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Status of the Habitat Evaluation Procedures

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Introduction

The 1970s was a decade of increased awareness of environmental problems, and emphasis was placed on the development of procedures for predicting impacts of proposed developmental activities on natural systems. Impact assessment has evolved from a focus on species numbers, human use, species richness, and related methods to include the investigation of habitat as a supplemental or alternative approach to environmental planning, mitigation, species management, and impact assessment (Schamberger 1979, U.S. Fish and Wildlife Service 1980a, 1980b). The impetus for habitat-based assessment techniques came primarily from two sources: (1) environmental legislation requiring noneconomic project evaluations; and (2) an awareness within the scientific community that traditional methods of inventory and analysis were inadequate for land and water planning purposes. Baseline studies of the early 1970s typically resorted to inventories of existing plant and animal species. Such inventories were time consuming, documented only existing conditions, and did not provide a framework appropriate for predicting and evaluating future conditions. In addition, Federal land management agencies generally focus on habitat, not species, management (e.g., Crawford and Lewis 1978). Thus, a documented need exists for a habitat approach to impact assessment. The U.S. Fish and Wildlife Service (FWS), in cooperation with the U.S. Soil Conservation Service (SCS), U.S. Army Corps of Engineers (COE), U.S. Bureau of Reclamation (BR), and State and private organizations developed a standardized, habitat-based evaluation technique to meet this need.

The development and implementation of a standardized habitat evaluation system serves two major purposes. First, a standardized system improves communication within and among organizations and professions. Biologists often are at a disadvantage in resource planning because, when compared to engineering and economics, established and reliable fish and wildlife evaluation methods are generally unavailable. The use of an evaluation method that focuses on habitat can lead to effective communication and, therefore, promote better fish and wildlife management. Secondly, a standardized method provides a framework around which species-habitat research can be focused. Other impact evaluation approaches for fish and wildlife resources also may be necessary in order to accommodate diverse needs of assessment and management. However, given present budget and personnel constraints throughout government, it is particularly important that the fish and wildlife profession focus, not disperse, their limited resources. A standard methodology helps provide this focus.

Historical Background

A task force of Federal, State, and private conservation group representatives prepared a report (White 1971) that gave early impetus for developing habitat-based evaluation procedures. This report contained a number of suggestions for improving the consideration of fish and wildlife resources in Federal projects, including the recommendation that the FWS begin development of a nonmonetary evaluation procedure for use in project planning. A number of available systems were evaluated, and a system published by Daniel and Lamaire (1974) was selected for further consideration and development. The *Ecological Planning and Evaluation Procedures* (Joint Federal-State-Private Conservation Organization Committee 1974) was developed and later revised and published as the *Habitat Evaluation Procedures: For Use by the Division of Ecological Services in Evaluating Water and Related Land Resource Development Projects* (U.S. Fish and Wildlife Service 1976). The Habitat Evaluation Procedures (HEP) were applied to numerous occasions, during which time conceptual and practical weaknesses were identified. Between 1977 and 1980, several approaches to improve the concept of habitat evaluations were identified and investigated (Schamberger and Farmer 1978).

HEP was revised in 1980 and published as three components within the FWS' Division of Ecological Services (ES) operational manual series: (1) an accounting procedure to handle habitat quality and quantity data (U.S. Fish and Wildlife Service 1980b); (2) a method to determine habitat quality by developing models to obtain a Habitat Suitability Index (U.S. Fish and Wildlife Service 1981); and (3) a method to convert habitat data into dollar values (U.S. Fish and Wildlife Service 1980c). The FWS is implementing HEP and will continue testing the concepts and practicality of HEP-80.

Some of the improvements incorporated in HEP-80 included the use of documented habitat models, an alteration of the basic accounting system so that species were followed throughout the evaluation, and the development of software for automated data processing.

HEP is receiving nationwide application in both the public and private sectors. Several conceptual papers have proposed the use of HEP for wetland evaluations (Schamberger et al. 1979, Short and Schamberger 1979a, 1979b, Schamberger and Kumpf 1980). A recent FWS survey indicated that HEP was the most widely used evaluation technique by ES, with 112 applications in 1981 (Hardy 1981).

