A FOUR-LEVEL HIERARCHY FOR ORGANIZING WILDLAND STREAM RESOURCE INFORMATION

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ABSTRACT. An analysis of current USDA Forest Service methods of collecting and using wildland stream resource data indicates that required information can be organized into a four-level hierarchy. Information at each level is tiered with information at the preceding level. Level 1 is the ASSOCIATION, which is differentiated by stream size and flow regime. Level 2, STREAM TYPE, is differentiated by valley bottom materials and morphology, riparian ecosystem vegetation and channel gradient. Level 3 is the REACH, which is defined by hydraulic patterns, changes in flow volume, substrate and bank composition. Level 4 is the HYDRAULIC UNIT, which is differentiated by water surface slope, low-flow constrictions, flow pattern, velocity and depth relative to reach average and water turbulence. Differentia for each level are measurable stream characteristics on which stream capability is dependent. The proposed hierarchy can reduce data costs, permit more accurate and precise resource evaluations, and allow local flexibility in information management.
KEY TERMS: wildland stream resources information hierarchy, aquatic ecological classification, stream classification, riparian areas.

INTRODUCTION

Wildland stream resource data and information are important for making management decisions by government and industry. Leading national stream management issues that require basic and interpreted data include: water quality and cumulative watershed impacts, riparian area management, fish habitat management, instream flow, and water rights. Hydrologists, biologists, engineers and foresters are involved in providing mutual and complementary stream information on these management issues.

Informed and efficient decision making depends on effective information management. Geographic information systems (GIS) are being adopted by many agencies. The USDA Forest Service (1988) Resource Information Project identified the current situation and some opportunities for information standardization based on a survey of data collection activities of 34 National Forests (NF). The Forest Service (FS) found that no uniform system for organizing stream resource information was in use. Common FS information needs and usage are the springboard for the stream information hierarchy proposed in this paper. The proposal has potential interagency application.

Use of a hierarchical classification system was proposed by Platts (1980) to efficiently organize stream resource data. At the present, there is no widely accepted

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hierarchical stream classification system. Although stream classification systems have been suggested or theoretically developed by several workers (Schumm, 1963; Lotspeich and Platts, 1982; Brussock, et al., 1985; Frissell, et al., 1986), they have only been implemented and documented for a few specific geographic areas (Collotzi, 1974; Cowardin, et al., 1979; Paustian et al., 1982; Rosgen, 1985). Substantial efficiency gains may be achieved by implementing a stream information hierarchy with a national scope.

We propose a four-level information hierarchy outlined in Table 1 to serve as the framework for a general stream information system. The term "information" is used broadly to include data measurements, calculated data, and interpretations. We analyze current FS stream information needs and usage and assume that these needs are representative of agencies involved in wildland water resource management. The proposed information hierarchy is based on common information needs within the National Forest System. We conclude with a discussion of the benefits of a hierarchical information organization and make recommendations on how to proceed with development.

Table 1. Stream Resource Information Hierarchy levels.

Level	Cartographic Scale	Length[1] (channel widths)	Inclusion[2] Size (channel widths)	Persistence[3] (years)
Hydraulic Unit, (4)	Site survey scale	1 to 10	None	1 to 10
Reach, (3)	< or = 1:12,000	< 10 to 100s	< 10	10 to 100
Stream Type, (2)	1:15,840	100s to 1,000s	< 100	> 100
Association, (1)	1:24,000 - 1:40,000	1,000s	< 1,000	> 1000

1 Relative length is expressed in multiples of bankfull width.

2 Inclusions are those areas that have physical characteristics different from those defined for the catagory, but are small enough in size or too infrequent in occurrence to be considered significant.

3 Persistence refers to the time over which the physical characteristics that define a particular catagory remain unchanged.

DATA USED FOR THIS ANALYSIS

The FS Resource Information Project (RIP) provides the data used for this analysis. The RIP background, sampling design, and procedures are documented in "Resource Information Project: Final Report" (USDA Forest Service, 1988).

Stream resource information examined during the RIP was categorized into three different types: data elements, rating methods, and classification systems. Data elements are distinct measurements or descriptions of stream resources. They may be used singularly or in combination with other data elements.

