. LIFESTA, LIFE STAGE COLUMN 22 TYPE (A)	V11. SIZE4, COLUMNS 41 - 43 TYPE (F3.1)	V26. WEIGHT, WEIGHT=0; TYPE (F) MISSING= 999999.
O = NOT KNOWN N = NYMPH P = PUPA J = JUVENILE	E = EGG L = LARVA A = ADULT	V27. TROPHCD, TROPHCD=' ' TYPE (A)
	V12. SIZE5, COLUMNS 47 - 49 TYPE (F3.1)	
	V13. SIZE6, COLUMNS 53 - 55 TYPE (F3.1)	
	V14. SIZE7, COLUMNS 59 - 61 TYPE (F3.1)	
	V15. SIZE8, COLUMNS 65 - 67 TYPE (F3.1)	
	V16. SIZE9, COLUMNS 71 - 73 TYPE (F3.1)	

S I R S Y S T E M 1 . 1
FILE ST RECORD 7 (INCOMATT) DETAILED LIST

-- RECORD TYPE 7 (INCOMATT)

MAXIMUM OF THIS RECORD TYPE PER CASE 400
NUMBER OF RECORDS OF THIS TYPE ON DATA FILE 70
NUMBER OF CARDS IN DATA RECORD 1

C1. ID,
COLUMNS 3 - 7 TYPE (A)

C2. CASETYPE, CASE TYPE IDENTIFIER
COLUMNS 3 - 4 TYPE (A)

C3. WEEK, WEEK NUMBER
COLUMNS 5 - 6 TYPE (I)

C4. STREAM, STREAM
COLUMN 7 TYPE (A)

E = EAST

W = WEST

V1. OMDW, ORGANIC MATTER DRY WEIGHT
COLUMNS 8 - 10 TYPE (F3.1)
MISSING= 99.9

V2. PAFDW, PERCENT ASH FREE DRY WEIGHT
COLUMNS 11 - 12 TYPE (I)
MISSING= 99

S I R S Y S T E M 1 . 1
FILE ST RECORD 8 (INCOTAXA)

MAXIMUM OF THIS RECORD TYPE PER CASE 400
NUMBER OF RECORDS OF THIS TYPE ON DATA FILE 1337
NUMBER OF CARDS IN DATA RECORD 1

SORT IDENTIFIER 1 - TAXACODE
SORT IDENTIFIER 2 - LIFESTA

-- RECORD TYPE 8 (INCOTAXA)

C1. ID, COLUMNS 3 - 7 TYPE (A)	V5. SIZE3, COLUMNS 33 - 35 TYPE (F3.1) MISSING= 99.9	V14. FREQ2, COLUMNS 30 - 32 TYPE (I)
V1. TAXACODE, TAXA CODE COLUMNS 13 - 19 TYPE (I)	V6. SIZE4, COLUMNS 39 - 41 TYPE (F3.1) MISSING= 99.9	V15. FREQ3, COLUMNS 36 - 38 TYPE (I)
V2. LIFESTA, LIFE STAGE COLUMN 20 TYPE (A)	V7. SIZE5, COLUMNS 45 - 47 TYPE (F3.1) MISSING= 99.9	V16. FREQ4, COLUMNS 42 - 44 TYPE (I)
0 = NOT KNOWN N = NYMPH P = PUPA J = JUVENILE	V8. SIZE6, COLUMNS 51 - 53 TYPE (F3.1) MISSING= 99.9	V17. FREQ5, COLUMNS 48 - 50 TYPE (I)
E = EGG L = LARVA A = ADULT	V9. SIZE7, COLUMNS 57 - 59 TYPE (F3.1) MISSING= 99.9	V18. FREQ6, COLUMNS 54 - 56 TYPE (I)
C2. CASETYPE, CASE TYPE IDENTIFIER COLUMNS 3 - 4 TYPE (A)	V10. SIZE8, COLUMNS 63 - 65 TYPE (F3.1) MISSING= 99.9	V19. FREQ7, COLUMNS 60 - 62 TYPE (I)
C3. WEEK, WEEK NUMBER COLUMNS 5 - 6 TYPE (I)	V11. SIZE9, COLUMNS 69 - 71 TYPE (F3.1) MISSING= 99.9	V20. FREQ8, COLUMNS 66 - 68 TYPE (I)
C4. STREAM, STREAM COLUMN 7 TYPE (A)	V12. SIZE10, COLUMNS 75 - 77 TYPE (F3.1) MISSING= 99.9	V21. FREQ9, COLUMNS 72 - 74 TYPE (I)
E = EAST W = WEST	V13. FREQ1, COLUMNS 24 - 26 TYPE (I)	V22. FREQ10, COLUMNS 78 - 80 TYPE (I)
V3. SIZE1, COLUMNS 21 - 23 TYPE (F3.1) MISSING= 99.9		V23. WEIGHT, WEIGHT=0; TYPE (F) MISSING= 999999.
V4. SIZE2, COLUMNS 27 - 29 TYPE (F3.1) MISSING= 99.9		V24. TROPHCD, TROPHCD=' ' TYPE (A)

S I R S Y S T E M 1 . 1
FILE ST RECORD 9 (STRMLIGH) DETAILED LIST

-- RECORD TYPE 9 (STRMLIGH)

MAXIMUM OF THIS RECORD TYPE PER CASE 400
NUMBER OF RECORDS OF THIS TYPE ON DATA FILE 106
NUMBER OF CARDS IN DATA RECORD 1

C1.	ID, COLUMNS 3 - 7 TYPE (A)	V5.	TEMPMAX, MAXIMUM TEMPERATURE COLUMNS 17 - 19 TYPE (F3.1) MISSING= 99.9
C2.	CASETYPE, CASE TYPE IDENTIFIER COLUMNS 3 - 4 TYPE (A)	V6.	TOTLITF, TOTAL LITTER FALL COLUMNS 20 - 23 TYPE (F4.1) MISSING= 999.9
C3.	WEEK, WEEK NUMBER COLUMNS 5 - 6 TYPE (I)	V7.	LEAVES, LEAVES COLUMNS 24 - 27 TYPE (F4.1) MISSING= 999.9
C4.	STREAM, STREAM COLUMN 7 TYPE (A)	V8.	TWIGS, TWIGS COLUMNS 28 - 31 TYPE (F4.1) MISSING= 999.9
	E = EAST W = WEST	V9.	FLOWFRU, FLOWERS AND FRUIT COLUMNS 32 - 35 TYPE (F4.1) MISSING= 999.9
V1.	LENODAY, LENGTH OF DAY COLUMNS 8 - 9 TYPE (I) MISSING= 99	V10.	MOSS, MOSS COLUMNS 36 - 39 TYPE (F4.1) MISSING= 999.9
V2.	MININT, MINIMUM INTENSITY COLUMNS 10 - 11 TYPE (F2.1) MISSING= 9.9	V11.	ALGAE, ALGAE COLUMNS 40 - 43 TYPE (F4.1) MISSING= 999.9
V3.	MAXINT, MAXIMUM INTENSITY COLUMNS 12 - 13 TYPE (F2.1) MISSING= 9.9	V12.	MISC, MISCELLANEOUS COLUMNS 44 - 47 TYPE (F4.1) MISSING= 999.9
V4.	TEMPMIN, MINIMUM TEMPERATURE COLUMNS 14 - 16 TYPE (F3.1) MISSING= 99.9		

