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Project Summary

A Review of Aquatic Habitat Assessment Methods

Gerald S. Schuytema

This project was an extensive literature review of aquatic habitat assessment techniques. The objective was to help water quality investigators and natural resource managers unfamiliar with such techniques to become aware of the methods and current trends in development, and to aid in deciding what techniques might best fit project goals. Approximately 30 methods were summarized and compared.

Most methods have been developed by Federal or state agencies and have had the greatest application in the western United States. They are classified here according to a number of mutually interacting categories such as project impact, inventory and general description, stream type, particular fish species orientation, and channel stability. Many of the methods have developed indices or numerical values which can be used for comparisons or evaluation. The U.S. Fish and Wildlife Service is channeling substantial effort into the development of habitat evaluation procedures (HEP), techniques designed for assessing project impacts oriented toward a particular species of interest.

Parameters most frequently considered in the reviewed methods have included flow, temperature, water surface, width, turbidity, gradient, velocity, depth, bank stability measures, bottom size distribution, siltation, cover, pool size, attached vegetation, fish and invertebrate types, riparian zone vegetation and shade, and obstructing factors such as waterfalls, dams, and culverts.

While many methods are similarly based on such parameters as substrate, cover, flow, depth, and stream and floodplain morphology, they still vary in effort required and objectives. Thus, the ultimate choice of methods for any purpose including nonpoint source pollution evaluation depends on geographical location, stream type, investigator expertise, economics, and precise project goals.

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

Introduction

Habitat assessment has long been recognized by natural resource agencies as an essential task in the management and preservation of fish and wildlife. Water quality agencies are beginning to realize that measuring characteristics of the water column is insufficient to predict the biological condition of a stream system because of changes that can also occur in the quality of the physical environment from land use impacts. Flow, water quality, habitat structure, and energy source are all important variables affecting biological integrity. Activities such as urbanization, agriculture, silviculture, mining, construction, land disposal, and hydrologic modifications often have severe impacts on physical habitat quality.

There are few compilations of the diverse and scattered literature on aquatic habitat assessment. This review includes approximately 30 methods, many interrelated, located in a literature base formed in large measure by state and Federal agency reports. While these methods are generally divided into categories based on stream type (salmonid and non-salmonid), purpose (impact assessment and general inventory) or technical approach, actual differences between many are slight.

This compilation will help water quality investigators and natural resource managers unfamiliar with aquatic habitat assessment techniques to become aware of sources and apparent trends in development, and to decide what techniques might best fit project goals.

Discussion

Many of the reviewed techniques are still under development, several are represented in a series of reports or publications, and some are unpublished. Federal agencies (U.S. Forest Service, U.S. Fish and Wildlife Service, U.S. Bureau of Land Management, U.S. Soil Conservation Service) have been responsible for the majority of the methods, and state agencies (Departments of Fish, Game, Conservation, Natural Resources, Wildlife) and interagency groups account for the remainder. Primary emphasis on methods development has been in the West.

The methods are classified into a variety of groups depending upon their intended purposes, stream types, and technical approaches. These groups are not necessarily mutually exclusive, as a given method can be represented in several categories or apply to a number of situations. For instance, while most of the reviewed methods (25) appear to be used in salmonid streams, six are also used in non-salmonid streams. Only two of the methods are used primarily in non-salmonid streams.

The methods can also be categorized according to purpose. Impact assessment techniques are used primarily to evaluate the impact of water and land resource development projects, construction, and alterations due to human activity, differing flow regimes, and pollution. General description or inventory methods are primarily used for fisheries, water and land use planning and management, habitat research, baseline data inventories, and environmental statements.

Some of the salmonid stream methods are based in part on the U.S. Forest Service (USFS) Stream Reach Inventory and Channel Stability Evaluation. This method was developed to systemize evaluations of the resistive capacity of mountain stream channels to bed and bank material detachment. Adding factors related specifically to aquatic organism habitat allows this approach to be used as a habitat assessment technique.