HEP Accounting System

HEP is based on combining a measure of habitat quantity with an index of habitat quality to determine habitat values (U.S. Fish and Wildlife Service 1980b). The relationship:

$$\text{Habitat area} \times \text{Habitat quality (HSI)} = \text{Habitat units (HUs)},$$

provides the basic framework by which habitats are inventoried and analyzed for the species or guilds of interest. The habitat quality measure (HSI) can be determined by a number of methods, as long as the method is documented and includes quantification of the evaluation criteria. The HSI is defined as a value between 0.0 and 1.0, with 1.0 representing maximum habitat quality in a defined area, assumed

to be positively correlated to carrying capacity (U.S. Fish and Wildlife Service 1981).

HEP provides data that can be used in baseline and impact assessments, planning, management, mitigation, or other actions that anticipate a change in either habitat quantity or quality, or both (Farmer 1979, Short and Schamberger 1979a). In baseline studies, different areas are compared at one point in time. For impact assessments, areas are compared at different points in time or under alternative management or development options to determine anticipated changes in available HUs.

Data generated from the HEP process provide information concerning: (1) the amount of habitat involved in the proposed action; (2) the quality of that area as habitat for species or species groups of concern; and (3) an index value derived from combining quality and quantity (HUs). Table 1 presents baseline data for four sites. Sites 1 and 3 contain habitat of the highest relative quality, and sites 2 and 4 have the lowest habitat quality. A decision might be made, on the basis of this information, to select sites 2 or 4 for economic development because they have the lowest habitat value for wildlife. The data can be used for different purposes depending on the study objectives (i.e., either to prevent the loss of valuable wildlife habitat or to select areas with the greatest management potential as wildlife habitat). It is important to note that HU data are generated for each species, life requisite, life stage, or guild used in the evaluation. It is extremely important that the objectives of the study be clearly stated and the evaluation species carefully selected.

In impact assessments, several potential management actions or perturbations may be anticipated for the same area, and the probable changes in both area and habitat quality must be predicted. Although it is difficult to predict future conditions, this is a requirement in all impact assessment studies and is not a HEP-specific problem. Data generated from these predictions can be used in decision making to determine which alternative best meets the stated objectives of a given project or management plan. In Table 2, Alternative C is a development action that would result in no suitable pine marten habitat. Alternative B is a development plan that includes some habitat management to compensate for adverse impacts; Alternative A is essentially a habitat management plan for the same area. In an actual project, the same types of data would be displayed for a number of species and/or alternative sites, providing an array of planning data.

The basic HEP accounting system is a straightforward combination of habitat quality and quantity data that has numerous applications. The accounting portion

Table 1. The use of HEP habitat unit data in baseline assessment (hypothetical data).

Study site	Area/acres	HSI	HU
1	1,000	1.0	1,000
2	1,000	0.2	200
3	10,000	0.9	9,000
4	10,000	0.4	4,000

Table 2. The use of HEP habitat unit data for impact assessment (hypothetical data for the pine marten).

Study site 4	Area/acres	HSI	HU
Baseline	10,000	0.4	4,000
Alternative A	10,000	0.8	8,000
Alternative B	1,000	0.2	200
Alternative C	1,000	0.0	0

of HEP is computerized, and the use of the software aids in the calculation of HU data, relative importance values, and trade off analyses.

Habitat Suitability Index Models

HEP-76 called for the subjective estimation of habitat suitability for selected species. These values were averaged and a single value for each cover type used for the rest of the assessment. In contrast, HEP-80 provides for the tracking of individual species, life stages, life requisites, or guilds throughout the evaluation and promotes the use of models for determining habitat quality. Results of studies at the University of Missouri indicated that the most repeatable methods for evaluating habitats are those that measure environmental variables rather than those that subjectively estimate habitat quality (Ellis et al. 1978, 1979). The models currently being developed by the FWS are called Habitat Suitability Index (HSI) models and focus on the measurement of physical and chemical habitat variables. HSI models include: information on habitat use; literature reviews; a model structure; and documentation of model assumptions, application, and related information. They usually do not include variables such as competition, disease, or environmental contaminants, although these variables can be included when appropriate.

The measurement of habitat quality is recognized as a difficult task and as having major importance to the reliability of HEP and other fish and wildlife assessment methods (Adams 1980, New England Research, Inc. 1980). The relative importance of biological versus physical factors in determining the carrying capacity of a habitat requires further study. Although the technical literature contains descriptive information on many species, few studies provide quantitative information on relationships between habitat variables (e.g., canopy cover, ground cover, size of trees, or distance to water) and animal numbers. It is difficult to derive a relationship that quantitatively predicts what will happen, for example, to gray squirrel populations when 50 percent of the mast trees are removed from a given forest. To partially overcome this problem, standards for modeling species-habitat relationships have been established (U.S. Fish and Wildlife Service 1981), and models are being developed using these standards. We are in the process of field testing several models with the COE and other agencies.