S I R S Y S T E M 1 . 1
FILE ST RECORD 10 (ALGATOTA) DETAILED LIST

-- RECORD TYPE 10 (ALGATOTA)

MAXIMUM OF THIS RECORD TYPE PER CASE 400
NUMBER OF RECORDS OF THIS TYPE ON DATA FILE 122
NUMBER OF CARDS IN DATA RECORD 1

SORT IDENTIFIER 1 - SECTION
SORT IDENTIFIER 2 - HABITAT

C1. ID,
COLUMNS 3 - 7 TYPE (A)

V1. SECTION, SECTION
COLUMN 8 TYPE (I)

V2. HABITAT, HABITAT
COLUMN 9 TYPE (A)

A = SHALLOW RIFFLE B = DEEP RIFFLE
C = POOL

C2. CASETYPE, CASE TYPE IDENTIFIER
COLUMNS 3 - 4 TYPE (A)

C3. WEEK, WEEK NUMBER
COLUMNS 5 - 6 TYPE (I)

C4. STREAM, STREAM
COLUMN 7 TYPE (A)

E = EAST W = WEST

V3. BIOEST, BIOMASS ESTIMATE
COLUMNS 10 - 12 TYPE (F3.1)

S I R S Y S T E M 1 . 1
FILE ST RECORD 11 (ALGAPERC) DETAILED LIST

-- RECORD TYPE 11 (ALGAPERC)

MAXIMUM OF THIS RECORD TYPE PER CASE 400
NUMBER OF RECORDS OF THIS TYPE ON DATA FILE 586
NUMBER OF CARDS IN DATA RECORD 1

SORT IDENTIFIER 1 - SECTION
SORT IDENTIFIER 2 - HABITAT
SORT IDENTIFIER 3 - TAXACODE

C1. ID,
COLUMNS 3 - 7 TYPE (A)

V1. SECTION, SECTION
COLUMN 8 TYPE (I)

V2. HABITAT, HABITAT
COLUMN 9 TYPE (A)

A = SHALLOW RIFFLE B = DEEP RIFFLE
C = POOL

V3. TAXACODE, TAXA CODE
COLUMNS 10 - 16 TYPE (I)

C2. CASETYPE, CASE TYPE IDENTIFIER
COLUMNS 3 - 4 TYPE (A)

C3. WEEK, WEEK NUMBER
COLUMNS 5 - 6 TYPE (I)

C4. STREAM, STREAM
COLUMN 7 TYPE (A)

E = EAST W = WEST

V4. POBE, PERCENT OF BIOMASS ESTIMATE
COLUMNS 17 - 18 TYPE (I)

S I R S Y S T E M 1 . 1
 FILE ST RECORD 12 (FISHDATA) DETAILED LIST

-- RECORD TYPE 12 (FISHDATA)

MAXIMUM OF THIS RECORD TYPE PER CASE 400
 NUMBER OF RECORDS OF THIS TYPE ON DATA FILE 109
 NUMBER OF CARDS IN DATA RECORD 1

SORT IDENTIFIER 1 - SECTION
 SORT IDENTIFIER 2 - HABITAT
 SORT IDENTIFIER 3 - GRIDN
 SORT IDENTIFIER 4 - GRIDL
 SORT IDENTIFIER 5 - OBSNUM
 SORT IDENTIFIER 6 - TAXACODE
 SORT IDENTIFIER 7 - LIFESTA

- | | |
|---|---|
| <p>C1. ID,
 COLUMNS 3 - 7 TYPE (A)</p> <p>V1. SECTION, SECTION
 COLUMN 8 TYPE (I)</p> <p>V2. HABITAT, HABITAT
 COLUMN 9 TYPE (A)</p> <p>A = SHALLOW RIFFLE B = DEEP RIFFLE
 C = POOL M = MISSING</p> <p>V3. GRIDN, GRID NUMBER
 COLUMNS 10 - 11 TYPE (I)</p> <p>V4. GRIDL, GRID LETTER
 COLUMN 12 TYPE (A)</p> <p>V5. OBSNUM, OBSERVATION NUMBER
 COLUMNS 13 - 14 TYPE (I)</p> <p>V6. TAXACODE, TAXA CODE
 COLUMNS 15 - 21 TYPE (I)</p> | <p>V7. LIFESTA, LIFE STAGE
 COLUMN 22 TYPE (A)</p> <p>0 = NOT KNOWN E = EGG
 N = NYMPH L = LARVA
 P = PUPA A = ADULT
 J = JUVENILE</p> <p>C2. CASETYPE, CASE TYPE IDENTIFIER
 COLUMNS 3 - 4 TYPE (A)</p> <p>C3. WEEK, WEEK NUMBER
 COLUMNS 5 - 6 TYPE (I)</p> <p>C4. STREAM, STREAM
 COLUMN 7 TYPE (A)</p> <p>E = EAST W = WEST</p> <p>V8. LENGTH, LENGTH
 COLUMNS 23 - 26 TYPE (F4.2)</p> <p>V9. WEIGHT, WEIGHT
 COLUMNS 27 - 30 TYPE (F4.2)</p> |
|---|---|

S I R S Y S T E M 1 . 1
FILE ST RECORD 13 (CURRVELO) DETAILED LIST

-- RECORD TYPE 13 (CURRVELO)

MAXIMUM OF THIS RECORD TYPE PER CASE 400
NUMBER OF RECORDS OF THIS TYPE ON DATA FILE 168
NUMBER OF CARDS IN DATA RECORD 1

SORT IDENTIFIER 1 - SECTION
SORT IDENTIFIER 2 - HABITAT
SORT IDENTIFIER 3 - GRIDN
SORT IDENTIFIER 4 - GRIDL

C1. ID,
COLUMNS 3 - 7 TYPE (A)

V1. SECTION, SECTION
COLUMN 8 TYPE (I)

V2. HABITAT, HABITAT
COLUMN 9 TYPE (A)

A = SHALLOW RIPPLE B = DEEP RIPPLE
C = POOL

V3. GRIDN, GRID NUMBER
COLUMNS 10 - 11 TYPE (I)

V4. GRIDL, GRID LETTER
COLUMN 12 TYPE (A)

C2. CASETYPE, CASE TYPE IDENTIFIER
COLUMNS 3 - 4 TYPE (A)