Some of the groups also contain index and transect aspects. Index or numerical values facilitate comparisons or judgments between stations or locations; all major method groups contain some index producing techniques. Transect methods are based upon sampling a transect across the stream in contrast to sampling a stream reach of particular length. Only Federal agencies seem to have emphasized this type of approach.

The major habitat parameters and related factors used or evaluated in the various types of methods are grouped in Table 1. The groups (surrounding area, riparian zone, general descriptors, stream banks, stream bottom, fish habitat, characteristics, and biology), are each presented with a percentage indicating the relative number of reviewed methods using the parameters within a group. Individual parameters are listed according to predominance of use.

Habitat parameters associated with surrounding stream areas are emphasized by topographical and geographical features and land use of the surrounding and upstream areas. A more closely associated area, the riparian zone, gives primary importance to vegetative type, shading effect, and streamside cover. Most of the methods use a large variety of descriptive terms to characterize habitat. Some of the more important include flow, temperature, width, velocity, gradient, turbidity, and depth.

Many methods stress various aspects of fish habitat, with instream cover and the number and size of pools ranking highest. Obstructions to fish migration are primarily characterized by culverts, dams, and debris piles. Nonphysical factors associated with habitat analysis include features such as attached algae and macrophytes, fish species, size, weight and abundance.

This review represents the status of assessment methods at a point in time and will become quickly outdated as new methods develop and older ones are revised. The grouping of the techniques as reviewed are but one way of examining them; other logical arrangements may become apparent with further additions and refinements. The purpose for which a method was intended or the basic philosophy of its development seem to be most important in determining its place in some sort of classification scheme.

The methods were classified in the review on the basis of stream type (salmonid, non-salmonid or both combined) primarily to allow potential users to become aware of methods in their own areas of interest. There is little upon which to differentiate these methods, however, based on the type of parameters examined. In fact, a method used for non-salmonid habitat was developed for salmonid streams. Some differences between these methods are: 1) less emphasis on surrounding area, riparian zone, stream banks, and fish habitat-related parameters in salmonid stream methods, and 2) less emphasis on stream banks by combination methods.

Validation is one of the most important aspects confronting management's decision on assessment technique selection. The lack of comparative studies to determine if different methods provide similar results using the same data base has been emphasized. The system that incorporates the best available data and that is the least subjective should be the most accurate, but that question will not be resolved until enough systems have been compared and sufficient replicated validations made.

The results of a survey of 40 state agencies indicate that very few have developed or used a habitat assessment technique specifically for non-point source pollution investigations, even though a majority of those queried did acknowledge the desirability of such techniques. The States of Oregon and Washington both use techniques based on channel stability with additional biotic variables. The State of Wisconsin uses a biotic index; this system, however, is not based on physical parameters. North Carolina uses a similar non-physical stream assessment system. South Dakota uses a general habitat assessment technique to inventory trout habitats in watersheds affected by road and railroad construction, timber management, agricultural practices, mining and flood control projects.

Conclusions and Recommendations

Some representative methods which are worthy of consideration in selecting a technique include: 1) methods based on U.S. Forest Service Channel Stability Methods with added factors of particular concern to salmonids;[1] 2) a general salmonid stream method with warm water stream potential which emphasizes computer storage, data manipulation,

Table 1. *Habitat Parameters and Related Factors Evaluated in the Reviewed Methods*[1]

Surrounding Area (26%)[2]
- *surrounding land use*
- *topography/geography*
- *upstream land use*
- *historical land use*
- *flood plain condition*
- *urbanization*

Riparian Zone (78%)
- *vegetation species/type*
- *percent shade*
- *streamside cover*
- *vegetation size*
- *vegetation density*
- *width of zone*
- *ungulate grazing/damage*
- *flood plain width*
- *vegetation successional stage*

General Descriptors (10%)
- *flow*
- *water temperature*
- *water surface width*
- *color/turbidity/transparency*
- *gradient*
- *velocity*
- *average depth*
- *air temperature*
- *channel width*
- *length of segment*
- *elevation*
- *pool/riffle ratio*
- *stream order*
- *stage/level*
- *stream length*
- *channel type/configuration*
- *tributaries/tributary of sinuosity*
- *pollution sources*
- *bottom composition—general*
- *valley bottom width*
- *valley type/configuration*
- *weather*
- *drainage area*
- *watershed type*
- *water source(s)*
- *water use*
- *percent channelized*
- *stream area*
- *direction of flow*