Rating methods are assessments of stream resource attributes that result in a composite numerical score or index. A distinguishing characteristic of rating procedures is that similarly rated resource features or conditions share a quality in common; however, they are not necessarily physically or functionally similar. The Channel Stability Rating (Pfankuch, 1975) is an example of a widely used rating procedure that utilizes a numerical score of several different channel features to index overall channel stability. Two different stream areas can have similar stability ratings, but have very different physical appearances. Rating methods are used frequently by the NFs to characterize the condition of a stream resource or environment.

Classification systems are used to distinguish individual categories by specific measurable attributes that either individually, or in combination, represent a unique resource feature. Classification systems are typically used by the NFs to describe general or specific resource features such as presence of perennial flow or groupings of morphologically similar channels. They differ from rating methods in that resource features that are classed as the same will generally have similar form or function.

The data collection procedures used in the RIP were based on some important assumptions and constraints that affect our analysis. It was assumed that the information presently being collected is sufficient to address NF information needs. Furthermore, all survey information was categorized using a four-level resolution scale to describe the cartographic scale or accuracy of the information (Table 1). This scale standard was necessary to allow for comparisons of how general or detailed specific information types were. This four-level categorization was reconsidered throughout the RIP survey to ensure that it adequately applied to all information types being used on the NFs.

The RIP focused on "permanent" resource characteristics that are expected to remain relatively unchanged over time, except for major landscape modifications. Information was excluded that had little basis in the physical form or function of streams, or that was so artificial or transient in nature as to be of limited use in evaluating long-term resource conditions. This includes data for predictive models that make estimates of future conditions (such as flow prediction models), water chemistry data, and stream characterizations that do not address long-term physical features (such as regulatory usage classifications or sport fishing designations). It was assumed that permanent resource characteristics are of fundamental importance, and that other resource information can be organized within a hierarchy based on permanent features.

ANALYSIS OF CURRENT INFORMATION USAGE

The NFs are similar in many aspects of their need for and use of stream resource information. Many NFs have similar water management issues. Figure 1 shows the primary management issues identified by the sampled NFs. Water quality, riparian area, and fish habitat condition and management were issues identified on over 60% of the sampled NFs. Importance of these issues may be more widespread because several less frequently identified issues are actually sub-issues of these three. Most issues involve how streams respond to management activities such as clearcutting and road construction. Stream responce is affected by physical channel characteristics.