C3. WEEK, WEEK NUMBER
COLUMNS 5 - 6 TYPE (I)

C4. STREAM, STREAM
COLUMN 7 TYPE (A)

E = EAST W = WEST

V5. CURV06, CURRENT VELOCITY (0.6 TOTAL DEPTH)
COLUMNS 13 - 15 TYPE (I)
MISSING= 999

V6. CURV00, CURRENT VELOCITY (BOTTOM)
COLUMNS 16 - 18 TYPE (I)
MISSING= 999

S I R S Y S T E M 1 . 1
FILE ST RECORD 14 (TAXACODE) DETAILED LIST

-- RECORD TYPE 14 (TAXACODE)

MAXIMUM OF THIS RECORD TYPE PER CASE 400
NUMBER OF RECORDS OF THIS TYPE ON DATA FILE 350
NUMBER OF CARDS IN DATA RECORD 1

SORT IDENTIFIER 1 - TAXACODE

C1. ID,
COLUMNS 3 - 7 TYPE (A)

V1. TAXACODE, TAXA CODE
COLUMNS 8 - 14 TYPE (I)

C2. CASETYPE, CASE TYPE IDENTIFIER
COLUMNS 3 - 4 TYPE (A)

C3. WEEK, WEEK NUMBER
COLUMNS 5 - 6 TYPE (I)

C4. STREAM, STREAM
COLUMN 7 TYPE (A)

M = NOT APPLICABLE

V2. ORDER, ORDER
COLUMNS 15 - 34 TYPE (A)

V3. FAMILY, FAMILY
COLUMNS 35 - 54 TYPE (A)

V4. GENUS, GENUS
COLUMNS 55 - 74 TYPE (A)

V5. SPECIES, SPECIES
COLUMNS 75 - 94 TYPE (A)

S I R S Y S T E M 1 . 1
FILE ST RECORD 15 (TROPCODE) DETAILED LIST

-- RECORD TYPE 15 (TROPCODE)

MAXIMUM OF THIS RECORD TYPE PER CASE 400
NUMBER OF RECORDS OF THIS TYPE ON DATA FILE 343
NUMBER OF CARDS IN DATA RECORD 1

SORT IDENTIFIER 1 - TAXACODE
SORT IDENTIFIER 2 - LIFESTA

C1. ID,
COLUMNS 3 - 7 TYPE (A)

V1. TAXACODE, TAXA CODE
COLUMNS 8 - 14 TYPE (I)

V2. LIFESTA,
COLUMN 15 TYPE (A)

C2. CASETYPE, CASE TYPE IDENTIFIER
COLUMNS 3 - 4 TYPE (A)

C3. WEEK, WEEK NUMBER
COLUMNS 5 - 6 TYPE (I)

C4. STREAM, STREAM
COLUMN 7 TYPE (A)

M = NOT APPLICABLE

V3. TROPH1, TROPHIC CODE 1
COLUMN 16 TYPE (A)

A = AUTOTROPHS H = MICROPHYTE HERBIVORE
P = MACROPHYTE HERBIVORE D = COARSE PARTICLE DETR
F = FINE PARTICLE C = CARNIVORES

V4. TROPH2, TROPHIC CODE 2
COLUMN 17 TYPE (A)

A = AUTOTROPHS H = MICROPHYTE HERBIVORE
P = MACROPHYTE HERBIVORE D = COARSE PARTICLE DETR
F = FINE PARTICLE C = CARNIVORES

V5. TROPH3, TROPHIC CODE 3
COLUMN 18 TYPE (A)

A = AUTOTROPHS H = MICROPHYTE HERBIVORE
P = MACROPHYTE HERBIVORE D = COARSE PARTICLE DETR
F = FINE PARTICLE C = CARNIVORES

TAXA CODE	ORDER	FAMILY	GENUS	SPECIES
0	UNKNOWN			
10	UNKNOWN	UNKNOWN	EUNOGRAMA	
11	UNKNOWN	UNKNOWN	EUNOGRAMA	#1
100000	CHROOCOCCALES			
101000	CHROOCOCCALES	CHROOCOCCACEAE		
101010	CHROOCOCCALES	CHROOCOCCACEAE	MICROCYSTIS	
101011	CHROOCOCCALES	CHROOCOCCACEAE	MICROCYSTIS	#1
200000	HORMOGONALES			
201000	HORMOGONALES	OSCILLATORIACEAE		
201010	HORMOGONALES	OSCILLATORIACEAE	OSCILLATORIA	
201011	HORMOGONALES	OSCILLATORIACEAE	OSCILLATORIA	REZZII
201020	HORMOGONALES	OSCILLATORIACEAE	SCHIZOTHRIX	
201021	HORMOGONALES	OSCILLATORIACEAE	SCHIZOTHRIX	CALEICOLA
202000	HORMOGONALES	NOSTOCACEAE		
202010	HORMOGONALES	NOSTOCACEAE	ANABAENA	
202011	HORMOGONALES	NOSTOCACEAE	ANABAENA	VARIAEKLIS
202020	HORMOGONALES	NOSTOCACEAE	NOSTOC	
202021	HORMOGONALES	NOSTOCACEAE	NOSTOC	COMMUNE
203000	HORMOGONALES	RIVULARIACEAE		
203010	HORMOGONALES	RIVULARIACEAE	CALOTHRIX	
203011	HORMOGONALES	RIVULARIACEAE	CALOTHRIX	PARENTINA
300000	CENTRALES			
301000	CENTRALES	COSCINODISACEAE		
301010	CENTRALES	COSCINODISACEAE	MELOSIRA	
301011	CENTRALES	COSCINODISACEAE	MELOSIRA	VARIANS
302000	CENTRALES	TABELLARIACEAE		
302010	CENTRALES	TABELLARIACEAE	TABELLARIA	
303000	CENTRALES	MERIDIONACEAE		
303010	CENTRALES	MERIDIONACEAE	MERIDION	
303011	CENTRALES	MERIDIONACEAE	MERIDION	CIRCULARE
304000	CENTRALES	DIATOMACEAE		
304010	CENTRALES	DIATOMACEAE	DIATOMA	
304011	CENTRALES	DIATOMACEAE	DIATOMA	VULGARE
305000	CENTRALES	FRAGILARIACEAE		
305010	CENTRALES	FRAGILARIACEAE	SYNEDRA	
305011	CENTRALES	FRAGILARIACEAE	SYNEDRA	RUMPENS
305012	CENTRALES	FRAGILARIACEAE	SYNEDRA	ULNA
306000	CENTRALES	EUNOTIACEAE		
306010	CENTRALES	EUNOTIACEAE	EUNOTIA	
306011	CENTRALES	EUNOTIACEAE	EUNOTIA	CURVATA
307000	CENTRALES	ACHNANTHACEAE		
307010	CENTRALES	ACHNANTHACEAE	ACHNANTHES	
307011	CENTRALES	ACHNANTHACEAE	ACHNANTHES	EXIGUA
307012	CENTRALES	ACHNANTHACEAE	ACHNANTHES	LANCEOLATA
307013	CENTRALES	ACHNANTHACEAE	ACHNANTHES	MINUTISSIMA
307020	CENTRALES	ACHNANTHACEAE	COCCONEIS	
307021	CENTRALES	ACHNANTHACEAE	COCCONEIS	PLACENTULA
307030	CENTRALES	ACHNANTHACEAE	RHOICOSPHENIA	
307031	CENTRALES	ACHNANTHACEAE	RHOICOSPHENIA	CURVATA
308000	CENTRALES	NAVICULACEAE		
308010	CENTRALES	NAVICULACEAE	NAVICULA	
308011	CENTRALES	NAVICULACEAE	NAVICULA	CRYPTOCEPHALA
308012	CENTRALES	NAVICULACEAE	NAVICULA	MINIMA
308013	CENTRALES	NAVICULACEAE	NAVICULA	RADIOSE
308014	CENTRALES	NAVICULACEAE	NAVICULA	SEMINULUM
308015	CENTRALES	NAVICULACEAE	NAVICULA	#1
308020	CENTRALES	NAVICULACEAE	NEIDIUM	

