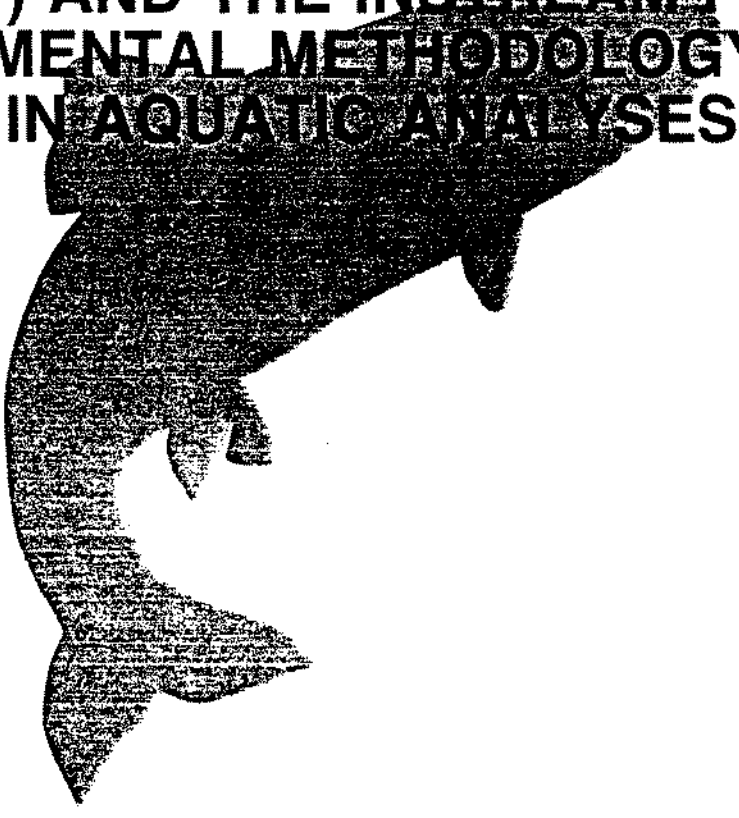
FWS/OBS-84/11
MAY 1984

COMPARISON OF THE USE OF THE HABITAT EVALUATION PROCEDURES (HEP) AND THE INSTREAM FLOW INCREMENTAL METHODOLOGY (IFIM) IN AQUATIC ANALYSES



Fish and Wildlife Service

U.S. Department of the Interior

FWS/OBS-84/11
May 1984

COMPARISON OF THE USE OF THE HABITAT EVALUATION PROCEDURES (HEP) AND THE INSTREAM FLOW INCREMENTAL METHODOLOGY (IFIM) IN AQUATIC ANALYSES

by

Carl L. Armour, Richard J. Fisher,
and James W. Terrell
Western Energy and Land Use Team
U.S. Fish and Wildlife Service
Drake Creekside Building One
2627 Redwing Road
Fort Collins, CO 80526-2899

Western Energy and Land Use Team
Division of Biological Services
Research and Development
Fish and Wildlife Service
U.S. Department of the Interior
Washington, DC 20240

This report should be cited as:

Armour, C. L., R. J. Fisher, and J. W. Terrell. 1984. Comparison of the use of the Habitat Evaluation Procedures (HEP) and the Instream Flow Incremental Methodology (IFIM) in aquatic analyses. U.S. Fish Wildl. Serv. FWS/OBS-84/11. 30 pp.

PREFACE

This report is designed to assist users in understanding when to apply the Habitat Evaluation Procedures (HEP) and the Instream Flow Incremental Methodology (IFIM) to aquatic analyses. These two methods were developed at the U.S. Fish and Wildlife Service's Western Energy and Land Use Team (WELUT) through interagency, multidisciplinary efforts. Depending on site-specific considerations, users must determine if HEP, IFIM, or both methods are applicable in an aquatic analysis. Information is presented in this document on the basic features, capabilities, and limitations of both methods to enable users to decide on the most appropriate procedure to meet specific study needs. References to detailed technical information for each method are included in the text. Training is necessary prior to applying either method to ensure proper application. Training and technical assistance for field applications are available from the U. S. Fish and Wildlife Service. Additional HEP information can be obtained from the HEP Group (FTS 323-5424, Comm. 303-226-9424) and IFIM information can be obtained from the Instream Flow and Aquatic Systems Group (FTS 323-5331, Comm. 303-226-9331). The address of both groups is the Western Energy and Land Use Team (WELUT), U.S. Fish and Wildlife Service, Creekside One, 2627 Redwing Road, Fort Collins, CO 80526-2899.

CONTENTS

	Page
PREFACE	iii
FIGURES	vi
TABLES	vii
ABBREVIATIONS	viii
INTRODUCTION	1
COMPARISON OF METHODS	2
HABITAT EVALUATION PROCEDURES (HEP)	10
INSTREAM FLOW INCREMENTAL METHODOLOGY (IFIM)	16
USES OF SI CURVES IN HEP AND IFIM AQUATIC APPLICATIONS	23
SUMMARY	27
REFERENCES	29

FIGURES

Number		Page
1	Project screening process to determine when to apply HEP and IFIM	9
2	Example of a mechanistic HSI model	11
3	Suitability Index (SI) curve for percent pool and backwater area for a hypothetical HSI model	12
4	SI aggregation equations for the largemouth bass riverine HSI model (Stuber et al. 1982)	13
5	Tree diagram for the northern pike riverine model (Inskip 1982)	14
6	Conceptualization of stream reach microhabitat simulation	18
7	Weighted usable area for brown trout vs. discharge for three study reaches in a segment of a hypothetical river (Bovee 1982)	19
8	Usable length of stream for a particular species life stage (e.g., adult brown trout) for a specific time period (e.g., August) for the three study reaches in Fig. 7	20
9	The IFIM computation of total habitat (ft^2) in a study area by multiplying the WUA derived for velocity, depth, substrate, and cover (microhabitat conditions) by the length of the area with suitable macrohabitat conditions for fish	22

TABLES

Number		Page
1	Overview of HEP and IFIM	3
2	HU's for rainbow trout for a hypothetical site	15
3	A partial listing of the availability of habitat suitability curves	26

ABBREVIATIONS

AAHU	Average Annual Habitat Unit
FWS	U.S. Fish and Wildlife Service
HA	Habitat Area
HEP	Habitat Evaluation Procedures
HSI	Habitat Suitability Index
HU	Habitat Unit
HUEE	Human Use and Economic Evaluation
IFIM	Instream Flow Incremental Methodology
ISTEMP	Instream Temperature Model
PHABSIM	Physical Habitat Simulation System
RVI	Relative Value Index
SI	Suitability Index
SSAM	Stream Simulation and Assessment Model
TDS	Total Dissolved Solids
WELUT	Western Energy and Land Use Team
WUA	Weighted Usable Area

INTRODUCTION

The Habitat Evaluation Procedures (HEP) are designed for quantifying habitat values and documenting impacts of habitat changes on fish and wildlife resources in both aquatic and terrestrial ecosystems (U.S. Fish and Wildlife Service 1980a,b). The Instream Flow Incremental Methodology (IFIM) is specifically designed for simulating and quantifying impacts of changes in flow, channel morphology, or water quality, resulting from water management or stream channelization activities, on fish, invertebrates, and instream recreational activities (Grenney and Kraszewski 1981; Milhous et al. 1981; Bovee 1982). Both methods were developed at the U.S. Fish and Wildlife Service's (FWS) Western Energy and Land Use Team (WELUT) as interagency, multidisciplinary efforts. This paper contains information on the: (1) differentiating features and recommended uses of the two methods for environmental assessment; and (2) development and use of Suitability Index (SI) curves. The discussion is restricted to considerations of the affects of habitat alterations on fish habitat.

COMPARISON OF METHODS

HEP and IFIM are similar in that they: (1) provide information about habitat changes over time; (2) provide a means of comparing the impact of alternative management practices on fish habitat; (3) combine habitat quality and quantity to obtain an index; (4) make use of suitability relationships between habitat variables and habitat quality; and (5) are computerized. Differences between the two methods (summarized in Table 1) include: (1) HEP is a flexible technique for use in terrestrial and aquatic habitats, whereas IFIM is designed for flowing waters only; (2) IFIM includes simulation models for predicting changes in the physical variables of velocity, depth, substrate, cover (microhabitat) and temperature and water quality (macrohabitat); (3) IFIM is primarily used for in-kind mitigation of stream flow, whereas HEP is designed as a more generalized method for mitigation evaluations, including both in-kind and out-of-kind mitigation; and (4) IFIM models always contain the velocity, depth, substrate, and cover variables and require the development and use of SI curves for each variable, whereas not all Habitat Suitability Index (HSI) models for HEP require the use of SI curves and not all HSI models with curves include velocity, depth, substrate, and cover. In addition, HEP can be used with types of models that do not require the development and use of SI curves; e.g., equations for standing crop or harvest, pattern recognition models, and narrative or word models. Both IFIM and HEP can aid planners and managers in the development of quantitative information for use in decision-making activities. Both IFIM and HEP are based on biological assumptions and consequently promote the use of well documented, logical analyses as the most effective way of providing biological information in impact assessment, planning, and habitat management activities. A process for selecting the appropriate method is presented in Figure 1.

Project scoping is the appropriate time to select the best method(s) to apply to a specific problem. Unfortunately, scoping is often neglected and arbitrary decisions on the analysis approach may be made. Scoping should involve individuals representing the organizations and interests that will be involved in, or affect, the final decisions. Participants, through an interdisciplinary process, should evaluate and agree on: (1) the details of the proposed action(s) and alternative actions, including project effects on existing or baseline conditions; (2) a general delineation of the habitat areas subject to impact; (3) the selection of evaluation species; (4) the habitat changes most likely to occur (i.e., model variables) that will impact the evaluation species; (5) species data requirements for an environmental impact analysis; (6) viable options for protecting the fish population; (7) the method or combination of methods to apply; (8) the resources available for performing the work and interpreting the results; (9) who has the responsibility for performing the work; and (10) the format and use of study results.

Table 1. Overview of HEP and IFIM.