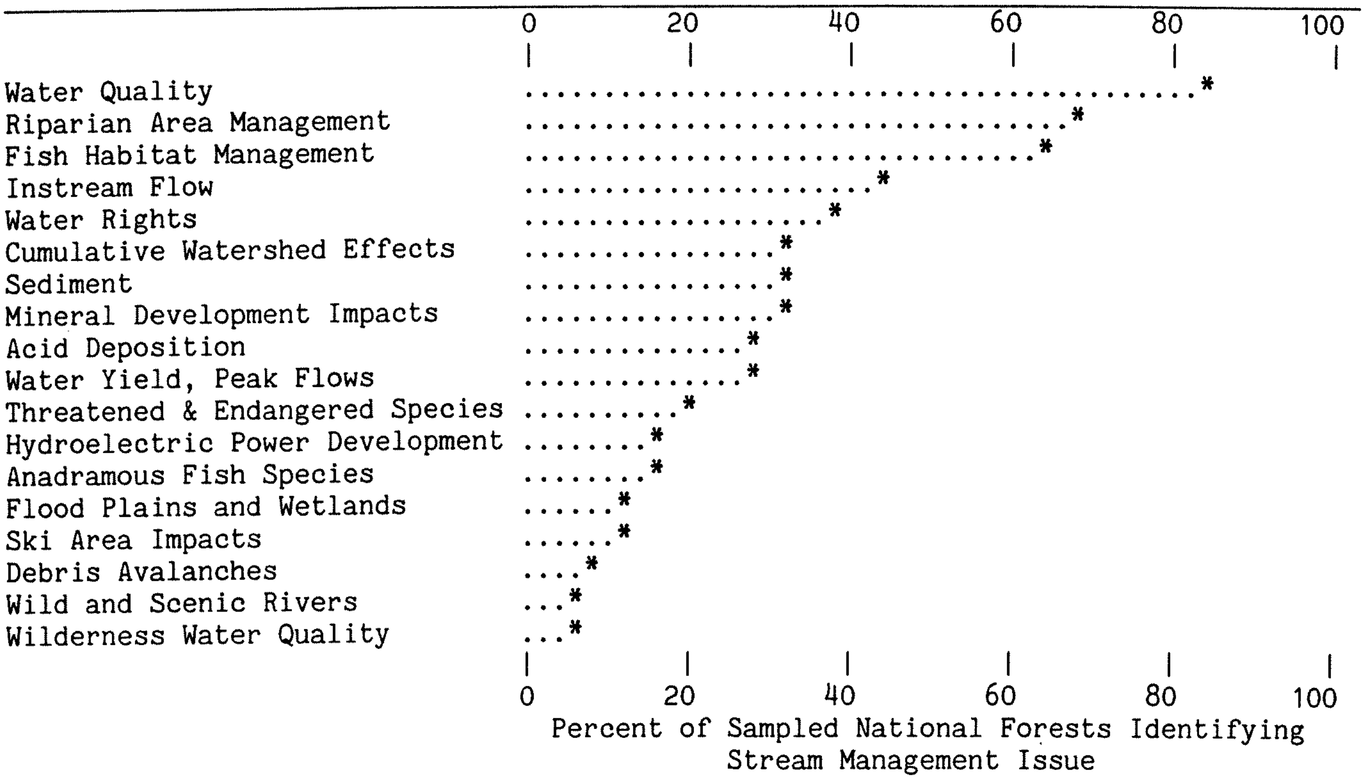

Figure 1. Stream resource management issues identified by 34 National Forests sampled during 1987 Resource Information Project survey (USDA Forest Service, 1988). These issues are not mutually exclusive.

The NFs collect similar data elements to provide information on management issues. Figure 2 lists the most frequently collected data . Over 50% of the sampled NFs collect the same 23 data elements. The accuracy standards of these data elements were not fully evaluated by the RIP (USDA Forest Service, 1988). However, there are strong indications of similar information use by the NFs.

The general types of rating methods are listed in Figure 3 by resolution level. Rating methods are grouped according to the rating objective and the parameters used. NFs primarily use ratings at large cartographic scales (Levels 3 and 4) to evaluate conditions specific to small geographic areas. Ratings focus on channel stability and gross habitat conditions at Level 3, while making more specific fish habitat characterizations at Level 4.

Although no single classification system is common to all NFs, they do utilize many of the same physical characteristics in their stream resource classifications (Figure 4). Stream order and flow regime characteristics are primarily used at the smallest cartographic scale (Level 1), while channel morphology is used at Level 2. Fifty-six percent or more of the sampled NFs use these respective physical features to classify at these scales. Fewer classification systems are being used at the larger cartographic scales (Levels 3 and 4), but those that exist all use morphologic features.

Data elements, rating methods, or classification systems may be used in assessing a single activity at a specific location, or a number of similar activities over a specified area. It was observed during the RIP that information acquired for one rating or classification purpose is rarely used for another purpose, even at the same cartographic scale. Information acquired at larger cartographic scales is not generally aggregated for use at smaller scales. Frequently the same information is collected separately by different specialists who may use different accuracy standards for information developed at the same cartographic scale.