TAXA CODE	ORDER	FAMILY	GENUS	SPECIES
308021	CENTRALES	NAVICULACEAE	NEEDIUM	BISCVLATUM
309000	CENTRALES	GOMPHONEMATACEAE		
309010	CENTRALES	GOMPHONEMATACEAE	GOMPHONEMA	
309011	CENTRALES	GOMPHONEMATACEAE	GOMPHONEMA	ACUMINATUM
309012	CENTRALES	GOMPHONEMATACEAE	GOMPHONEMA	OLIVACEUM
309013	CENTRALES	GOMPHONEMATACEAE	GOMPHONEMA	PARVULUM
309014	CENTRALES	GOMPHONEMATACEAE	GOMPHONEMA	SUBCLAVATUM
310000	CENTRALES	CYMBELLACEAE		
310010	CENTRALES	CYMBELLACEAE	CYMBELLA	
310011	CENTRALES	CYMBELLACEAE	CYMBELLA	MINIMA
310012	CENTRALES	CYMBELLACEAE	CYMBELLA	TUMIDA
311000	CENTRALES	NITZSCHIACEAE		
311010	CENTRALES	NITZSCHIACEAE	HANTZSCHIA	
311011	CENTRALES	NITZSCHIACEAE	HANTZSCHIA	#1
311020	CENTRALES	NITZSCHIACEAE	NITZSCHIA	
311021	CENTRALES	NITZSCHIACEAE	NITZSCHIA	AMPHIBIA
311022	CENTRALES	NITZSCHIACEAE	NITZSCHIA	LINEARIS
311023	CENTRALES	NITZSCHIACEAE	NITZSCHIA	PALEA
311024	CENTRALES	NITZSCHIACEAE	NITZSCHIA	#1
312000	CENTRALES	SURIRELLACEAE		
312010	CENTRALES	SURIRELLACEAE	SURIRELLA	
312011	CENTRALES	SURIRELLACEAE	SURIRELLA	ANGUSTATA
400000	ULOTRICHALES			
401000	ULOTRICHALES	CHAETOPHORACEAE		
401010	ULOTRICHALES	CHAETOPHORACEAE	STIGEOCLONIUM	
401011	ULOTRICHALES	CHAETOPHORACEAE	STIGEOCLONIUM	SUBSECUNDUM
402000	ULOTRICHALES	CLADOPHORACEAE		
402010	ULOTRICHALES	CLADOPHORACEAE	CLADOPHORA	
402011	ULOTRICHALES	CLADOPHORACEAE	CLADOPHORA	GLOMERATA
500000	ZYGNEMATALES			
501000	ZYGNEMATALES	DESMIDIACEAE		
501010	ZYGNEMATALES	DESMIDIACEAE	CLOSTERIUM	
501011	ZYGNEMATALES	DESMIDIACEAE	CLOSTERIUM	#1
800000	BRYOPHYTA			
801000	BRYOPHYTA	FONTINALACEAE		
801010	BRYOPHYTA	FONTINALACEAE	FONTINALIS	
802000	BRYOPHYTA	HYPANACEAE		
802010	BRYOPHYTA	HYPANACEAE	HYGROHYPNUM	
802011	BRYOPHYTA	HYPANACEAE	HYGROHYPNUM	BESTII
1000000	HYDROIDA			
1001000	HYDROIDA	HYDRIDAE		
1001010	HYDROIDA	HYDRIDAE	HYDRA	
1200000	TRICLADIDA			
1201000	TRICLADIDA	PLANARIIDAE		
1201010	TRICLADIDA	PLANARIIDAE	DUGESIA	
1400000	NEMATODA			
1600000	PULMONATA			
1601000	PULMONATA	PHYSIDAE		
1601010	PULMONATA	PHYSIDAE	PHYSA	
1602000	PULMONATA	PLANORBIDAE		
1602010	PULMONATA	PLANORBIDAE	GYRAULUS	
1700000	PROSOBRANCHIA			
1701000	PROSOBRANCHIA	PLEUROCERIDAE		
1701010	PROSOBRANCHIA	PLEUROCERIDAE	JUGA	
1701011	PROSOBRANCHIA	PLEUROCERIDAE	JUGA	PLECIFERA
1701012	PROSOBRANCHIA	PLEUROCERIDAE	JUGA	SILICULA
1900000	PELECYPODA			