Feature	HEP	IFIM	Special considerations
Applicable to both aquatic and terrestrial species.	Yes. Can be used to evaluate effects of altered habitat on aquatic and terrestrial species.	No. Restricted to evaluating effects of altered flows, channel morphology change, and accompanying water quality changes on fish, invertebrates, and recreational activities in streams.	When altered flow and/or stream morphology is a concern, IFIM will provide the more accurate and reliable results. In other cases, HEP is the more appropriate procedure.
Applicable to negotiating for flow releases and designing flow regimes.	Not recommended.	Yes. IFIM was specifically designed for this use.	
Applicable to stream channelization evaluations.	Yes. As with any other habitat alteration, HEP is useful in comparing present and alternative future conditions.	Yes. IFIM is especially useful when channel structure design is negotiable or increasing the carrying capacity is a possible mitigation feature.	The primary consideration in a channelization study is the amount of potential involvement by the fishery manager in the design of the new channel.
Applicable to defining instream flow needs to maintain the existing fishery resource.	Not recommended.	Not necessarily. IFIM is designed for trade-off analyses and negotiating for streamflows below control structures. IFIM should only be used when future negotiations of this nature are likely.	Use of methods based on flow records or single transect measurements may be the most useful as guidance to project planners during feasability studies when no construction or change in the flow regime is proposed at the present time or initial maintenance flows are needed.

Table 1. (continued)

Feature	HEP	IFIM	Special considerations
Method is used to predict physical/chemical changes that will result in habitat impacts.	No. Predictions of impacts of environmental changes (e.g., loss of spawning areas or elevated water temperatures) on habitat are made through use of HSI models. Developers must provide HEP users with prediction of changes over time for each model variable.	Yes. Proposed alternative flow regime data required from developer. Simulated physical/chemical changes and the habitat condition over time, as a consequence of the proposed action flow, is an output of IFIM. Recommended changes in the actual flow are the focus of negotiations by the user of IFIM.	Neither method is designed for making final decisions. Individual is provided information to consider in combination with other factors. Methods are used to predict impacts.
Involves use of HSI models.	Yes. Models can be developed for specific life stages or they can pertain to all life stages. Most models are in the latter category. HSI models also can be used for other purposes; e.g., designating inventory data needs for land management activities and designing land management plans to protect and enhance fish habitat.	No. Involves SI data for velocity, depth, substrate, and cover, in addition to information, to compute Weighted Usable Area (WUA) values. SI data for temperature and water quality variables are combined with WUA values to evaluate total Habitat Area (HA).	Habitat Unit (HU) output for HEP corresponds to life stage specificity of HSI model. WUA and HA output for IFIM is for all riverine life stages.
Involves use of SI curves.	Sometimes. Curves for various biotic and abiotic variables are used for some HSI models. Other models (e.g., linear regression for standing crop and harvest and pattern recognition models) do not involve the use of curves.	Yes. Curves are used for the standard microhabitat variables of velocity, depth, substrate, and cover. Curves for the macrohabitat descriptors of temperature and water quality are also used.	Curves can be developed from published data, use of professional judgement, and/or field data. Users of either tool can modify curves for site-specific applications.

Table 1. (continued)

Feature	HEP	IFIM	Special considerations
SI variables are integrated into a model for evaluating relative habitat quality.	Yes. Curve values are aggregated into a species-specific HSI model. Users can determine alternative aggregation approach.	Yes. SI data for the microhabitat variables are processed by computer in combination with other data to calculate WUA. User determines aggregation approach involving macrohabitat variables.	Curves for both methods quite often need to be developed or modified to suit needs of users.
Interchangeability of SI curves.	Possibly. If IFIM utilization or preference curves for velocity, depth, substrate, and cover variables are available, it is possible to modify the curves for HEP applications when no other data are available.	Yes. Literature-based SI curves from HSI models can be used in IFIM when no field data are available and biologists conclude that the curves are an adequate representation of the microhabitat preferences of the species to be evaluated. SI curves that are used in HSI models to represent temperature and water quality variables can be used in IFIM.	Interchange requires a thorough understanding of how a curve was developed and appropriateness for applications based on site-specific considerations and available information on species requirements.
Field sampling is necessary.	Not necessarily. Data needs are dependent on HSI model requirements, which depend on application objectives. WELUT provides guidance to users on field approaches for documenting HU's. Specific approach best for field conditions is determined by users.	Yes. Field collection of velocity, depth, substrate, and cover data are intrinsic steps of each application. Individuals who perform IFIM analyses typically collect data. Field approach is precisely defined because data must be compatible with specific computer program requirements. A field techniques manual is available, and a field techniques course is offered several times a year for users of IFIM.	Aerial photographs can be used to evaluate baseline habitat for HEP applications if sufficient information can be obtained to meet study objectives. A Field Sampling Design and Techniques Course will be initiated in FY84 for HEP users. The objective for the course is to provide detailed technical guidance on designing and conducting field sampling.

Table 1. (continued)

Feature	HEP	IFIM	Special considerations
Computer analysis required for application.	No. Manual analysis is possible, although computerization is available.	Yes. Use of a computer is necessary. The following users guides are available: Physical Habitat Simulation System (PHABSIM) (physical habitat); Stream Simulation and Assessment Model (SSAM IV) (water quality); and Instream Temperature Model (ISTEMP) (stream temperature).	Computer production of SI curves for IFIM is possible with use of field data collected following specified procedures.
Habitat output has absolute meaning.	No. HU's and Average Annual Habitat Units (AAHU's) cannot be equated directly to population numbers unless an HSI or fish population model capable of predicting species numbers is used.	No. WUA's and HA's cannot be equated directly to characteristics of the fish populations. However, habitat information can be used with fish population models where sufficient data are available for a site.	The Human Use and Economic Procedures (HUEE) can be used with either method if method output can be converted to potential population numbers. HEP output cannot be used for PHABSIM input. IFIM output can be used for HEP input by equatting HA's with HU's for the same life stage. However, this should be done only when both methods are being used for a given study.
Comparison of impacts of proposed no action and action alternative.	Yes. Data can be generated to compare impacts for aquatic and terrestrial species. User is often dependent on the developer to describe future conditions.	Yes. Specifically applicable to evaluating impacts of flows and channel modifications and resulting water quality changes on fish, invertebrates, and instream recreational uses. Output can be used to evaluate different water management and channel design alterations.	In addition to evaluating impacts of typical actions (e.g., power plants), HEP is suitable for land use management applications, including grazing, timber harvest, and mining, that may not affect flows or streams. IFIM is specifically useful in negotiating operating rules for water releases.

Table 1. (continued)

Feature	HEP	IFIM	Special considerations
Habitat assessment data integrated over time and space.	Partially. HU's and AAHU's are calculated for target years. No sampling strategy has been developed for modeling spatially-graded conditions (such as temperature) over a longitudinal profile of a stream. When this is needed, appropriate IFIM submodels can be used (i.e., the stream temperature model).	Yes. IFIM sampling strategy overlays numerous microhabitat sites with water quality profiles to compute total habitat under graded conditions. Time series can accommodate any user-specified time period (e.g., hourly, daily, monthly, seasonally, or annually).	HEP can be used to model graded conditions by establishing numerous HSI measurement sites and presenting the data for the full length of the river when the developer provides similar graded physical/chemical environmental projections.
Evaluation of mitigation for unavoidable impacts and trade-off analysis.	Yes. Routine component of HEP analysis. Useful for evaluating compensation involving substitution of one type of habitat for another (e.g., stream for reservoir).	Yes. For comparison of mitigation for flows and channel morphology. Cannot be used to evaluate nonstream habitat substitutions but can be used to recommend flow regimes for other streams to replace lost habitat.	HEP can be routinely applied to evaluate effects of trade-offs, including "out-of-kind", when unavoidable habitat damage occurs. IFIM can be used to evaluate alternative flow releases, channel modifications, and stocking schedules as possible "in-kind" mitigation activity.
Testing status of habitat evaluation output.	Testing of HU's in correlation with population parameters in progress. Statistical models not requiring use of SI curves are available for some species.	Testing of limiting habitat in correlation with population parameters is in progress. Most work to date is for trout streams.	Testing of HSI model, SI curves, and WUA output is ongoing. Results will be provided to users.

Table 1. (concluded)

Feature	HEP	IFIM	Special considerations
Habitat impacts are expressed in terms of economic costs and benefits.	No. Economic analyses are not a component of HEP.	No. Economic analyses are not a component of IFIM.	When IFIM or HEP data can be related to population data, an economic analysis can be performed with HUEE.
Field biologists can use methods.	Yes. Procedure is designed for application by field biologists.	Yes. Procedure is designed for application by field biologists.	Involvement by hydrologists and engineers in IFIM applications is advisable. For applications of both methods, involvement of interdisciplinary, interagency Teams will facilitate acceptance of results.
User training provided to apply method.	Yes. Approximately 1,600 individuals have been trained to date.	Yes. Approximately 1,000 individuals have been trained and over 800 applications made throughout the United States and in Canada, New Zealand, and Australia.	Acceptance of both methods is indicated by the widespread user training and field applications. Individuals from Federal, State, and local government agencies, in addition to representatives of the academic community and the consulting industry, have received training. Follow-up field experience is required to qualify individuals for proficient procedures application.