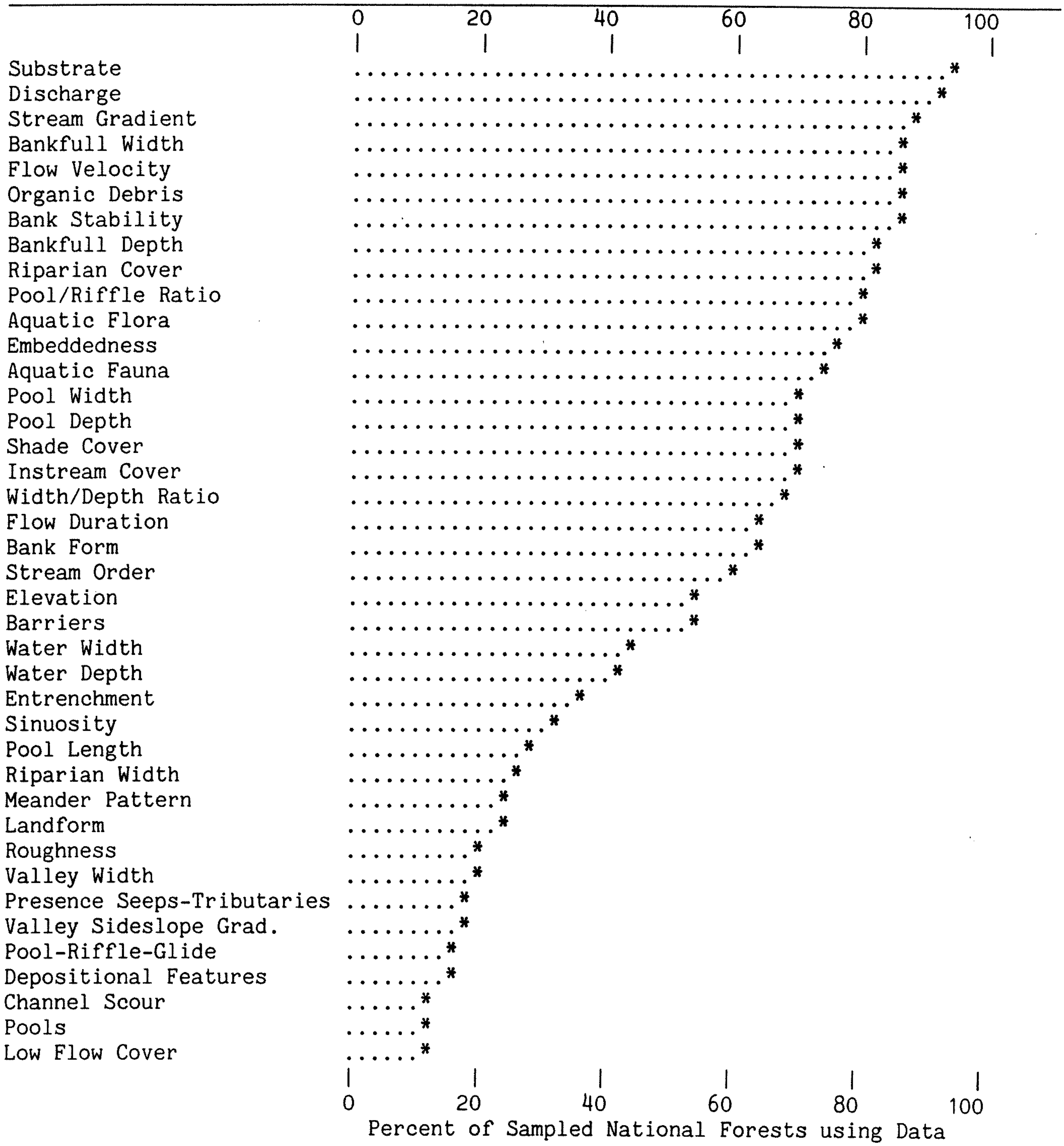

Figure 2. Stream data elements used by 34 National Forests sampled during 1987 Resource Information Project survey (USDA Forest Service, 1988). Only those data elements relating to "permanent" resource characteristics are shown.

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                                 0         20        40        60        80       100
                                 |         |         |         |         |         |
Level 1, 1,000s of Channel Widths in Length
  Size/Flow                      ...*
  Fish Habitat                   .*
  Water Quality                  .*
Level 2, 100s-1,000s of Channel Widths in Length
  Debris Torrent Evaluation      .*
Level 3, 10-100s of Channel Widths in Length
  Channel Stability              ..................................*
  Cow Fish                       .................*
  Biotic Condition Index         ...............*
  Habitat Condition Index        .............*
  Riparian Scorecard             .........*
  Habitat Quality Index          ...*
  Biological Condition Index     .*
  Fish Habitat Model             .*
  Habitat Condition              .*
  Habitat Vulnerability          .*
  Riparian Quality               .*
  Riparian Evaluation            .*
  Spawning Habitat               .*
Level 4, 1-10 Channel Widths in Length
  Fish Habitat                   .........................*
                                 |         |         |         |         |         |
                                 0         20        40        60        80       100
                                  Percent of Sampled National Forests using System
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Figure 3. Stream rating methods used by 34 National Forests sampled during 1987 Resource Information Project survey (USDA Forest Service, 1988). Methods are listed according to four levels of cartographic scale/accuracy.