The use of quantitative habitat models that require the measurement of environmental variables places an additional burden on field biologists. Sampling design, especially in terms of the accuracy and precision of sampling procedures, must be

carefully evaluated. An inventory techniques manual is available that provides guidance to field biologists in selection of measurement techniques for terrestrial habitat variables (Hays et al. 1981).

The marten (*Martes americana*) will be used to demonstrate habitat model applications to management. The species-habitat relationships for the marten were developed through literature surveys and reviews by experts. For the complete model, including references and documentation, see Allen (1982).

Hypothetical data were selected for the environmental variables used to calculate habitat suitability for the marten (Table 3). These hypothetical field measurements were plotted against the standards of comparison in Figure 1 to obtain the suitability index for each model variable. Index values were aggregated using the equation $(V_1 \times V_2 \times V_3 \times V_4)^{1/2}$ to obtain the estimates of habitat suitability (HSI) displayed in Table 3. An analysis of the suitability indices for the model variables can assist the manager in locating habitat factors that are limiting. Management or mitigative measures designed to maintain or improve habitat should focus on the most limiting habitat factors, assuming that all habitat variables are equally manageable.

Approximately 15 terrestrial, 15 inland aquatic, and 5 estuarine HSI models are scheduled for publication in 1982. These models are being developed by the Western Energy and Land Use Team and National Coastal Ecosystems Team of the FWS' Office of Biological Services. In addition to the mechanistic models, a variety of other species-habitat models can be used in HEP by following the guidelines for conversion in ESM 103 (U.S. Fish and Wildlife Service 1981).

Human Use and Economic Evaluations

Sometimes it is desirable to convert habitat data into data useful for economic analyses. This can be accomplished by the Human Use and Economic Evaluation (HUEE) procedures (U.S. Fish and Wildlife Service 1980c). HUEE can be used to convert fish and wildlife resource data to the dollar value of human use (both consumptive and nonconsumptive). Basically, this procedure utilizes biological supply as the limiting factor in the economic analysis. HUs are converted to estimates of animal populations, from which sustainable use is predicted. Changes in HUs will be reflected in the animal population that can be supported by the habitat, and changes in animal populations are directly related to changes in sustainable use. HUEE analyses can provide supplemental information for cost-benefit studies that address changes in the availability of wildlife for human use.

Implementation

Training

The success of any new technology depends on user understanding and acceptance. A nationwide training program was initiated to introduce users to the concepts of habitat evaluation techniques and to provide general information about the actual steps of a HEP evaluation. A one-week course has been offered at over 25 locations in the United States, and over 1,300 persons have received training in the use of HEP. Participants in the training courses have included representa-

Variable

(V_1) % tree canopy closure

(V_2) % of overstory canopy closure comprised of fir or spruce

(V_3) Successional stage of stand
A) shrub-seedling
B) pole sapling
C) young
D) mature or old growth

(V_4) % of ground surface covered by downfall which is ≥ 7.6 cm (3 in.) in diameter

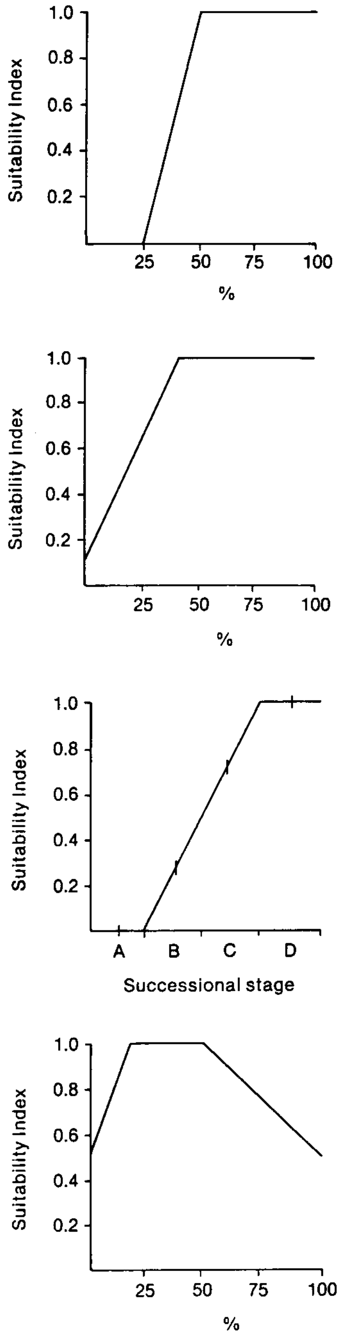

Figure 1. Suitability Index graphs for winter cover for the pine marten.