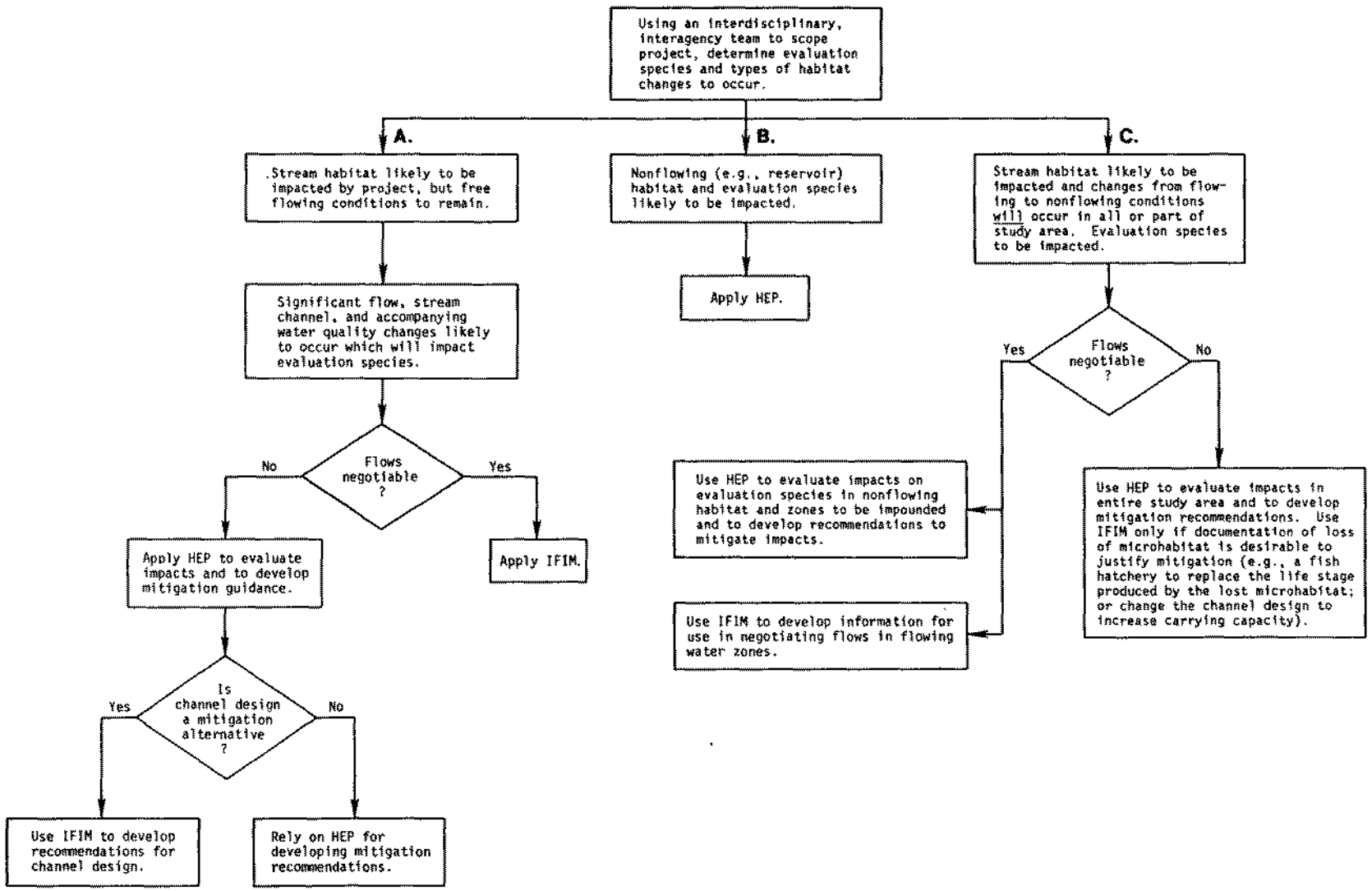


Figure 1. Project screening process to determine when to apply HEP and IFIM.

Although other decisions must be made during the scoping exercise, the selection of evaluation species and a determination of the adequacy of existing analysis technology (e.g., SI curves and HSI models) are critical.

HABITAT EVALUATION PROCEDURES (HEP)

HEP is a computerized method for use in habitat inventory, planning, management, impact asessment, and mitigation studies. The method consists of a basic accounting procedure that combines habitat quality, defined as the HSI, with habitat area to calculate the HU, which is sensitive to changes in both the amount and the quality of available habitat. The basic accounting procedure enables comparisons of habitat availability at several sites (baseline studies) or for changes in habitat over time (impact assessments) for various sites, management actions, or project alternatives. HEP output consists of quantitative information for each species evaluated. The information can pertain to all life stages of a species or to a specific life stage. Basic steps in a HEP analysis include the following:

Step 1. Scoping. Scoping includes defining study objectives, delineating the boundary of the study area, and selecting aquatic evaluation species. The selection of evaluation species can be based on ecological importance, importance for human use (e.g., sport or commercial fishing), or other factors, including legal protection status.

Step 2. Development and use of HSI models. An HSI model can be in one of several forms, including equations for standing crop or harvest, mathematical and nonmathematical mechanistic models that involve aggregations of variables that affect life requisites of a species, pattern recognition models, or narrative (word) models. The mechanistic model (Fig. 2) is a commonly used model and requires development and use of Suitability Index (SI) curves (Fig. 3). Each variable in a model is described by one or more symbols. For example, percent pool bottom cover (Fig. 2) is identified by V_3 and V_4. V_3 is for adults and juveniles and V_4 is for the fry stage.

Mechanistic models use tree diagrams to depict the relationships between variables and habitat suitability (Fig. 2). Once the variables have been identified, the relationships between the variables and habitat suitability must be determined. These relationships are based on information obtained from literature reviews, expert opinion, and field studies. SI curves (Fig. 3) are developed and used to determine site specific values for each variable. In Figure 3, for example, the suitability index would be 0.77 if there were 50% pools and backwater areas in the study site.

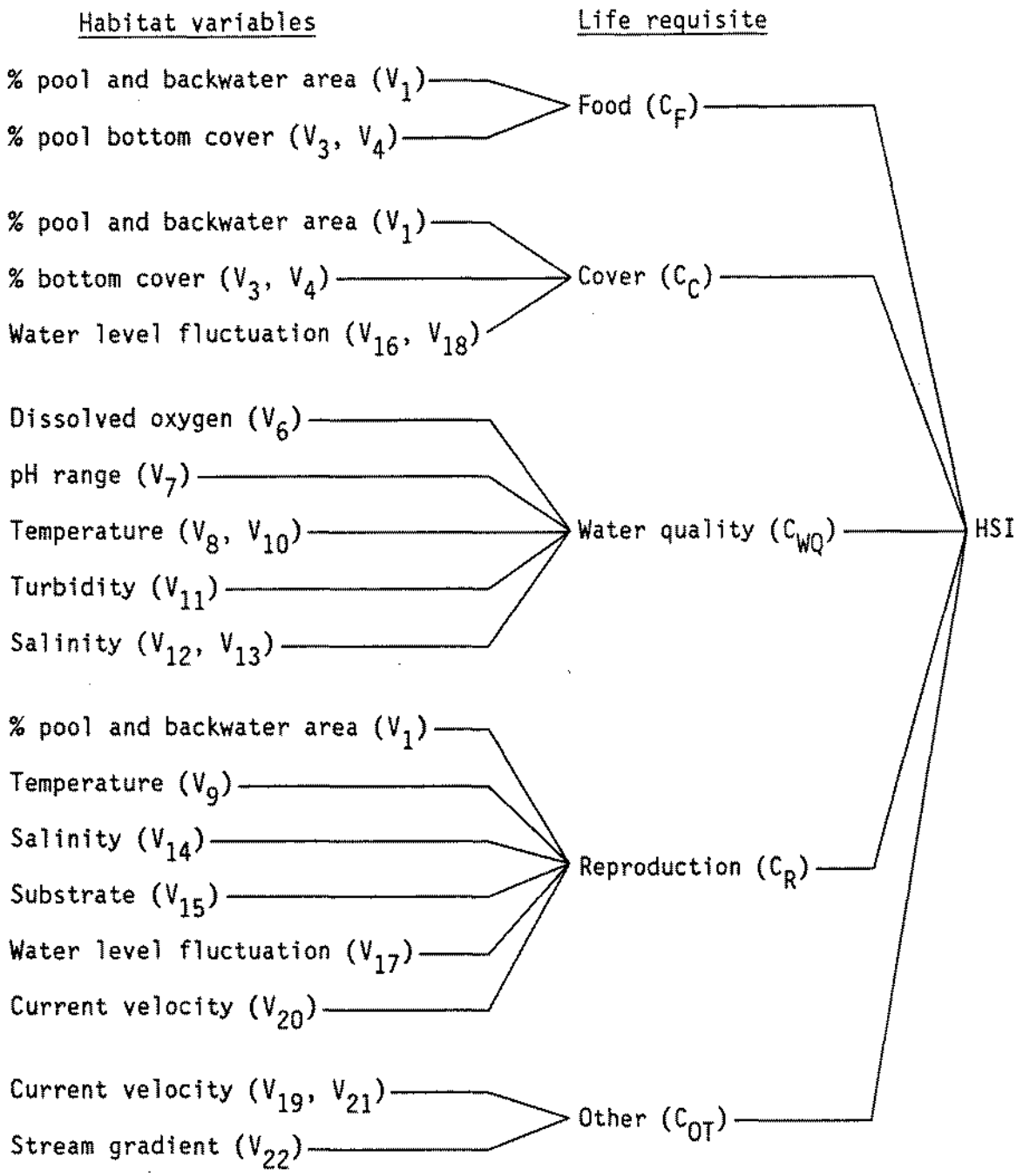


Figure 2. Example of a mechanistic HSI model. The tree diagram illustrates the structure of the largemouth bass riverine model (Stuber et al. 1982). The value of each variable (V_n) is determined from a suitability curve.

Variable

V_1 Percent pool and backwater area during average summer flow.

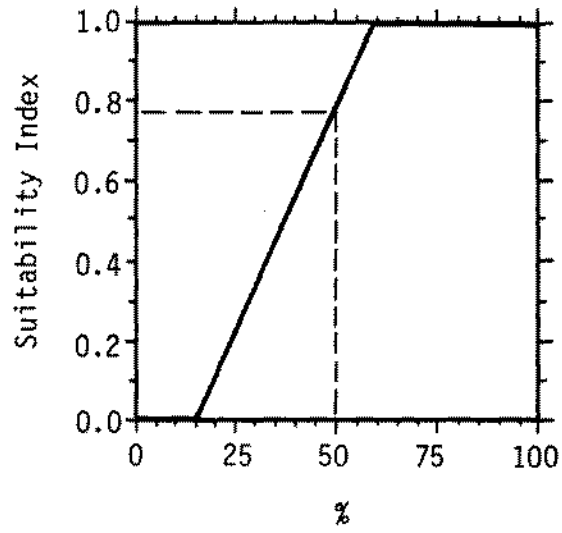


Figure 3. Suitability Index (SI) curve for percent pool and backwater area for a hypothetical HSI model.

The SI's are aggregated to derive the HSI. An example of one mathematical approach to aggregating SI's is presented in Figure 4; an example of a nonmathematical approach is presented in Figure 5. In the example in Figure 5, the HSI for a study site is defined as the lowest SI for any one of the nine variables. It is important to note that nonmechanistic models (e.g., linear regression models) do not require the development and use of SI curves. Regardless of the type of HSI model used, the model simply provides a measure of habitat suitability for a HEP analysis.