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                              0         20        40        60        80       100
                              |         |         |         |         |         |
Level 1, 1,000s of Channel Widths in Length
  Flow Regime                 .................................*
  Stream Order                .............................*
  Channel Morphology          ............*
  Fish Habitat                ..........*
  Stream Size                 ...*
Level 2, 100s-1,000s of Channel Widths in Length
  Channel Morphology          ............................*
  Valley Bottom               ....*
  Fish Habitat                .*
Level 3, 10-100s of Channel Widths in Length
  Channel Morphology          ..........*
Level 4, 1-10 Channel Widths in Length
  Channel Morphology          .......*
                              |         |         |         |         |         |
                              0         20        40        60        80       100
                               Percent of Sampled National Forests using System
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Figure 4. Stream classification systems used by 34 National Forests sampled during 1987 Resource Information Project survey (USDA Forest Service, 1988). Systems are listed by the features used to distinguish individual classes at four levels of cartographic scale/accuracy.

In summary, NFs have the following in common:

1. Stream resource management issues;

2. Data elements measured to address management issues;

3. Rating methods used to evaluate stream conditions;

4. Physical features employed to classify stream areas;

5. Information needed at several scales with differing levels of accuracy.

An information hierarchy is described in the following section that satisfies the NFs needs based on these commonalities. The hierarchy may fulfill stream resource information needs of other federal agencies and states.

STREAM RESOURCE INFORMATION HIERARCHY

The stream resource information hierarchy (SRIH) outlined in Table 1 and described below is recommended for organizing and integrating the information used by various professions at different scale and accuracy levels. The hierarchy tiers information at each level to other levels. Managers can incrementally "buy" information as requirements for accuracy increase. For example, ASSOCIATION-level information may be adequate for preparing resource management plans, while project designs to implement these plans may require STREAM TYPE-, REACH-, or HYDRAULIC UNIT-level information.

To be most effective, the SRIH should be nested within a larger geoclimatic classification. A geoclimatic classification would be used to differentiate large regions with similar hydrologic environments. It would account for differences in climate, geology, geochemistry, and geomorphic history between regions. No geoclimatic classification has been adequately tested to determine if it successfully stratifies areas for differing hydrology. Therefore, a particular system is not recommended.

Each SRIH level is described below. For each, a description is given of how information is currently being gathered at this level, along with an explanation of the "differentia" used to distinguish categories within the level. Differentia are the qualitative or quantitative criteria used to stratify a given level into differing classes. The proposed differentia for each level are those currently used most frequently, or ones that are useful in making subdivisions. In some cases, the specific differentia criteria listed will require further definition.

Level 4: HYDRAULIC UNIT

Description. The HYDRAULIC UNITs are pools, riffles, cascades, runs and glides. These units are hydraulically distinct from each other (Sullivan, 1986). HYDRAULIC UNIT distribution and form result from interactions between channel-forming bankfull flows and base-level controls (such as bedrock, large woody debris). Convergent flow and bed scour produce pools, whereas divergent flow and bedload deposition produce riffles. The range of HYDRAULIC UNIT types is most apparent in third- and fourth-order streams. Their presence in larger and smaller streams requires further definition. Most HYDRAULIC UNITs maintain their flow characteristics at all stages between base flow and bankfull.

HYDRAULIC UNITs are currently the focus of fish habitat research. Only 15% of the NFs surveyed are systematically classifying HYDRAULIC UNIT information (Figure 4). In contrast, 50% of the surveyed NFs are making ratings at this level (Figure 3). Predominant rating factors are channel morphology and fish habitat characteristics. Fish habitat ratings are typically dependent on shape, size, and distribution of the HYDRAULIC UNITs. Forty-five percent of the differentia used for these ratings are morphologic measures, and 15% are substrate characterizations. These attributes are accounted for at the ASSOCIATION-, STREAM TYPE-, and REACH level of the hierarchy.