TAXA CODE	ORDER	FAMILY	GENUS	SPECIES
2100000	OLIGOCHAETA			
2101000	OLIGOCHAETA	NAIDIDAE		
2102000	OLIGOCHAETA	TUBIFICIDAE		
2300000	ACARINA			
2500000	CLADOCERA			
2700000	OSTRACODA			
2701000	OSTRACODA	CANDONIDAE		
2701010	OSTRACODA	CANDONIDAE	CANDONA	
2701011	OSTRACODA	CANDONIDAE	CANDONA	ANCEPS
2701012	OSTRACODA	CANDONIDAE	CANDONA	STAGNALIS
2702000	OSTRACODA	CYPRIDAE		
2702010	OSTRACODA	CYPRIDAE	CYPRICERCUS	
2702011	OSTRACODA	CYPRIDAE	CYPRICERCUS	DENTIFERA
2702020	OSTRACODA	CYPRIDAE	HERPETOCYPRIS	
2702021	OSTRACODA	CYPRIDAE	HERPETOCYPRIS	REPTANS
2900000	EUCOPEPODA			
2901000	EUCOPEPODA	HARPACTICOIDA		
2902000	EUCOPEPODA	CYCLOPOIDA		
3100000	ISOPODA			
3400000	COLLEMBOLA			
3401000	COLLEMBOLA	ENTOMOBRYIDAE		
3402000	COLLEMBOLA	SMINTHURIDAE		
3402010	COLLEMBOLA	SMINTHURIDAE	SMINTHURIDES	
3600000	EPHEMEROPTERA			
3601000	EPHEMEROPTERA	SIPHONURIDAE		
3601010	EPHEMEROPTERA	SIPHONURIDAE	AMELETUS	
3601011	EPHEMEROPTERA	SIPHONURIDAE	AMELETUS	SUFFUSUS
3602000	EPHEMEROPTERA	BAETIDAE		
3602010	EPHEMEROPTERA	BAETIDAE	BAETIS	
3602011	EPHEMEROPTERA	BAETIDAE	BAETIS	BICAUDATUS
3602012	EPHEMEROPTERA	BAETIDAE	BAETIS	PARVUS
3602013	EPHEMEROPTERA	BAETIDAE	BAETIS	TRICAUDATUS
3602020	EPHEMEROPTERA	BAETIDAE	CENTROPTILUM	
3602021	EPHEMEROPTERA	BAETIDAE	CENTROPTILUM	PROB. ELSA
3603000	EPHEMEROPTERA	HEPTAGENIIDAE		
3603010	EPHEMEROPTERA	HEPTAGENIIDAE	CINYGMA	
3603011	EPHEMEROPTERA	HEPTAGENIIDAE	CINYGMA	INTEGRUM
3603020	EPHEMEROPTERA	HEPTAGENIIDAE	CINYGMULA	
3603021	EPHEMEROPTERA	HEPTAGENIIDAE	CINYGMULA	RETICULATA
3603030	EPHEMEROPTERA	HEPTAGENIIDAE	EPEORUS (IRON)	
3603031	EPHEMEROPTERA	HEPTAGENIIDAE	EPEORUS (IRON)	DECEPTIVUS
3603032	EPHEMEROPTERA	HEPTAGENIIDAE	EPEORUS (IRON)	LONGIMANUS
3603040	EPHEMEROPTERA	HEPTAGENIIDAE	EPEORUS (IRONODES)	
3603041	EPHEMEROPTERA	HEPTAGENIIDAE	EPEORUS (IRONODES)	NITIDUS
3604000	EPHEMEROPTERA	LEPTOPHELEBIIDAE		
3604010	EPHEMEROPTERA	LEPTOPHELEBIIDAE	FARALEPTOPHELEBIA	
3604011	EPHEMEROPTERA	LEPTOPHELEBIIDAE	PARALEPTOPHELEBIA	DEBILIS
3604012	EPHEMEROPTERA	LEPTOPHELEBIIDAE	PARALEPTOPHELEBIA	GREGALIS
3604013	EPHEMEROPTERA	LEPTOPHELEBIIDAE	PARALEPTOPHELEBIA	TEMPORALIS
3800000	ODONATA			
3801000	ODONATA	GOMPHIDAE		
3801010	ODONATA	GOMPHIDAE	OCTOGOMPEIS	
3801011	ODONATA	GOMPHIDAE	OCTOGOMPEIS	SPECULARIS
4000000	PLECOPTERA			
4001000	PLECOPTERA	NEMOURIDAE		
4001010	PLECOPTERA	NEMOURIDAE	MALENKA	
4001020	PLECOPTERA	NEMOURIDAE	SCYEDINA	

TAXA CODE	ORDER	FAMILY	GENUS	SPECIES
4001030	PLECOPTERA	NEMOURIDAE	ZAPADA	
4001031	PLECOPTERA	NEMOURIDAE	ZAPADA	CINCTIPES
4001032	PLECOPTERA	NEMOURIDAE	ZAPADA	COLUMBIA
4001033	PLECOPTERA	NEMOURIDAE	ZAPADA	OREGONENSIS
4002000	PLECOPTERA	TAENIOPTERYGIDAE		
4002010	PLECOPTERA	TAENIOPTERYGIDAE	TAENIONEMA	
4003000	PLECOPTERA	CAPNIIDAE		
4003010	PLECOPTERA	CAPNIIDAE	CAPNIA	
4003020	PLECOPTERA	CAPNIIDAE	EUCAPNOPSIS	
4003021	PLECOPTERA	CAPNIIDAE	EUCAPNOPSIS	BREVICAUDA
4004000	PLECOPTERA	PELTOPERLIDAE		
4004010	PLECOPTERA	PELTOPERLIDAE	SOLIPERLA	
4004011	PLECOPTERA	PELTOPERLIDAE	SOLIPERLA	QUADRISPINULA
4004020	PLECOPTERA	PELTOPERLIDAE	YORAPERLA	
4004021	PLECOPTERA	PELTOPERLIDAE	YORAPERLA	BREVIS
4005000	PLECOPTERA	PTERONARCYIDAE		
4005010	PLECOPTERA	PTERONARCYIDAE	PTERONARCELLA	
4005011	PLECOPTERA	PTERONARCYIDAE	PTERONARCELLA	REGULARIS
4006000	PLECOPTERA	PERLODIDAE		
4006010	PLECOPTERA	PERLODIDAE	ISOPERLA	
4006011	PLECOPTERA	PERLODIDAE	ISOPERLA	EBRIA (=SOBRIA)
4006012	PLECOPTERA	PERLODIDAE	ISOPERLA	FULVA
4006013	PLECOPTERA	PERLODIDAE	ISOPERLA	MARMORATA
4006014	PLECOPTERA	PERLODIDAE	ISOPERLA	MORMONA
4006020	PLECOPTERA	PERLODIDAE	CULTUS	
4006030	PLECOPTERA	PERLODIDAE	SKWALA	
4007000	PLECOPTERA	PERLIDAE		
4007010	PLECOPTERA	PERLIDAE	CALINEURIA	
4007011	PLECOPTERA	PERLIDAE	CALINEURIA	CALIFORNICA
4008000	PLECOPTERA	CHLOROPERLIDAE		
4008010	PLECOPTERA	CHLOROPERLIDAE	ALLOPERLA	
4200000	HEMIPTERA			
4201000	HEMIPTERA	GERRIDAE		
4201010	HEMIPTERA	GERRIDAE	GERRIS	
4400000	MEGALOPTERA			
4401000	MEGALOPTERA	SIALIDAE		
4401010	MEGALOPTERA	SIALIDAE	SIALIS	
4401011	MEGALOPTERA	SIALIDAE	SIALIS	CALIFORNICA
4401012	MEGALOPTERA	SIALIDAE	SIALIS	ROTUNDA
4600000	COLEOPTERA			
4601000	COLEOPTERA	HYDRAENIDAE		
4601010	COLEOPTERA	HYDRAENIDAE	HYDRAENA	
4601011	COLEOPTERA	HYDRAENIDAE	HYDRAENA	VANDYKEI
4602000	COLEOPTERA	HYDROPHILIDAE		
4602010	COLEOPTERA	HYDROPHILIDAE	AMETOR	
4602011	COLEOPTERA	HYDROPHILIDAE	AMETOR	LATCS
4602020	COLEOPTERA	HYDROPHILIDAE	ANACAENA	
4602021	COLEOPTERA	HYDROPHILIDAE	ANACAENA	LIMBATA
4602030	COLEOPTERA	HYDROPHILIDAE	HYDROPORUS	
4603000	COLEOPTERA	HELODIDAE		
4603010	COLEOPTERA	HELODIDAE	ELOCDES	
4604000	COLEOPTERA	ELMIDAE		
4604010	COLEOPTERA	ELMIDAE	LARA	
4604020	COLEOPTERA	ELMIDAE	NARPUS	
4604021	COLEOPTERA	ELMIDAE	NARPUS	CONCOLOR
4604030	COLEOPTERA	ELMIDAE	OPTIOSERVUS	
4604031	COLEOPTERA	ELMIDAE	OPTIOSERVUS	SERIATUS