HSI's range from 0 to 1, with unity representing the most favorable habitat condition possible at a site. The selection of the specific type of model for a site application depends on analysis objectives, the availability of data, funding and time constraints, and availability of models for an application species. HSI models published by the FWS (Schamberger et al. 1982) should be evaluated by users to determine if they meet site-specific requirements. If the requirements are not met, the models can be modified or the user can develop new models for application. This flexibility is necessary because the user, not the developer of the HSI model, is responsible for defending information derived from a HEP application. Guidance for developing HEP models is presented in Standards for the Development of Habitat Suitability Index Models (U.S. Fish and Wildlife Service 1981a).

$$\text{Food } (C_F) = \left[V_1 \times \frac{(V_3 + V_4)}{2} \right]^{1/2}$$

$$\text{Cover } (C_C) = \left[V_1 \times \frac{(V_3 + V_4)}{2} \times \frac{(V_{16} + V_{18})}{2} \right]^{1/3}$$

$$\text{Water Quality } (C_{WQ}) = \frac{2V_6 + V_7 + 2V_8 + V_{10} + V_{11}}{7} \qquad \text{if } V_{12} \text{ and } V_{13} = 1.0$$

or

$$= \frac{2V_6 + V_7 + 2V_8 + V_{10} + V_{11} + \frac{(V_{12} + V_{13})}{2}}{8} \qquad \text{if } V_{12} \text{ or } V_{13} < 1.0$$

(If V_6, V_8, or $V_{10} \leq 0.4$, C_{WQ} equals the lowest of the following: V_6, V_8, V_{10}, or output from the above equation.)

$$\text{Reproduction } (C_R) = (V_1 \times V_9 \times V_{15} \times V_{17} \times V_{20})^{1/5} \qquad \text{if } V_{14} = 1.0$$

or

$$= (V_1 \times V_9 \times V_{14} \times V_{15} \times V_{17} \times V_{20})^{1/6} \qquad \text{if } V_{14} < 1.0$$

$$\text{Other } (C_{OT}) = \frac{V_{19} + V_{21}}{2} \text{ or } V_{22}$$

$$\text{HSI} = (C_F \times C_C \times C_{WQ} \times C_R \times C_{OT})^{1/5}$$

(If C_{WQ} or $C_R \leq 0.4$, the HSI equals the lowest of the following: C_{WQ}, C_R, or output from the above equation.)

Figure 4. SI aggregation equations for the largemouth bass riverine HSI model (Stuber et al. 1982).

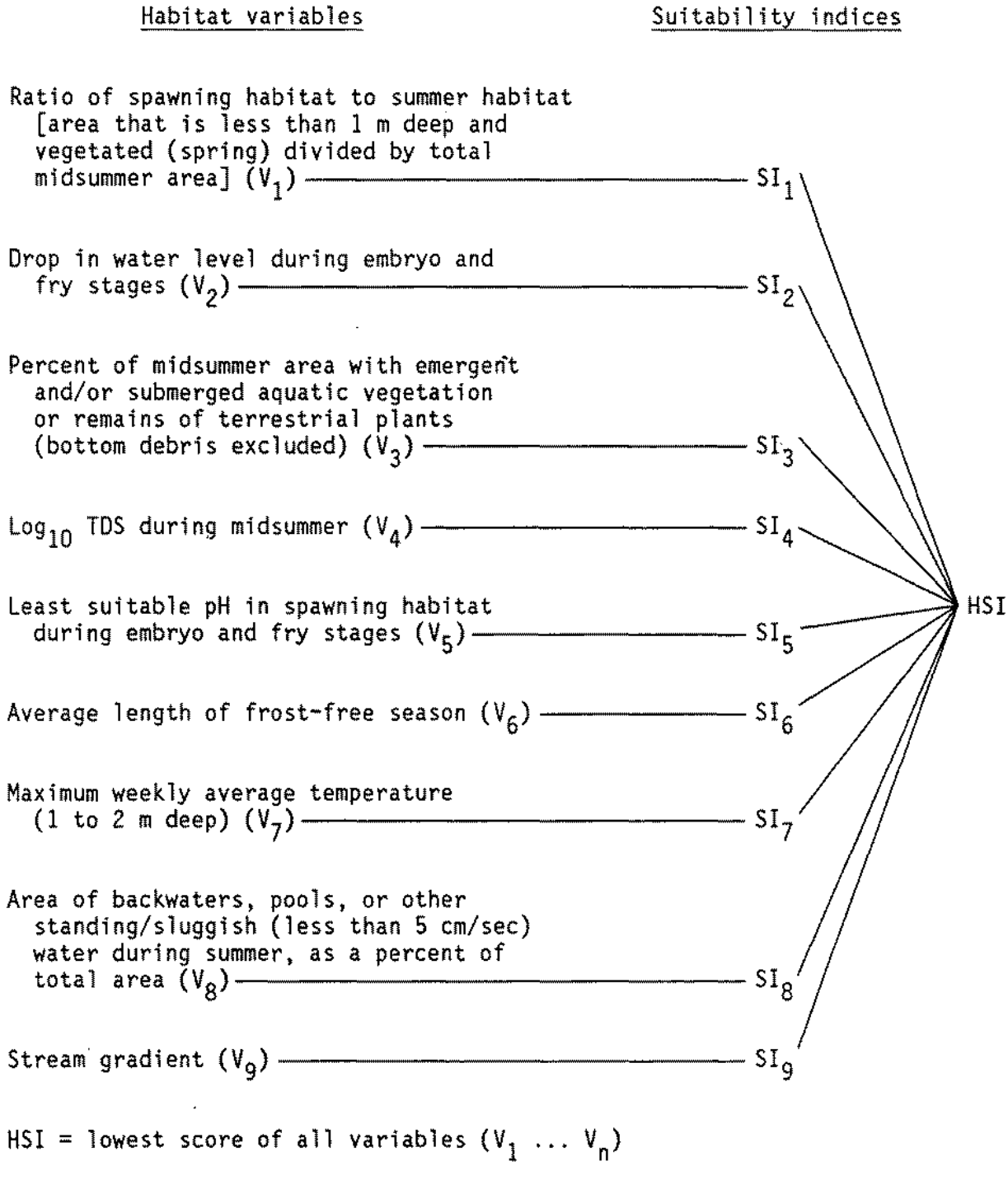


Figure 5. Tree diagram for the northern pike riverine model (Inskip 1982).

Step 3. Baseline assessment. The objective of this step is to quantify existing or baseline HU's within the study area for each evaluation species. HU's are derived by delineating the area of each habitat type for each evaluation species and then multiplying the area by its average HSI (HSI x area = HU). The number of HU's in the study area for an evaluation species is derived by summing the individual HU's for all habitat types and locations that provide habitat for the species or a particular life stage within the study site.

Step 4. Impact assessment. Target years are designated at specific points in time throughout the lifespan of the proposed project or study. A target year is defined as a specific year for which habitat conditions can be predicted and evaluated. Target years should be selected for points in time when the rates of loss or gain in HSI, or area of available habitat, are predicted to change. Target years are usually selected with help from specialists associated with the agency or developer proposing an action. The values for habitat variables for evaluation species must be predicted for each target year. Therefore, the planning agency must be able to predict habitat conditions for each alternative at each target year. HEP does not include any procedures for predicting future habitat conditions. The HSI model, regardless of the type, is used to calculate the HSI's and HU's for each species by target year based on each set of predicted conditions for the no action condition and each proposed alternative (Table 2).

Table 2. HU's for rainbow trout for a hypothetical site.

Target year	Proposed action implemented			No action alternative			Net change
	HSI	Hectares	HU's	HSI	Hectares	HU's	HU's
Baseline	0.75	1,000	750	0.75	1,000	750	0
1	0.70	500	350	0.75	1,000	750	-400
20	0.20	500	100	0.60	900	540	-440
100	0.20	500	100	0.60	600	360	-260

AAHU's for each action are calculated from HU's using formula 2 (U.S. Fish and Wildlife 1980b). The average annual net impact of the proposed action over the life of the project described in Table 2 would be -361 AAHU's. During the operation of the project, there would be an average annual loss of 361 HU's of trout habitat in this example.

Step 5. Mitigation. Because HEP can be used to quantify losses resulting from proposed alternatives, it can be used in mitigation studies. Habitat losses are determined and the areas designated for compensation are evaluated for various management alternatives to determine the habitat gains attributable to selected mitigation measures. Partial or full compensation or enhancement to fish and wildlife habitat can be quantified. The analyses can be for in-kind compensation (one HU is provided for each HU lost for an evaluation species), equal replacement (a gain of one HU for a species to offset the loss of one HU for another, equally important, species), and relative trade-off. The relative trade-off analysis involves using Relative Value Indices (RVI) that reflect human value judgements about the relative value of one species compared to another. For example, if trout have a perceived RVI of 1.0 and whitefish have an RVI of 0.5, one HU for trout would equal two HU's for whitefish. Mitigation recommendations made by the FWS should be consistent with the 1981 Mitigation Policy (U.S. Fish and Wildlife Service 1981b).

Step 6. Decision on course of action. After the HEP analysis is completed, information is prepared for evaluation and use by decisionmakers. If the user can convert the HEP output data (e.g., HU's or AAHU's) to an estimate of the fish population numbers that the habitat can support, then the HUEE procedures (U.S. Fish and Wildlife Service 1980c) can be used to estimate the economic consequences of land use options from a fish and wildlife resource use perspective.

INSTREAM FLOW INCREMENTAL METHODOLOGY (IFIM)

The IFIM is a technique designed to evaluate and integrate the dynamic nature of riverine habitat into water management practices. IFIM simulates hydraulic conditions of the microhabitat[1] in order to evaluate the effects of flow-induced changes on fish and invertebrate habitat. The standard microhabitat variables are velocity, depth, substrate, and cover. Velocity and depth are directly and instantaneously influenced by discharge, as is the biological utility of substrate and cover. Consideration of water quality is limited to the macrohabitat[2] variables affected by project-induced changes or the influx of waterborne substances for which effects can be controlled by

---

[1]Microhabitat is defined as the aggregate of the three dimensional distribution of the standard habitat variables within a habitat type, expressed in terms of the suitability for an evaluation species.