Differentia. Stream channel attributes used to distinguish individual HYDRAULIC UNITS are:

1. Water surface slope at low flow: 0-1%, 1-4%, 4-6%, >6%;
2. Flow constrictions at low flow: < 25%, > 25% & < 100%, 100%;
3. Flow patterns: divergent or convergent;
4. Velocity changes;
5. Mean depth;
6. Water surface turbulence.

Level 3: REACH

Description. REACH units are sets of distinct HYDRAULIC UNITs. REACH unit distribution and form are a function of floods, flood plain topography, and stream network processes. During bankfull floods, changes in containment, flow obstruction, or streambank resistance create a characteristic pattern of HYDRAULIC UNITs. These patterns tend to be stable over time and define the REACH units. The term and concept of "Reach" have often been used to imply uniformity without explicit definition. Reaches are used to stratify streams to rate condition. Sixty-five percent of the NFs surveyed rate reaches. However, only 21% used specific methods to classify REACH units (Figure 4).

Differentia. REACH units are differentiated by the following characteristics:

1. HYDRAULIC UNIT pattern: pools, riffles, cascades, runs and glides;
2. Changes in flow volume;
3. Shape and size of HYDRAULIC UNIT types;
4. Substrate composition;
5. Bank composition.

Level 2: STREAM TYPE

Description. STREAM TYPE units have relatively homogeneous valley bottom materials, valley bottom morphology, riparian cover, and channel gradient. The STREAM TYPE level integrates information on stream channels, flood plains and riparian lands immediately adjacent to hillslopes. Channel structure and stability are the primary concerns at this hierarchy level. Sixty-five percent of the surveyed NFs use Level 2 classification. Sixty-five percent use channel structure and stability factors to stratify resource information at this level (Channel Morphology

+ Valley Bottom Types, Figure 4). Predominant classification factors used are channel gradient, landform materials and shape, channel entrenchment and shape, and riparian vegetation.

Differentia. Similar to the "Valley Types" described by Cole (1972), the following features are used to distinguish STREAM TYPE units.

Valley Bottom Materials:

1. Consolidated materials (e.g. bedrock, possibly overlain by thin soils);
2. Unconsolidated, cohesive materials (e.g., deep clay soils);
3. Unconsolidated, noncohesive materials (e.g., deep sand or gravel).

Valley Bottom Morphology:

1. Valley Bottom Width - wide, moderate, narrow;
2. Sideslope Angle - steep, moderately steep, gentle, none;
3. Entrenchment - very deep, deep, moderate, shallow.

Riparian Vegetation may be the vegetation community association, overstory type, or volume class. The focus is on riparian characteristics that affect channel stability, large woody debris, and in-channel nutrient cycling.

Channel Gradient:

1. Steep Gradient (>6%);
2. Moderately High Gradient (4%-6%);
3. Moderate Gradient (1% - <4%);
4. Low Gradient (<1%).

Level 1: ASSOCIATION

Description. The ASSOCIATION level subdivides a drainage network based on flow regime and relative stream size. Flow regime describes annual stream flow continuity: perennial versus nonperennial. Stream size characterizes the relative flow magnitude and stream position in the drainage network. Hydrologists and fisheries biologists recognize a need to distinguish watershed areas that have different size and flow-duration characteristics. Hydrologists use this level for gross characterizations of channel shape and low flow patterns. Fisheries biologists use flow regime and stream size to assess general habitat accessibility and capability. Eighty-eight percent of the surveyed NFs use this classification level. Sixty-five percent classify flow regime and 65% either classify stream size directly, or use stream order, a surrogate for stream size (Figure 4).