Table 3. Baseline and impact assessments using HEP-80 on hypothetical marten data.

	Variable	Field measurement	Suitability index value[a]	Habitat suitability index[b]	Area (acres)	Habitat units
Baseline	(V_1) Percentage tree canopy closure	85%	1.0	1.0	2,000	2,000
	(V_2) Percentage of overstory canopy comprised of fir or spruce	60%	1.0			
	(V_3) Successional stage of stand	old growth	1.0			
	(V_4) Percentage of ground surface covered by downfall	20%	1.0			
Alternative A	(V_1) Percentage tree canopy closure	30%	0.1	0.1	2,000	200
	(V_2) Percentage of overstory canopy comprised of fir or spruce	10%	0.3			
	(V_3) Successional stage of stand	pole/ sapling	0.3			
	(V_4) Percentage of ground surface covered by downfall	40%	1.0			

[a]From Suitability Index, Figure 1.
[b]Derived by use of Suitability Index Values and the model: HSI = $(V_1 + V_2 + V_3 + V_4)^{1/2}$.

tives from the COE, SCS, U.S. Bureau of Land Management, U.S. Forest Service, other Federal natural resource agencies, Federal and State departments of transportation, over 40 State fish and game agencies, private consultants, universities, and several foreign governments. Training also is available on the use of HEP software, site specific development and application of HSI models, and economic concepts as they relate to habitat.

Demonstration Projects

The FWS entered into a joint testing program with the COE and SCS to evaluate the institutional effectiveness and technical credibility of HEP-80. Four projects were selected by the COE and three by the SCS for initial evaluation. Although the final evaluation is not completed, the overall concensus to date is that HEP does supply useful and reasonable planning information. Strong points of HEP include: (1) HEP is a habitat based system; (2) the use of documented HSI models provides a record of the evaluation and a sound basis for recommendations; and (3) the use of documented models provides assistance in identifying limiting factors, thus providing a good diagnostic tool for management and impact assessment.

Certain weaknesses in HEP-80 also are being identified by the demonstration projects. The use of mechanistic models requires numerous measurements and mathematical calculations, and HSI models must be solved many times in a single study. Software is being developed to expedite computations, although early studies did not have access to computer software. The lack of adequate data in the literature for developing habitat models is a basic problem that will continue to plague habitat evaluation systems for years to come. However, the proper use of the literature and input from species experts, combined by standardized modelling techniques, have led to the development of models that users find reasonable and helpful.

Efficient Use of HEP

It is recognized that many environmental assessments do not require a detailed study, and portions of the HEP system can effectively be adapted and used for special purposes. Although detailed guidance cannot be provided in this paper, there are several adaptations that can simplify the application, thus reducing the time and costs of using HEP.

1. *Proper Setting of Study Objectives:* The appropriate definition of study objectives can greatly narrow data requirements. For example, if decision makers are concerned about only one or two featured species, there would be little need to evaluate the entire faunal community.
2. *Cover Type Selection:* Costs will decrease if only those cover types or habitats that are critical to important species or guilds (i.e., related to the managers' concerns and objectives) are evaluated. If some cover types are not significant, or comprise only a very small portion of the impacted area, they may not need to be considered in a small study.
3. *Species Selection:* If the impact will be on selected habitats, include only species or guilds that are important components of those cover types. Multicover type species are more difficult to model and evaluate than single cover type users.

If a choice exists between species, choose single cover type users in order to simplify data requirements and model calculations.