[2]Macrohabitat is defined as the aggregate of the average condition of important variables, such as channel morphology, water quality, temperature, and flow regime, within a habitat type, expressed in terms of the suitability for an evaluation species.

negotiating flows. IFIM simulates temperature and water quality conditions longitudinally (one dimension) down the stream environment. Products of the IFIM include variability of habitat over time displayed for each life stage of an evaluation species (i.e., Habitat Time series). Basic steps in an IFIM analysis include the following:

Step 1. Scoping. Scoping involves the: (1) definition of study objectives; (2) delineation of the study boundaries; (3) determination of the characteristics of the macrohabitat variables (watershed, channel morphology, water quality, temperature, and flow regime) for conditions with and without the proposed action; (4) the designation of the evaluation species; and (5) the definition of the life history, food sources, water quality tolerances, microhabitat (velocity, depth, substrate, and cover), and macrohabitat (temperature and dissolved oxygen) preferences of the evaluation species. It is recommended that microhabitat preferences (i.e., suitability index curves) be determined by obtaining measurements in the immediate vicinity of where individual fish are found. Current research results always should be evaluated by users to determine the merits of existing SI curves and whether or not new empirical data are needed for the species selected for evaluation. Guidance for developing preference curves is discussed in A Guide to Stream Habitat Analysis Using the Instream Flow Incremental Methodology (Bovee 1982:173-178).

Step 2. Study reach delineation and site selection. Study reach selection involves identifying on maps: (1) the points of major inflows (tributaries) and diversions; (2) the delineation of major changes and transition zones of relief, water quality, and distribution of the evaluation species; (3) the delineation of critical reaches to be sampled (those portions of a river with a unique habitat type that is absolutely essential for one or more life stages of a species and is absent or in very short supply throughout the rest of the project influence area); and (4) the delineation of randomly selected reaches to be sampled that represent larger segments of the river. Based on the mapped information and ground truthing, study sites are carefully selected within the study reaches to ensure that the characteristics of the study reaches can be extrapolated over the entire project area, allowing the spatial integration of habitat information over entire streams or networks of streams (Bovee 1982:38-55).

Step 3. Data collection. Within each study site, transects are selected to characterize the hydraulic and instream microhabitat conditions. Procedures are specified in IFIM documents for data collection, compilation, and reduction; these procedures must be compatible with the requirements for the IFIM computer models and analytical procedures. It is necessary to document the longitudinal and lateral distribution of microhabitat characteristics. This step also includes the establishment of water quality sampling networks and/or acquisition of water quality information, as appropriate, from Steps 1 and 2.

Step 4. Computer simulation. Processed field data are entered into the computer programs of PHABSIM in order to generate data that describes the reach as a series of small cells (Fig. 6). Velocity, depth, substrate, and cover are assumed to be homogenous within each cell at a specified flow. Computer models for predicting changes in water quality and temperature, as affected by flow and channel morphology changes, have been developed recently and linked with PHABSIM. A suitability index for velocity, depth, substrate, and cover in each cell is determined by the use of SI curves for each life stage. Note that SI curves for PHABSIM are restricted to a standard set of four variables. These data are combined through a user-selected aggregation technique to estimate the composite suitability for that combination of variables. The composite index is multiplied by the surface area of each cell to derive the WUA for each cell for each life stage for each flow. Computer simulations are produced for the distribution of microhabitat variables (velocity, depth, substrate, and cover) for selected unmeasured flow conditions, for existing, proposed, and alternative actions. WUA values, expressed in terms of 1,000 linear feet of stream, are calculated and plotted for each flow in order to obtain a flow/microhabitat function for each sampled reach (Fig. 7). Separate simulations for temperature and water quality are conducted for the same specified flows. The linear extent of acceptable water quality conditions (macrohabitat) in the stream segment is computed (Fig. 8) for each species at a user-determined time interval (i.e., monthly, seasonally, or yearly).

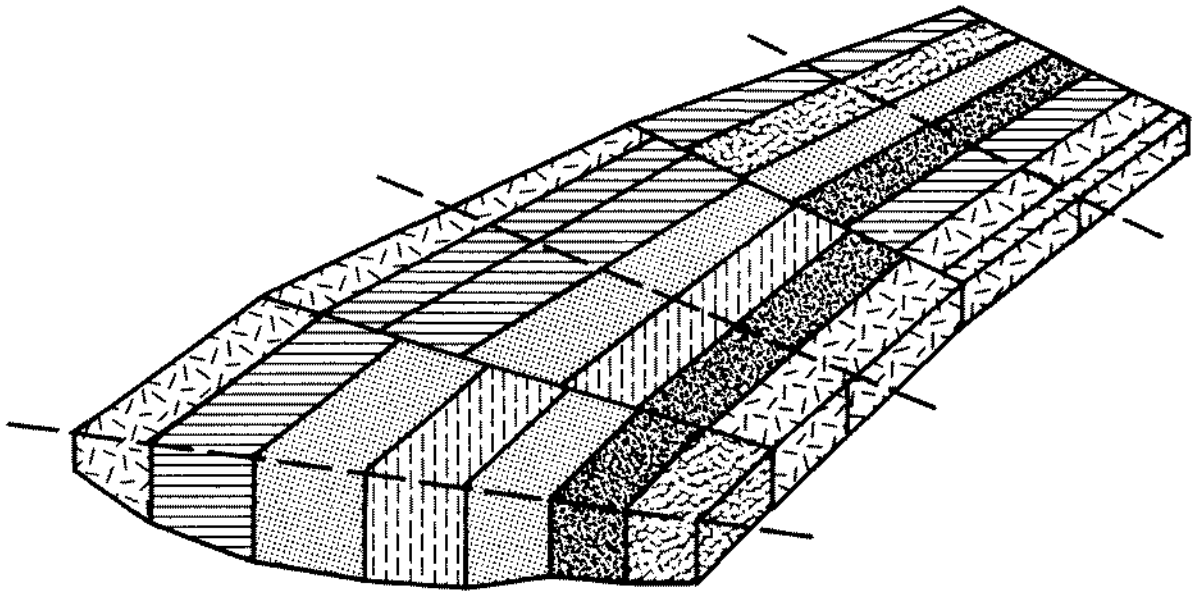


Figure 6. Conceptualization of stream reach microhabitat simulation. Subsection cells with identical shading patterns have similar velocity, depth, substrate, and cover ranges.

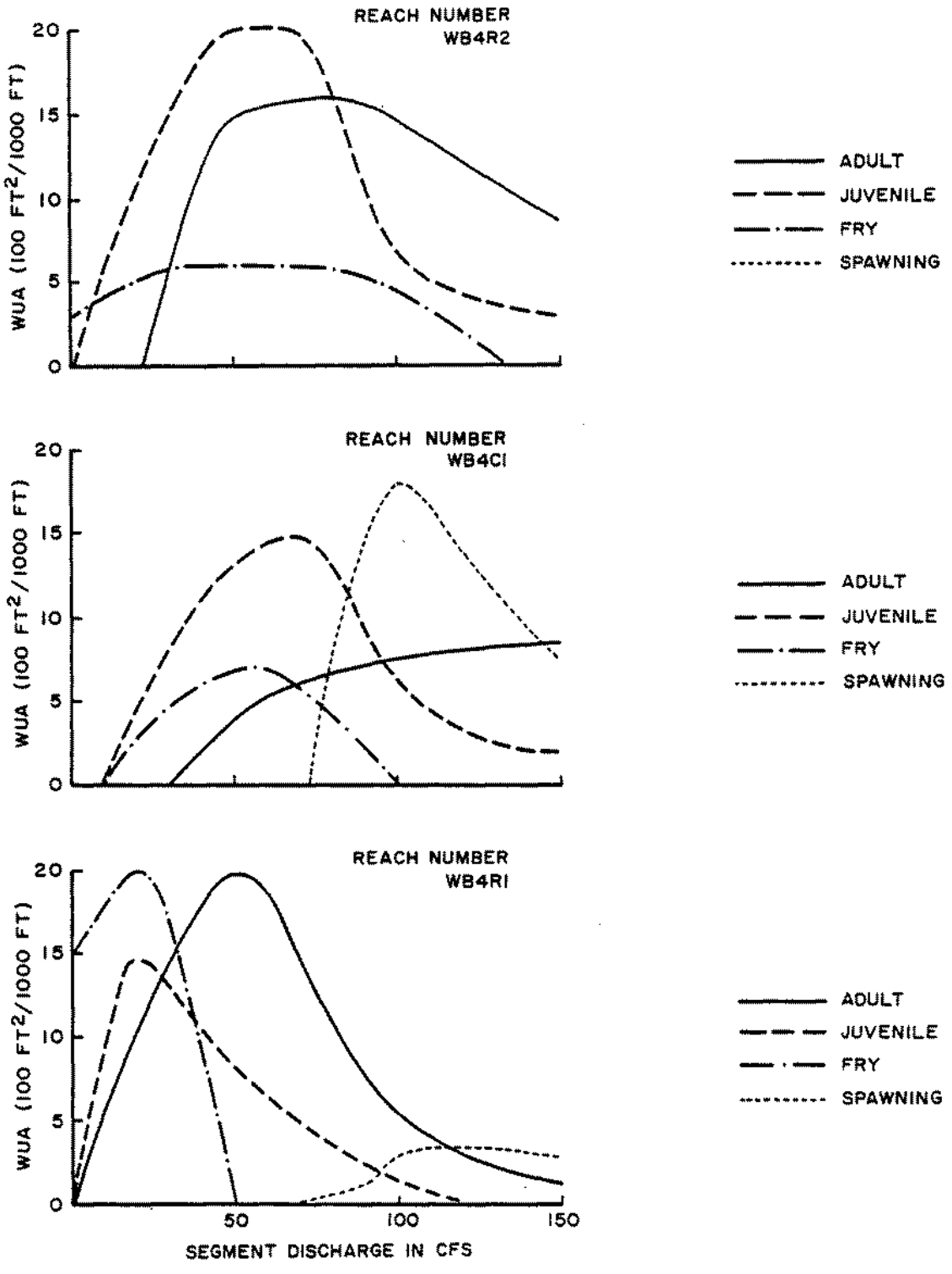


Figure 7. Weighted usable area for brown trout vs. discharge for three study reaches in a segment of a hypothetical river (Bovee 1982).