TAXA CODE	ORDER	FAMILY	GENUS	SPECIES
4604040	COLEOPTERA	ELMIDAE	ORDOBREVIA	
4604050	COLEOPTERA	ELMIDAE	ZAITZEVIA	
4604051	COLEOPTERA	ELMIDAE	ZAITZEVIA	PARVULA
4605000	COLEOPTERA	STAPEYLINIDAE		
4800000	TRICHOPTERA			
4801000	TRICHOPTERA	PEILOPOTAMIDAE		
4801010	TRICHOPTERA	PEILOPOTAMIDAE	WORMALDIA	
4802000	TRICHOPTERA	POLYCENTROPODIDAE		
4802010	TRICHOPTERA	POLYCENTROPODIDAE	POLYCENTROPUS	
4803000	TRICHOPTERA	HYDROPSYCHIDAE		
4803010	TRICHOPTERA	HYDROPSYCHIDAE	PARAPSYCHE	
4803011	TRICHOPTERA	HYDROPSYCHIDAE	PARAPSYCHE	PROB. ALMATA
4803020	TRICHOPTERA	HYDROPSYCHIDAE	HOMOPLECTRA	
4803030	TRICHOPTERA	HYDROPSYCHIDAE	HYDROPSYCHE	
4804000	TRICHOPTERA	RHYACOPHILIDAE		
4804010	TRICHOPTERA	RHYACOPHILIDAE	REYACOPHILA	
4804011	TRICHOPTERA	RHYACOPHILIDAE	REYACOPHILA	GRANDIS
4804012	TRICHOPTERA	RHYACOPHILIDAE	REYACOPHILA	NARVAE
4804013	TRICHOPTERA	RHYACOPHILIDAE	REYACOPHILA	VEDRA
4805000	TRICHOPTERA	GLOSSOSOMATIDAE		
4805010	TRICHOPTERA	GLOSSOSOMATIDAE	GLOSSOSOMA	
4805020	TRICHOPTERA	GLOSSOSOMATIDAE	AGAPETUS	
4806000	TRICHOPTERA	HYDROPTILIDAE		
4806010	TRICHOPTERA	HYDROPTILIDAE	HYDROPTILA	
4807000	TRICHOPTERA	BRACHYCENTRIDAE		
4807010	TRICHOPTERA	BRACHYCENTRIDAE	MICRASEMA	
4807011	TRICHOPTERA	BRACHYCENTRIDAE	MICRASEMA	SP. A
4808000	TRICHOPTERA	LIMNEPHILIDAE		
4808010	TRICHOPTERA	LIMNEPHILIDAE	CRYPTOCHIA	
4808011	TRICHOPTERA	LIMNEPHILIDAE	CRYPTOCHIA	FILOSA
4808020	TRICHOPTERA	LIMNEPHILIDAE	CYRANDA	
4808021	TRICHOPTERA	LIMNEPHILIDAE	CYRANDA	CENTRALIS
4808040	TRICHOPTERA	LIMNEPHILIDAE	PSYCHOGLYPHA	
4808041	TRICHOPTERA	LIMNEPHILIDAE	PSYCHOGLYPHA	PROB. AVIGO
4808050	TRICHOPTERA	LIMNEPHILIDAE	NEOPHYLAX	
4809000	TRICHOPTERA	LEPIDOSTOMATIDAE		
4809010	TRICHOPTERA	LEPIDOSTOMATIDAE	LEPIDOSTOMA	
4809011	TRICHOPTERA	LEPIDOSTOMATIDAE	LEPIDOSTOMA	UNICOLOR
4810000	TRICHOPTERA	ODONTOCERIDAE		
4810010	TRICHOPTERA	ODONTOCERIDAE	NEROPHILUS	
4811000	TRICHOPTERA	CALAMOCERATIDAE		
4811010	TRICHOPTERA	CALAMOCERATIDAE	HETEROPECTRON	
4811011	TRICHOPTERA	CALAMOCERATIDAE	HETEROPECTRON	CALIFORNICUM
5000000	DIPTERA			
5001000	DIPTERA	TIPULIDAE		
5001010	DIPTERA	TIPULIDAE	ANTOCHA	
5001020	DIPTERA	TIPULIDAE	DICRANOTA	
5001030	DIPTERA	TIPULIDAE	LIMNOPHILA	
5001040	DIPTERA	TIPULIDAE	LIMONIA	
5001050	DIPTERA	TIPULIDAE	LIPSOThRIX	
5001060	DIPTERA	TIPULIDAE	PEDICIA	
5001070	DIPTERA	TIPULIDAE	PSUEDOLIMNOPHILA	
5002000	DIPTERA	PTYCHOPTERIDAE		
5002010	DIPTERA	PTYCHOPTERIDAE	PTYCHOPTERA	
5003000	DIPTERA	BLEPHARICERIDAE		
5003010	DIPTERA	BLEPHARICERIDAE	AGATHON	
5003020	DIPTERA	BLEPHARICERIDAE	BIBIOCEPHALA	