Differentia. ASSOCIATION-level differentia characterize general conditions over the entire channel length within the Level 1 unit. The distinction of perennial from nonperennial streams is the pertinent flow regime characteristic at this level. Flow regime can change over short distances in some geoclimatic areas, especially in karst regions. Similarly, perennial surface flow may be interrupted through areas with deep porous substrate. Stream order is used by 59% of the surveyed NFs as a surrogate for stream size and relative flow magnitudes (Figure 4). Proposed significant stream order groupings at the ASSOCIATION level are: 1-2, 3-4, 5-6, 7 and larger. The proposed standard for stream order delineation is the 1:24,000 USGS topographic map series with the drainage network extended beyond "blue lines" to the probable location that channel bed and bank are not distinct from the adjacent soils.

THE THEORY BEHIND STREAM INFORMATION HIERARCHY

Stream resource information and interpretations should be structured similar to ecosystems. Interdependent ecosystems vary in size and are nested within larger systems in a hierarchy of spatial scales (Allen and Starr, 1982). The SRIH accomplishes this and follows the interdisciplinary concepts of landscape ecology, which has explicitly acknowledged the value of hierarchy theory (Urban et al., 1987). The SRIH is conceptually most similar to the hierarchical concepts outlined by Frissell et al. (1986), but does differ somewhat in actual application and detail.

A stream classification should be based on a model of how stream systems are spatially organized and how they change over time (Frissell et al., 1986). The criteria for classification should be independent variables that control ecosystem Structure and process (Lewis, 1969; Strahler, 1975; Lotspeich and Platts, 1982; Warren and Liss, 1983). Although stream classification is still in an immature state, a unity of opinion is developing on the causal mechanisms behind the behavior of stream systems. Fluvial geomorphologists are progressing from general theory (Leopold et al., 1964) to predictive models of channel evolution (Schumm, 1981). The existence of discrete channel forms that result from watershed processes (Schumm, 1981) suggests that classification of watershed structure may stratify ecological processes. The six variables that control watershed evolution are time, initial relief, geology, climate, vegetation and system relief/volume (Schumm, 1981), thus underscoring the need for integrating several environmental parameters in stratifying stream resources. The relief/volume (contributing basin) geomorphic variable, as stratified by the geoclimatic and SRIH Level 1 criteria, ensures that scale-dependent physical and ecological process information is spatially organized.

Aquatic ecology research results recognize the tie between physical channel characteristics and stream ecology. Aquatic ecologists have taken a descriptive model (river zonation review, Hynes, 1970) and refined it as an ecological abstraction with predictive properties (River Continuum Concept, Vannote et al., 1980). The River Continuum proponents question the ecological value of discrete reaches (Cushing et al., 1983), but acknowledge that deviations from general theory could result from the effect of mean geomorphic conditions prevailing in a given reach (Minshall et al., 1985). Reviews of the River Continuum work have suggested the need for incorporating channel hydraulics, sediment dynamics, and regional geomorphic character within this ecological abstraction (Statzner and Higler, 1986; Brussock et al., 1985). Culp and Davies (1982) found the classification techniques of Lotspeich (1980) aided ecological comparisons within a watershed.

At spatial scales equivalent to the SRIH Level 1 through Level 4, the structure and ecology of a given site have been found to relate as strongly with geomorphic variables as they do with site attributes (Ziemer, 1971; Platts, 1979; Huryn and Wallace, 1987; Lanka et.al., 1987; Minshall et.al., 1987; Naiman et.al., 1987). The SRIH is not an overt ecological classification, but through a process of hierarchically stratifying physical processes that are being linked to ecological properties, water resource information and interpretation are linked to the causal phenomena behind stream structure and ecology. Interpretations and modeling of site capability can then pursue more refined deterministic or stochastic simulations of site ecology and processes with multivariate or hierarchical interpretations.

Existing land classification systems are not adequate for effectively organizing stream information. Stream systems are not hierarchical in the same sense as terrestrial systems, and frequently overlap terrestrial biome boundaries due to the motive forces driving the aquatic system. Land classifications frequently ignore this distinction, and treat stream ecosystems as holes in the landscape, or as static surficial features (Welch, 1978). Ecosystem classifications typically define large biomes without specifically addressing the stream system (e.g., Bailey, 1988), or couple stream and terrestrial systems (Warren, 1979; Lotspeich and Platts, 1982; Driscoll et al., 1984) with an untested assumption that terrestrial boundaries have aquatic ecological significance (e.g., Rowe, 1980).