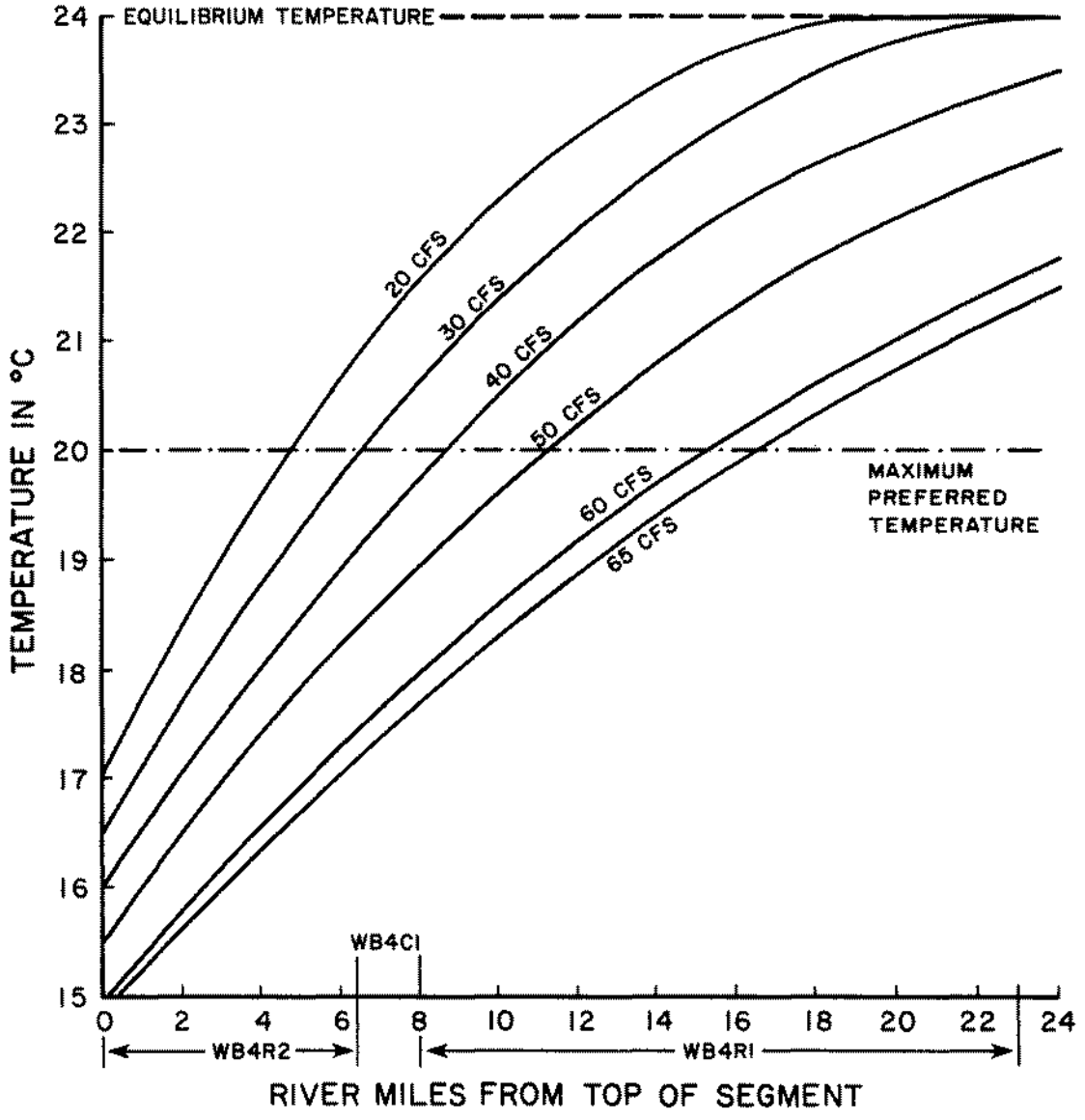


Figure 8. Usable length of stream for a particular species life stage (e.g., adult brown trout) for a specific time period (e.g., August) for the three study reaches in Fig. 7.

Step 5. Preparing and interpreting results. Total HA is a discrete value for each sampled stream segment for each life stage of a species for a specific flow. Total habitat is, therefore, a complete expression of the functional relationship between microhabitat availability (WUA), water quality, and streamflow (Fig. 9). Total habitat for a specified flow is the product of the unit WUA (ft^2/1,000 ft) times the length of stream (miles) having suitable water quality and temperature. There are numerous ways of displaying habitat values. The basic approach starts with summary tables and plots of WUA and HA against discharge. More sophisticated analyses also include longitudinal water quality profiles. Time series of flow WUA and HA values for baseline and alternative water management schemes can be used to formulate flow recommendations and mitigation plans. Data interpretation techniques include: (1) optimization to determine the combinations of flow conditions that will yield the best mix of benefits; (2) time-series analyses summarized into habitat duration curves that depict the frequency of occurrence of streamflow and habitat events; and (3) effective habitat time-series curves that display the amount of habitat potentially available throughout a given time period at designated flow regimes.

Step 6. Recommend a flow regime for the river reach. Based on a biologist's interpretation of the results, managers and decision-makers can negotiate for flow regimes suitable for the evaluation species of concern. Site specific habitat trade-offs for selected or all life stages of a species are feasible. Maintaining a desired level of stream channel habitat for a fish species requires the establishment of instream flow regimes for: (1) wet years for sediment and bed load transport; (2) average years to establish a base level of fish production; and (3) dry years to ensure minimum survival conditions for "seed" stock necessary for replenishing the stream reach. The development of a dynamic flow regime, rather than a single "minimum" flow, is the desired result of using IFIM. If the response of the fish population to changes in HA can be determined, HUEE can be used to determine the economic impacts in a similar manner to its use with HEP-generated data. The process for using IFIM data in a HUEE analysis involves conversion of WUA information to total Habitat Area (HA) values (Bovee 1982).

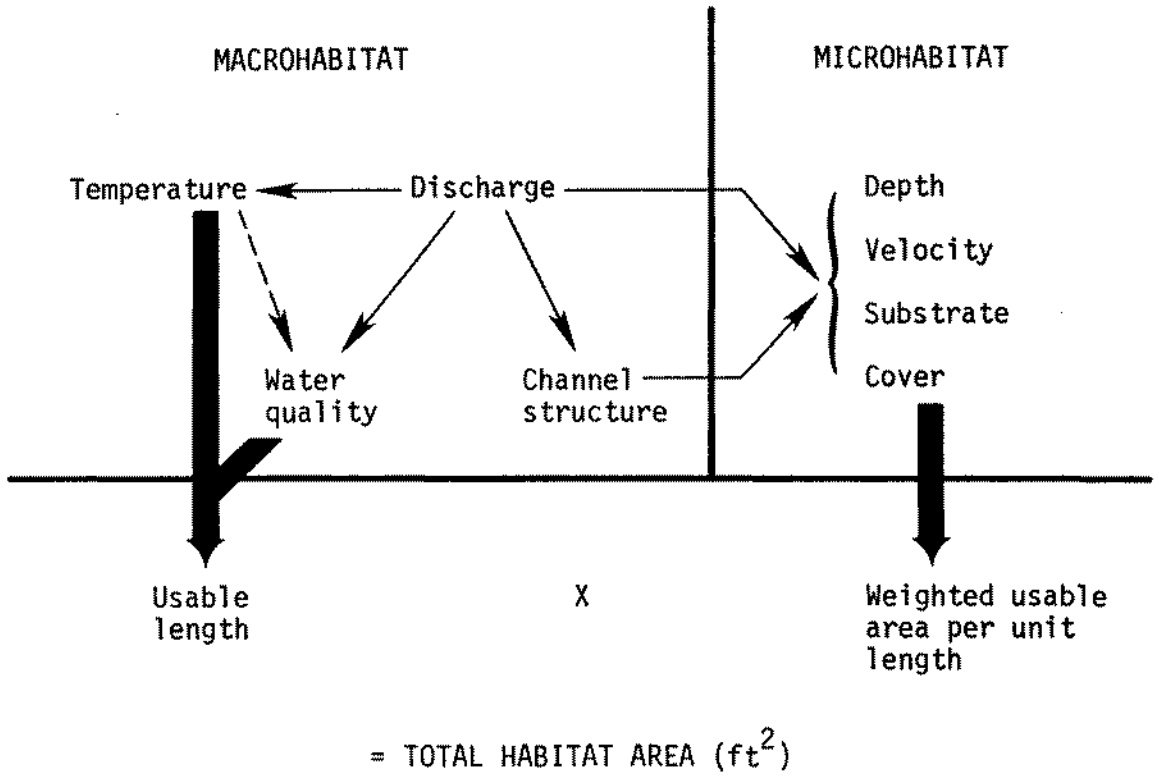


Figure 9. The IFIM computation of total habitat (ft^2) in a study area by multiplying the WUA derived for velocity, depth, substrate, and cover (microhabitat conditions) by the length of the area with suitable macrohabitat conditions for fish.

USES OF SI CURVES IN HEP AND IFIM AQUATIC APPLICATIONS

Confusion among users has resulted from the availability of two sets of SI curves, one for HEP and one for IFIM, for four variables (velocity, depth, substrate, and cover) for some fish species. The confusion has been compounded by the fact that the curves have been published in different formats with the use of different terminology. These problems resulted because of the independent evolution of IFIM and HEP over a 5-year period, 1977-1982. The current use of standard terminology and the correct matching of the method (HEP and/or IFIM) to the environmental problem under study should resolve the confusion.

When IFIM first became operational in 1978, the only "model" available to the user was the microhabitat descriptor (PHABSIM), which utilized SI curves for velocity, depth, substrate, and, to a limited extent, instream cover. The first group of curves compiled were published under the title of Probability-of-use curves (Bovee 1978). Suggested field procedures for gathering fish microhabitat utilization data and curve construction techniques specific to the use of PHABSIM were described by Bovee and Cochnauer (1977). The IFIM now makes use of both micro- and macrohabitat curves. Curve scores for the microhabitat variables for velocity, depth, substrate, and cover are aggregated in the computer program PHABSIM. The macrohabitat variables of temperature, dissolved oxygen and biological oxygen demand, nitrogen compounds, and other dissolved chemicals are aggregated in the program ISTEMP (Theurer and Voos 1982) and the water quality simulation model (Grenney and Kraszewski 1981) through the use of curves for the appropriate macrohabitat variable.