TAXA CODE	ORDER	FAMILY	GENUS	SPECIES
5004000	DIPTERA	CHAOBORIDAE		
5004010	DIPTERA	CHAOBORIDAE	EUCORETHRA	
5005000	DIPTERA	DIXIDAE		
5005010	DIPTERA	DIXIDAE	DIXA	
5005020	DIPTERA	DIXIDAE	DIXA (PARADIXA)	
5006000	DIPTERA	SIMULIIDAE		
5006010	DIPTERA	SIMULIIDAE	PROSIMULIUM	
5006020	DIPTERA	SIMULIIDAE	SIMULIUM	
5007000	DIPTERA	CHIRONOMIDAE		
5007100	DIPTERA	CHIRONOMIDAE	MACROPELOPIINI	
5007110	DIPTERA	CHIRONOMIDAE	NATARSIA	
5007200	DIPTERA	CHIRONOMIDAE	PENTANEURINI	
5007210	DIPTERA	CHIRONOMIDAE	PARAMERINA-ZAVREL.	
5007220	DIPTERA	CHIRONOMIDAE	PENTANEURA	
5007230	DIPTERA	CHIRONOMIDAE	THIENZMANNIMYIA SER.	
5007240	DIPTERA	CHIRONOMIDAE	PROB. CONCHAPELOPIA	
5007300	DIPTERA	CHIRONOMIDAE	DIAMESINI	
5007310	DIPTERA	CHIRONOMIDAE	DIAMESA	
5007320	DIPTERA	CHIRONOMIDAE	PSUEDODIAMESA	
5007400	DIPTERA	CHIRONOMIDAE	PRODIAMESINI	
5007410	DIPTERA	CHIRONOMIDAE	MONODIAMESA	
5007500	DIPTERA	CHIRONOMIDAE	ORTHOCLADIINAE	
5007510	DIPTERA	CHIRONOMIDAE	CORYNONEURA	
5007600	DIPTERA	CHIRONOMIDAE	ORTHOCLADINI	
5007610	DIPTERA	CHIRONOMIDAE	BRILLA	
5007620	DIPTERA	CHIRONOMIDAE	CHAETOCADIUS	
5007630	DIPTERA	CHIRONOMIDAE	CRICOTOPUS	
5007631	DIPTERA	CHIRONOMIDAE	CRICOTOPUS	#1
5007632	DIPTERA	CHIRONOMIDAE	CRICOTOPUS	#2
5007640	DIPTERA	CHIRONOMIDAE	EUKIEFFERIELLA	
5007641	DIPTERA	CHIRONOMIDAE	EUKIEFFERIELLA	#1
5007642	DIPTERA	CHIRONOMIDAE	EUKIEFFERIELLA	#2
5007643	DIPTERA	CHIRONOMIDAE	EUKIEFFERIELLA	#3
5007644	DIPTERA	CHIRONOMIDAE	EUKIEFFERIELLA	#4
5007645	DIPTERA	CHIRONOMIDAE	EUKIEFFERIELLA	#5
5007646	DIPTERA	CHIRONOMIDAE	EUKIEFFERIELLA	#6
5007647	DIPTERA	CHIRONOMIDAE	EUKIEFFERIELLA	SP. NR. CORYNONEURA
5007648	DIPTERA	CHIRONOMIDAE	EUKIEFFERIELLA	POSS. BREVICALCAR
5007649	DIPTERA	CHIRONOMIDAE	EUKIEFFERIELLA	PROB. CLA. OR POT.
5007650	DIPTERA	CHIRONOMIDAE	ORTHOCLADIUS (EUD.)	
5007660	DIPTERA	CHIRONOMIDAE	ORTHOCLADIUS (ORTH.)	
5007670	DIPTERA	CHIRONOMIDAE	PARAKIEFFERIELLA	
5007680	DIPTERA	CHIRONOMIDAE	PARAMETRIOCNEMUS	
5007690	DIPTERA	CHIRONOMIDAE	RHEOCRICOTOPUS	
5007700	DIPTERA	CHIRONOMIDAE	TANYTARSINI	
5007710	DIPTERA	CHIRONOMIDAE	MICROPSECTRA	
5007720	DIPTERA	CHIRONOMIDAE	STEMPELLINA	
5007730	DIPTERA	CHIRONOMIDAE	STEMPELLINELLA	
5007740	DIPTERA	CHIRONOMIDAE	TANYTARSUS	
5008000	DIPTERA	CERATOPOGONIDAE		
5008010	DIPTERA	CERATOPOGONIDAE	PALPOMYIA GRP.	
5009000	DIPTERA	EMPIDIDAE		
5009010	DIPTERA	EMPIDIDAE	CLINOCERA	
6000000	SALMONIFORMES			
6001000	SALMONIFORMES	SALMONIDAE		
6001010	SALMONIFORMES	SALMONIDAE	SALMO	
6001011	SALMONIFORMES	SALMONIDAE	SALMO	CLARKI CLARKI

TAXA CODE	ORDER	FAMILY	GENUS	SPECIES
620000	CYPRINIFORMES			
620100	CYPRINIFORMES	CYPRINIDAE		
620101	CYPRINIFORMES	CYPRINIDAE	RHINICHTHYS	
6201011	CYPRINIFORMES	CYPRINIDAE	RHINICHTHYS	OSCULUS NUBILUS
990000	NOTHING			
999900	NOTHING	NOTHING		
999990	NOTHING	NOTHING	NOTHING	
999999	NOTHING	NOTHING	NOTHING	NOTHING

APPENDIX III

Taxa and Trophic Subsystem Codes

Food utilization of aquatic life stages is based on food habit information found in the literature which may be incomplete or uncertain for some taxa. A capital letter designates the trophic subsystem assigned for calculation of trophic subsystem biomasses. Lower case letters designate trophic subsystems also occupied by the taxa for a less significant portion of its stream life.

l	larva
a	adult
A	Autotroph
P	Macrophyte herbivore
H	Microphyte herbivore
F	Fine-particle detritivore
D	Coarse-particle detritivore
C	Carnivore

Chroococcales	
<u>Microcystis</u>	A
Hormogonales	
<u>Oscillatoria retzii</u>	A
<u>Schizothrix caleicola</u>	A
<u>Anabaena variabilis</u>	A
<u>Nostoc commune</u>	A
<u>Calothrix parentina</u>	A
Centrales	
<u>Melosira varians</u>	A
<u>Tabellaria</u>	A
<u>Meridion circulare</u>	A
<u>Diatoma vulgare</u>	A
<u>Synedra rumpens</u>	A
<u>S. ulna</u>	A
<u>Eunotia curvata</u>	A
<u>Achnanthes exigua</u>	A
<u>A. lanceolata</u>	A
<u>A. minutissima</u>	A
<u>Cocconeis placentula</u>	A
<u>Rhoicosphenia curvata</u>	A
<u>Navicula cryptocephala</u>	A
<u>N. minima</u>	A
<u>N. radiosa</u>	A
<u>N. seminulum</u>	A
<u>N. unknown #1</u>	A
<u>Neidium bisculatum</u>	A
<u>Gomphonema acuminatum</u>	A
<u>G. olivaceum</u>	A
<u>G. parvulum</u>	A
<u>G. subclavatum</u>	A
<u>Cymbella minima</u>	A
<u>C. tumida</u>	A
<u>Hantzschia</u>	A
<u>Nitzschia amphibia</u>	A
<u>N. linearis</u>	A
<u>N. palea</u>	A
<u>N. unknown #1</u>	A
<u>Surirella angustata</u>	A
<u>Eumograma</u>	A
Ulotrichales	
<u>Stigeoclonium subsecundum</u>	A
<u>Cladophora glomerata</u>	A