The SRIH is an abstraction of the real world, and incorporates rapidly advancing theory. The intent of the SRIH is to identify the type of data and information that can be organized to achieve the goal of spatially and conceptually refined water resource management.

BENEFITS OF INFORMATION HIERARCHY

The SRIH addresses the growing need for efficient resource information management that will reach a critical stage as GISs become common tools. The growing body of water resource information is becoming increasingly stale and disorganized due, in part, to the lack of a standard conceptual model. As new concepts, theories, and models assume prominence, the tendency is toward replacement of existing information. Effective and continued use of existing information requires that it be deliberately organized, rather than being treated solely as a time- or concept-specific site condition. The SRIH would produce substantial gains in resource management effectiveness now and in the future by making information organized, accessible, and stable.

In addition to organizing information in a more ecological model structure, the SRIH can extend information use beyond the original data sites. The ability to extrapolate information to classified, but uninventoried, sites is a powerful benefit of classification. Initially, the SRIH would do little classification of information, but it would organize the existing information along ecological lines for more effective use.

Increasing demands for integrated stream resource evaluations will eventually preclude all options except ecological management. The SRIH provides data and interpretations needed for integrated resource management decisions. It allows for the recapture and categorization of existing information based on an ecological organization and on interpretive needs. A standardized information model should unite the various terrestrial and aquatic sciences in effective resource management. The reduced statistical variance that a classification permits will optimize the ability to verify and validate information through use of more rigorous sampling designs (Hankin, 1984).

Stream resource management will not necessarily become more effective as our data-gathering abilities become more precise and accurate. The requisite step of organizing our knowledge in the context of a realistic model may be the fundamental need today. The level of realism that a management decision requires predetermines the type of information needed. The SRIH, by virtue of its causal basis, will reduce the core information needs and data acquisition to that which determines watershed processes. By extension, this reduced information set will focus attention on those resource properties most influenced by management activities, and reduce the tendency to gather large sets of dependent attribute and rating information.

The analysis of current stream information management leads us to conclude that a timely structuring (rather than replacement) of information would produce benefits while still providing local flexibility. The SRIH allows retention of biome-specific information and methodologies. Local needs are accommodated rather than dictated. The SRIH promotes information sharing across functional lines and managerial boundaries. Adoption of this ecological information framework would lead to more effective and realistic interpretations, and to improved resource management. We propose that the SRIH is a useful advancement beyond the common situation of an infinite number of unique and independent sites, all of which must be thoroughly investigated prior to management recommendations.

RECOMMENDATIONS

Professionals providing stream resource information to managers are challenged to ecologically integrate water resource information for maximum efficiency. The SRIH provides a framework for prioritizing information needs based on the required scale and accuracy of the decision to be made. The proposed hierarchy is a conceptual structure for managing data based on permanent attributes that determine stream resource capability. Interpretations may be made at each level of the hierarchy depending on current knowledge of cause-effect relationships. Challenges that we face include:

* Establishing and using standard definitions for data elements.
* Adopting scale and accuracy standards for each hierarchy level.
* Building an information hierarchy based on causative factors.
* Developing resource interpretations for each hierarchy level based on current knowledge of cause-effect relationships and issues.
* Integrating stream capability information into a single hierarchy with interpretations for water quality, cumulative impacts, riparian area management, fisheries habitat, instream flow, water rights and other issues.
* Objectively testing hierarchical stratifications and interpretations.
* Establishing and requiring peer review procedures to ensure quality control.
* Developing similar hierarchies for wetland, estuarine, and riparian systems so as to produce a complete, integrated aquatic resource information hierarchy.

Our recommendations are that:

1. The American Water Resources Association's (AWRA) Wildland Hydrology and Watershed Management Working Group, in cooperation with the American Fisheries Society, should develop and publish guidelines for a wildland stream resource information hierarchy; including similar guidelines for wetlands, estuarine and riparian systems.

2. The AWRA, working with an interagency steering committee, should submit guidelines for an integrated aquatic resource information hierarchy to be incorporated into the "National Handbook of Recommended Methods for Water-Data Acquisition" printed by the US Geological Survey.

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