About the same time, the 1976 version of HEP was revised (U.S. Fish and Wildlife Service 1980b) to facilitate the use of HEP in aquatic systems. Some early HSI models were developed for HEP applications in aquatic habitats. These models contained several variables and included curves (suitability indices) for some of the same variables (i.e., velocity and depth) as those described in the early IFIM publications. The channel catfish HSI model, published in Standards for the Development of Habitat Suitability Index Models (U.S. Fish and Wildlife Service 1981a), contained an SI aggregation technique that used the geometric mean [$HSI = (SI_1 SI_2 SI_3 \ldots SI_n)^{1/n}$]. This aggregation technique was sometimes incorrectly construed as the "standard approach" for all aquatic HSI model applications, and the assumption was made that an "Aquatic HEP" technology was to be developed. However, "Aquatic HEP" was never developed as a separate tool and does not exist. The impossibility of developing a "standard HEP model" for each species became increasingly evident as more models were developed and alternative modeling approaches were devised. It is now recognized that a single, standard species HSI model for all HEP applications is unrealistic and that different "models" are needed for different application objectives and site-specific conditions.

Work continues on the development of fish HSI models for HEP applications in flowing and standing water. These models can be used with or without modification by the user, depending on site-specific conditions. When desirable, the user can take the curve information from existing HSI model publications and develop completely different models that are more appropriate to a specific application (U.S. Fish and Wildlife Service 1980b).

All species curves for HEP and IFIM are referred to collectively as suitability index (SI) curves or graphs. Terminology pertaining to SI curves has been standardized and four categories of curves have been designated for IFIM applications. The designation of a curve as belonging to a particular category does not imply that there are differences in the quality or accuracy of curves among the four categories.

The first category of curves is based on available information, including literature sources and expert opinion, usually concerning a species response to a variable (e.g., juveniles can survive within a temperature range of 4 to 24° C). These data are used to develop a curve that describes the SI relationships for temperature, depth, velocity, or substrate (e.g., temperatures of 3, 12, and 25° C might correspond to SI's of 0.0, 1.0, and 0.0, respectively).

The second category of curves (utilization curves) is based on frequency analyses of fish observations in the stream environment, with microhabitat variables measured at each sighting (Bovee and Cochnauer 1977; Bovee 1982). These curves are designated as utilization curves because they depict the habitat conditions a fish has been shown to use within a range of available conditions. Because of the way the data are collected for utilization curves, the resulting function represents the probability of occurrence of a particular environmental condition, given the presence of a fish of a particular species and size. However, because of sampling problems, a utilization curve cannot be assumed to reflect fish preferences or optimum conditions. These curves are generally more precise for the microhabitat variables used in IFIM applications than are the category one curves because they are based on specific measurements of the microhabitat characteristics where the fish are observed. However, this category of curves may not be transferable to streams that differ in size and habitat complexity or when there are differences in species interactions and the timing of life functions.

The third category (preference curves) contains utilization curves that have been corrected for environmental bias. For example, if 50% of the fish are found in pools over 1.0 m deep, but only 10% of the stream has these pools, the fish are actively selecting that type of habitat. The category three curves approximate the function of the probability of occurrence of a fish, given any set of environmental conditions. Only a limited number of experimental data sets have been compiled into IFIM preference curves.

Category four curves are mostly conceptual at this time. One type of category four curve that is under consideration is a cover-conditioned, or season-conditioned, preference curve set. Such a curve set would consist of

different velocity, depth, and substrate preference curves for different conditions or types of cover present or for different times of year. No category four curves have been developed for use with IFIM at this time.

To minimize confusion, all known information on SI curves for a given species should be incorporated into all future FWS publications on fish habitat produced by WELUT. The species habitat requirements, origin of the data, assumptions made in data interpretation, and suggestions for curve applications in either or both impact assessment methods should be included. SI curves for temperature and water quality variables can be used interchangeably with either HEP or IFIM, but modifications are usually required. SI curves for velocity, depth, substrate, and cover may not be interchangeable. Table 3 is a partial summary of SI information available as of May 1984. Such information will aid users in deciding which HSI models, SI curves, and assumptions are most appropriate for specific applications of either HEP or IFIM.

In general, category one SI curves are most useful in HSI models, as used in HEP analyses, and IFIM analyses of temperature and water quality. If category one curves are the only curves available for velocity, depth, substrate, and cover, and aquatic biologists determine that they are acceptable surrogates for microhabitat descriptors, these curves can be used in IFIM analyses. However, utilization and preference curves give more precise results in IFIM analyses. When existing information is not suitable for curve development and new research is required, the development of preference and conditional preference curves is the recommended approach for IFIM.

Table 3. A partial listing of the availability of habitat suitability curves.

Species	Spawning VDSCT	Egg incubation VDSCT	Fry VDSCT	Juvenile VDSCT	Adult VDSCT	Habitat suitability information published	Publication planned for FY84
Bass, Largemouth	211X1	101X1	11211	22211	22211	*,A	
Bass, Rock	000X0	000X0	33330	33330	33330		
Bass, Smallmouth	11101	11101	11111	11101	11111	*,A	
Bass, Spotted	11101	11101	11111	11111	11111		*
Bass, Striped	11XX1	11XX1	111X1	XXXXX	11XX1		*
Bass, White	111X1	000X0	222X1	222X1	112X1		*
Bluegill	211X1	101X1	22201	22211	22211	*,A	
Buffalo, Bigmouth	00100	00101	00010	00010	10011	*	
Buffalo, Smallmouth	001X0	101X1	10011	10011	10001	*	
Bullhead, Black	00111	00111	00011	10011	10011	*	
Carp, Common	22211	00011	22211	22211	22211	*,A	
Catfish, Channel	22211	00011	21111	22211	21111	*,A	
Chub, Creek	101X0	101X1	10001	11111	11111	*	
Crappie, Black	21111	00011	11111	22211	22211	*,A	
Crappie, White	21211	00011	21211	12211	22111	*,A	
Dace, Blacknose	111X1	111X1	10111	10111	10111	*	
Dace, Longnose	111X0	111X1	11101	11111	11111	*,A	
Darter, Blackside	11101	00000	00000	00000	11100		
Darter, Channel	11101	00000	00000	00000	11100		
Darter, Fantail	11101	00000	00000	00000	11100		
Darter, Greenside	11101	00000	11101	11101	11101		
Darter, Johnny	00000	00000	00000	00000	22200		
Darter, Orangebelly	12100	00000	00000	00000	12200		
Darter, Orangethroat	11100	00000	00000	00000	22201		
Darter, Rainbow	11100	00000	00000	12101	12100		

V - Velocity
D - Depth
S - Substrate
C - Cover
T - Temperature
0 - No SI curve available
X - No SI curve necessary
1 - Category one (literature-based) SI curve available
2 - Category two (utilization) SI curve available
3 - Category three (preference) SI curve available

A - Some of the available curves are not included in the publication
B - More recent habitat information has become available since publication
* - Means either published and/or publication planned for FY84

SUMMARY

Project scoping is necessary to determine if HEP, IFIM, or a combination of the two methods is appropriate. Scoping by an interdisciplinary, interagency group will help ensure that information resulting from the analysis will be beneficial to decisionmakers and planners and that resources available for data gathering and analyses will be used effectively. Technical assistance with scoping and other activities related to HEP and IFIM applications is available from WELUT and the appropriate FWS Regional Office.

HEP and IFIM are two methods developed at WELUT for use in evaluating the impacts of environmental changes on fish habitat. HEP is designed for general application to habitat assessment problems in flowing and standing water. IFIM is a specialized tool for evaluating the impacts of altered flows, changes in channel morphology, and accompanying water quality changes. IFIM is especially useful in the designation of flows designed to meet fish management objectives and in the negotiation of flow regimes to protect fish habitat.

Habitat Units are the basic output from a HEP analysis. These units are computed by multiplying the area of habitat by the HSI, which is an index of habitat quality. An HSI is obtained by applying an HSI model. These models can be in several forms, including equations for standing crop and harvest, mathematical and nonmathematical mechanistic models that involve aggregations of variables that affect life requisites, pattern recognition models, and descriptive word models.

Mechanistic HSI models that contain components for life requisites require the development and use of SI curves for each variable in the model. These curves, in combination with field data, are used to derive site specific SI's. A standard set of variables does not exist for all models because application objectives vary.

WUA's and HA's are the basic products of an IFIM analysis. These units are computed using SI curves developed for both the macro- and micro- habitat suitability for each species. The PHABSIM model requires use of curves for four standard microhabitat variables (velocity, depth, substrate, and cover) for computation of WUA. WUA units are developed for each life stage to represent the amount of habitat available during a given time period for a specified flow regime. Temperature and water quality curves are used to combine water quality and PHABSIM model output into total usable HA.

Habitat unit (HEP) and habitat area (IFIM) data can be developed for existing, proposed, and alternative action conditions to provide comparative information for decisionmakers and planners and to develop mitigation plans.

Most of the available SI curves for both methods were developed from published information and professional opinion. For IFIM, a set of curves for standard microhabitat variables (velocity, depth, substrate, and cover) is applied. Mechanistic models developed for HEP applications can require the use of SI curves for the same four variables as IFIM applications, plus additional variables. Nonmechanistic models for HEP do not require the use of SI curves. Where curve development is needed for an IFIM application, utilization and preference SI curves should be developed through field sampling because these curves are considered more precise. The direct interchange of curves specifically developed for either method is possible but modifications are usually necessary. Future HSI publications will contain SI curves for use with both methods. The origin and applicability of the data to specific study objectives are the most important factors to consider in curve selection, rather than the method for which the curve was originally developed.

Although HEP can be used to analyze the impacts of different water development activities at a stream site, IFIM should be the preferred procedure when streamflow recommendations are the study objective.