Stream Banks (57%)
- *bank stability*
- *landform slope*
- *mass wasting*
- *debris jam potential*
- *vegetative bank protection*
- *channel capacity*
- *bank rock content*
- *obstructions*
- *cutting*
- *deposition*
- *percent erosion/bare soil*
- *height banks*
- *percent damage*
- *percent grazing*

Stream Bottom (86%)
- *bottom size distribution*
- *siltation/sedimentation*
- *consolidation/particle packing*
- *rock angularity*
- *brightness*
- *scouring/deposition*
- *inbeddedness*
- *percent channel movement*
- *roughness coefficient*

Fish Habitat (75%)
- *instream cover*
- *pool length/width*
- *pools number/percent*
- *riffle width*
- *pool depth*
- *spawning gravel abundance/volume*
- *pool area*
- *spawning gravel quality*
- *riffle depth*
- *riffles percent*
- *spawning gravel size*
- *runs percent*
- *nursery habitat*
- *riffle velocity*
- *runs width*
- *runs depth*
- *runs velocity*

Biology (86%)
- *attached algae/macrophytes*
- *fish species*
- *invertebrate type/species*
- *invertebrate abundance/rank*
- *fish size/weight*
- *fish abundance*
- *invertebrate diversity*

Obstructions (45%)
- *waterfalls*
- *beaver dams/dams*
- *culverts*
- *debris piles/slides*
- *log jams*
- *channelization*
- *dredging*
- *impoundments*
- *levies/dikes*
- *riprap*

[1] *Rated according to predominance of use within each group.*
[2] *Percent of methods using parameters in each group.*

transect sampling, and index value of optimum habitat;[2] 3) a method orientated toward chosen species of interest and designed to demonstrate the impact of any given flow regime on fish habitat potential in all stream types;[3] 4) a method appropriate to large projects in all stream types and orientated toward chosen species of interest (uses a habitat suitability index value where selected parameters are measured and compared with habitat requirements as indicated by response curves);[4] and 5) a supplemental salmonid stream method based only on substrate and survival-to-emergence relationships.[5]

The development of habitat assessment procedures has progressed from simple surveys, many designed for inventory, and from simple index type rating systems to more complex, often species-orientated systems, frequently assisted by computerized information storage and retrieval. This increased develop-

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ment is a reflection of the recognition of the importance and usefulness of aquatic habitat in stream baseline and impact assessment. Many governmental agencies are presently developing techniques applicable to their own needs. The trend in method development is toward systems that recognize habitat potential as valuable in the definition of baseline conditions or in impact evaluation. Comparing a stream's condition to its own potential is a large step forward in understanding perturbation effects.

A universal habitat technique is probably not realistic because of the diversity of watershed and stream types, but a number of methods have the potential, with regional adaptations, to be used over wide areas. The development of a technique applicable only to a certain type of pollutant or impact is also impractical, but the selection of a method which objectively measures the impact upon a stream parameter of interest can be useful. The development of method criteria applicable to non-salmonid streams would be of great benefit to lowland watershed and resource managers.

Diverse interests and goals in different Federal and state agencies concerned with the enforcement of water quality standards, detection, and documentation of pollution, protection of the natural environment, and management of natural resources has led naturally to the development of different types or views of habitat assessment techniques. Increased cooperation between agencies and increased awareness of new techniques can do much to promote the use and improvement of habitat technology. The ultimate choice of an aquatic habitat method, however, may hinge upon economics, expertise, and project goals.

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The EPA author ***Gerald S. Schuytema*** *(also the EPA Project Officer, see below) is with the Environmental Research Laboratory, Corvallis, OR 97333.*

The complete report, entitled "A Review of Aquatic Habitat Assessment Methods," (Order No. PB 82-189 648; Cost: $7.50, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
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U.S. Environmental Protection Agency
Corvallis, OR 97333

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