(continued)

Zygnematales	
<u>Closterium</u>	A
Bryophyta	
<u>Fontinalis</u>	A
<u>Hygrohypnum bestii</u>	A
Hydroida	
<u>Hydra</u>	C
Tricladida	
<u>Dugesia</u>	fC
Nematoda	pFc
Pulmonata	
<u>Physa</u>	Hf
<u>Gyraulus</u>	Hf
Prosobranchia	
<u>Juga</u>	fHd
Pelecypoda	hFc
Oligochaeta	F
Acarina	
<u>Aturus</u>	C
<u>Hygrobates</u>	C
<u>Lebertia</u>	C
<u>Piona</u>	C
<u>Protzia</u>	C
<u>Sperchon</u>	C
<u>Torrenticola</u>	C
Cladocera	Hf
Ostracoda	
<u>Candona anceps</u>	hF
<u>C. stagnalis</u>	hF
<u>Cypricercus dentifera</u>	hF
<u>Herpetocypris reptans</u>	hF
Eucopepoda	
Harpacticoida	hF
Cyclopoida	hFc
Isopoda	
<u>Ligidium gracilis</u>	dFc

(continued)

Collembola	
Entomobryidae	hF
<u>Sminthurides</u>	hF
Ephemeroptera	
<u>Ameletus suffusus</u>	dHf
<u>Baetis bicaudatus</u>	dHf
<u>B. parvus</u>	dHf
<u>B. tricaudatus</u>	dHf
<u>Centroptilum elsa</u>	Hf
<u>Cinygma integrum</u>	dHf
<u>Cinygmula reticulata</u>	hFd
<u>Epeorus (Iron) deceptivus</u>	hF
<u>E. longimanus</u>	hF
<u>Epeorus (Ironodes) nitidus</u>	hFd
<u>Paraleptophlebia debilis</u>	hDf
<u>P. gregalis</u>	hDf
<u>P. temporalis</u>	hDf
Odonata	
<u>Octogomphis specularis</u>	C
Plecoptera	
<u>Malenka</u>	Df
<u>Soyedina</u>	Df
<u>Zapada cinctipes</u>	Df
<u>Z. columbia</u>	Df
<u>Z. oregonensis</u>	Df
<u>Taenionema</u>	Df
<u>Capnia</u>	D
<u>Eucapnopsis brevicauda</u>	D
<u>Soliperla quadrispinula</u>	D
<u>Yoraperla brevis</u>	Hd
<u>Pteronarcella regularis</u>	hDc
<u>Isoperla ebria</u>	fCh
<u>I. fulva</u>	fCh
<u>I. marmorata</u>	fCh
<u>I. mormona</u>	fCh
<u>Cultus</u>	C
<u>Skwala</u>	C
<u>Calineuria californica</u>	C
<u>Alloperla</u>	fC
Hemiptera	
<u>Gerris</u>	C
Megaloptera	
<u>Sialis californica</u>	C
<u>S. rotunda</u>	C

(continued)

Coleoptera

<u>Hydraena vandykei</u>	1: C	a: Hf
<u>Ametor latus</u>	1: C	a: F
<u>Anacaena limbata</u>	1: C	a: F
<u>Hydroporus</u>	1: C	a: Cf
<u>Elodes</u>	hFd	
<u>Lara</u>	D	
<u>Narpus concolor</u>	1: hF	a: D
<u>Optioservus seriatus</u>	1: hF	a: Hf
<u>Ordobrevia</u>	hF	
<u>Zaitzevia parvula</u>	hF	

Trichoptera

<u>Wormaldia</u>	Fc
<u>Polycentropus</u>	fC
<u>Parapsyche</u> prob. <u>almata</u>	hFc
<u>Homoplectra</u>	hCf
<u>Hydropsyche</u>	hFc
<u>Rhyacophila grandis</u>	C
<u>R. narvae</u>	hCf
<u>R. vedra</u>	hCf
<u>Glossosoma</u>	H
<u>Agapetus</u>	Hf
<u>Hydroptila</u>	hP
<u>Micrasema</u> sp. A	hPf
<u>Cryptochia pilosa</u>	D
<u>Chyranda centralis</u>	Df
<u>Psychoglypha</u> prob. <u>avigo</u>	fDc
<u>Neophylax</u>	Hf
<u>Lepidostoma</u>	Df
<u>L. unicolor</u>	Df
<u>Nerophilus</u>	fDc
<u>Heteroplectron californicum</u>	Df

(continued)

Diptera

<u>Antocha</u>	hF
<u>Dicranota</u>	C
<u>Limnophila</u>	C
<u>Limonia</u>	Pd
<u>Lipsothrix</u>	D
<u>Pedicia</u>	C
<u>Psuedolimnophila</u>	?
<u>Ptychoptera</u>	dF
<u>Agathon</u>	Hf
<u>Bibliocephala</u>	Hf
<u>Eucorethra</u>	C
<u>Dixa</u>	hFc
<u>D. (Paradixa)</u>	hFc
<u>Prosimulium</u>	hF
<u>Simulium</u>	hF
<u>Natarsia</u>	Ch
<u>Paramerina-Zavreliomyia</u>	Ch
<u>Pentaneura</u>	fC
<u>Thienemannimyia</u> ser. of gen.	hC
<u>T. prob. Conchapelopia</u>	C
<u>Diamesa</u>	hF
<u>Psuedodiamesa</u>	F
<u>Monodiamesa</u>	F
<u>Corynoneura</u>	hF
<u>Brillia</u>	fD
<u>Chaetocladius</u>	F
<u>Cricotopus</u> sp. 1	hPf
<u>C. sp. 2</u>	hPf
<u>Eukiefferiella</u> poss. <u>Brevicalcar</u> grp.	hFc
<u>E. prob. Claripennis</u> grp.	hFc
<u>E. prob. Potthastia</u> grp.	hFc
<u>E. sp. 1</u>	hFc
<u>E. sp. 2</u>	hFc
<u>E. sp. 3</u>	hFc
<u>E. sp. 4</u>	hFc
<u>E. sp. 5</u>	hFc
<u>E. sp. 6</u>	hFc
<u>E. new sp. nr. Corynoneura</u>	hFc
<u>Orthocladius (Eudactylocladius)</u>	hF
<u>O. (Orthocladius)</u>	hF
<u>Parakiefferiella</u>	F
<u>Parametricnemus</u>	F
<u>Rheocricotopus</u>	pFc
<u>Micropsectra</u>	F
<u>Stempellina</u>	F
<u>Stempellinella</u>	F
<u>Tanytarsus</u>	hF
<u>Palpomyia</u> grp.	fC
<u>Clinocera</u>	fC

Salmoniformes

<u>Salmo clarki clarki</u>	C
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Cypriniformes

<u>Rhinichthys osculus nubilus</u>	C
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