It may be feasible and appropriate to use both methods on the same study area; e.g., when there will be a conversion of some free flowing conditions to standing water conditions and the remaining free-flowing reaches will have altered flow regimes. For this type of application, HEP can be applied in reaches that will be impounded and IFIM can be applied to reaches where flows and/or the shape of the channel is negotiable. In other cases, it may be advisable to use HEP early in the project site selection process or when a large number of alternative sites are proposed; then use IFIM on the sites selected for detailed study.

REFERENCES

Bovee, K. D. 1978. Probability-of-use criteria for the family Salmonidae. Instream Flow Information Paper 4. U.S. Fish Wildl. Serv. FWS/OBS-78/07. 80 pp.

Bovee, K. D. 1982. A guide to stream habitat analysis using the instream flow incremental methodology. Instream Flow Information Paper 12. U.S. Fish Wildl. Serv. FWS/OBS-82/26. 248 pp.

Bovee, K. D., and T. Cochnauer. 1977. Development and evaluation of weighted criteria probability-of-use curves for instream flow assessment: fisheries. Instream Flow Information Paper 3. U.S. Fish Wildl. Serv. FWS/OBS-77/63. 39 pp.

Grenney, W. J., and A. K. Kraszewski. 1981. Description and application of the stream simulation and assessment mode: Version IV (SSAM IV). Instream Flow Information Paper 17. U.S. Fish Wildl. Serv. FWS/OBS-81/46. 199 pp.

Inskip, P. D. 1982. Habitat suitability index models: Northern pike. U.S. Fish Wildl. Serv. FWS/OBS-82/10.17. 40 pp.

Milhous, R. T., D. L. Wegner, and T. Waddle. 1981. User's guide to the Physical Habitat Simulation System. Instream Flow Information Paper 11. U.S. Fish Wildl. Serv. FWS/OBS-81/43. 254 pp.

Schamberger, M., A. H. Farmer, and J. W. Terrell. 1982 Habitat Suitability Index models: Introduction. U.S. Fish Wildl. Serv. FWS/OBS-82/10. 2 pp.

Stuber, R. J., G. Gebhart, and O. E. Maughan. 1982. Habitat Suitability Index models: Largemouth bass. U.S. Fish Wildl. Serv. FWS/OBS-82/10.16. 32 pp.

Theurer, F. D., and K. A. Voos. 1982. IFG's instream water temperature model validation. Pages 513-518 in F. Kilpatrick and D. Matchett (eds.). Proceedings of the conference on water and energy technical and policy issues. Am. Soc. Civil Eng.

U.S. Fish and Wildlife Service. 1980a. Habitat as a basis for environmental assessment. ESM 101. U.S. Fish Wildl. Serv., Div. Ecol. Serv., Washington, DC. n.p.

U.S. Fish and Wildlife Service. 1980b. Habitat Evaluation Procedures (HEP). ESM 102. U.S. Fish Wildl. Serv., Div. Ecol. Serv., Washington, DC. n.p.

U.S. Fish and Wildlife Service. 1980c. Human Use and Economic Evaluation (HUEE). ESM 104. U.S. Fish Wildl. Serv., Div. Ecol. Serv., Washington, DC. n.p.

U.S. Fish and Wildlife Service. 1981a. Standards for the development of Habitat Suitability Index models. ESM 103. U.S. Fish Wildl. Serv., Div. Ecol. Serv., Washington, DC. n.p.

U.S. Fish and Wildlife Service. 1981b. U.S. Fish and Wildlife Service mitigation policy. Federal Register 46(15):7644-7663.

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. FWS/OBS-84/11	2.	3. Recipient's Accession No.

4. Title and Subtitle
Comparison of the use of the Habitat Evaluation Procedures (HEP) and the Instream Flow Incremental Methodology (IFIM) in aquatic analyses

5. Report Date May 1984

6.

7. Author(s)
Carl L. Armour, Richard J. Fisher, and James W. Terrell

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
Western Energy and Land Use Team
U.S. Fish and Wildlife Service
Drake Creekside One Building
2627 Redwing Road
Fort Collins, CO 80526-2899

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C)
(G)

12. Sponsoring Organization Name and Address
Western Energy and Land Use Team
Division of Biological Services
Research and Development
Fish and Wildlife Service
U.S. Department of the Interior
Washington, DC 20240

13. Type of Report & Period Covered

14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

The Habitat Evaluation Procedures (HEP) are designed for quantifying habitat values and documenting impacts of habitat changes on fish and wildlife resources in both aquatic and terrestrial ecosystems. The Instream Flow Incremental Methodology (IFIM) is specifically designed for simulating and quantifying impacts of changes in flow, channel morphology, or water quality on fish, invertebrates, and instream recreational activities. This paper contains information on the: (1) differentiating features and recommended uses of the two methods for environmental assessment; and (2) development and use of Suitability Index (SI) curves. The discussion is limited to consideration of the affects of habitat alterations on fish habitat.

17. Document Analysis a. Descriptors

Fishes
Water resources
Habitability

b. Identifiers/Open-Ended Terms

Habitat Suitability Index
Instream Flow Incremental Methodology

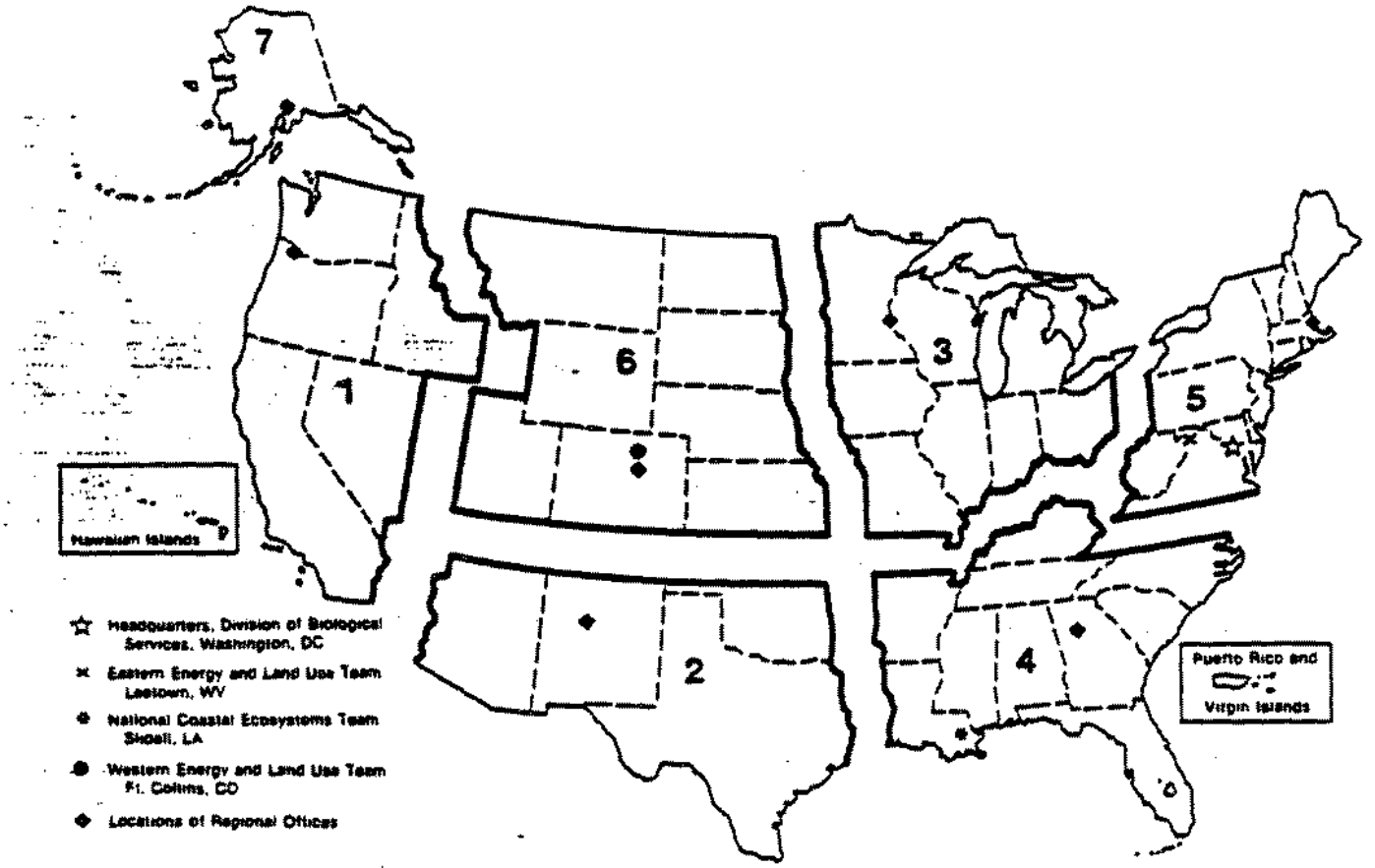
Environmental assessment

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
Release unlimited	Unclassified	30
	20. Security Class (This Page) Unclassified	22. Price

(See ANSI-Z39.18) See Instructions on Reverse OPTIONAL FORM 272 (4-77) (Formerly NTIS-35) Department of Commerce

☆ U.S. GOVERNMENT PRINTING OFFICE:1988-575-516/85150



REGION 1
Regional Director
U.S. Fish and Wildlife Service
Lloyd Five Hundred Building, Suite 1692
500 N.E. Multnomah Street
Portland, Oregon 97232

REGION 2
Regional Director
U.S. Fish and Wildlife Service
P.O. Box 1306
Albuquerque, New Mexico 87103

REGION 3
Regional Director
U.S. Fish and Wildlife Service
Federal Building, Fort Snelling
Twin Cities, Minnesota 55111

REGION 4
Regional Director
U.S. Fish and Wildlife Service
Richard B. Russell Building
75 Spring Street, S.W.
Atlanta, Georgia 30303

REGION 5
Regional Director
U.S. Fish and Wildlife Service
One Gateway Center
Newton Corner, Massachusetts 02158

REGION 6
Regional Director
U.S. Fish and Wildlife Service
P.O. Box 25486
Denver Federal Center
Denver, Colorado 80225

REGION 7
Regional Director
U.S. Fish and Wildlife Service
1011 E. Tudor Road
Anchorage, Alaska 99503

DEPARTMENT OF THE INTERIOR
U.S. FISH AND WILDLIFE SERVICE

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.