4. *Habitat Models:* Models can be selected or developed with a view toward using only a few variables. Habitat models also can be developed or modified for studies utilizing aerial photography in lieu of field data collection. Although there will be less resolution, valuable habitat information can be obtained from aerial photographs for use in early planning stages. Pettinger et al. (1979) concluded that some habitat variables could be accurately measured from infrared aerial photographs and that habitat quality could be estimated from those photographs.
5. *Target Years:* Impact assessments require the analysis of conditions at future years. These are referred to as target years in a HEP application and can be selected at any future point in time when study conditions are expected to change. In studies where a number of anticipated changes are identified, several target years may be used. One way to simplify the study is to determine the end point and compare the baseline conditions with those that are expected to occur once all changes have taken place (i.e., pre and post project conditions).
6. *Number of Alternatives:* The number of alternative futures with or futures without the project can be limited. In cases where only one component of the study will change, it may be unnecessary to completely reevaluate each project alternative. Simply separate the portion that is different from the others, and conduct the analysis on that part of the study.
7. *Sampling Reliability:* A common approach to impact studies is to obtain baseline data that are highly accurate with high confidence levels. However, when these data are projected for 100-year evaluations, the level of resolution in the 100-year projection is far below that of the baseline data. In such cases, the sampling design could require fewer field samples to reduce the time and costs for both data gathering and data analysis. The level of reliability used to determine baseline conditions should correspond to the level of resolution for the study as a whole.

Future of HEP

Problems identified in HEP applications will continue to be addressed as we work to improve habitat based evaluations. A shortage of good quality habitat models is recognized as a problem because habitat approaches are difficult to apply without reliable models. To meet this problem, habitat models are currently being published, and we intend to continue with these publications over the next several years. The primary short term thrust will be the testing and improvement of species habitat models; the COE and BR presently are assisting in this effort. We are investigating the possibility of using guilds to develop a community model (Short and Burnham 1982), and the use of multivariate statistical methods is a promising approach to a more quantitative definition of wildlife habitats (Capen 1981). The HEP accounting software is now available, and the development of software for building and applying HSI models is continuing, with assistance from the COE. Training will be continued, although at a reduced level of effort.

Summary

Fish and wildlife evaluation methods can take many approaches, and techniques based on animal numbers, human use, and habitat relationships are all successfully being used to influence land and water management decisions. A habitat-based method also is needed because habitat management is an important part of many State and Federal land management programs. Future conditions can be predicted by examining habitat variables. Legislative mandates and pressures from various groups provided the impetus for the FWS to develop HEP. During the past four years, HEP has been evaluated, refined, and published as part of the FWS Division of Ecological Services Manual series. A nationwide training program in the theory and use of HEP has trained over 1,300 people from more than 40 States. HEP currently is being used by ES, COE, SCS, State agencies, consultants, and others. The general lack of data quantifying the relationships between species and their habitats is a limitation to model development, but this problem is not unique to HEP. In order to help overcome this problem, methods and standards have been developed to produce useful species habitat models. Computer software is now available to expedite the use of HEP accounting procedures, and HSI software soon will be available. Once software and HSI models are readily available, we anticipate a further expansion in HEP use. Suggestions on improving HEP are appreciated.

References Cited

Adams, D. A. 1980. Wildlife habitat models as aids to impact evaluation. Environmental Professional 2: 253–262.

Allen, A. 1982. Habitat Suitability Index (HSI) model; Marten (*Martes americana*). FWS/OBS-82/10.11. USDI Fish and Wildlife Service, Washington, D.C.

Capen, D. E., ed. 1981. The use of multivariate statistics in studies of wildlife habitats. General Tech. Rept. RM-87. USDA Forest Service, Washington, D.C. 249 pp.

Crawford, J. E., and D. E. Lewis. 1978. U.S. Bureau of Land Management views: Wildlife and wilderness management on the public lands. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 43: 362–367.

Daniel, C., and R. Lamaire. 1974. Evaluating effects of water resource developments on wildlife habitat. Wildl. Soc. Bull. 2(3): 114–118.

Ellis, J. A., J. M. Burroughs, M. J. Armbruster, D. L. Hallett, P. A. Korte, and T. S. Baskett. 1978. Results of testing four methods of habitat evaluation. Contract 14-16-0008-2014. Prepared by University of Missouri–Columbia for USDI Fish and Wildlife Service, Washington, D.C.

Ellis, J. A., J. N. Burroughs, M. J. Armbruster, D. L. Hallett, P. A. Korte, and T. S. Baskett. 1979. Appraising four field methods of terrestrial habitat evaluation. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 44: 369–379.

Farmer, A. H. 1979. Development of mitigation alternatives: A process. Pages 327–330 *in* Proceedings: The mitigation symposium: A national workshop on mitigating losses of fish and wildlife habitats. General Technical Report RM-65. USDA Forest Service, Fort Collins, Colo.

Hardy, J. W. 1981. A survey of the habitat evaluation methods used by the U.S. Fish and Wildlife Service. USDI Fish and Wildlife Service, Office of Biological Services, Washington, D.C. Mimeo report. 10 pp.

Hays, R. L., C. Summers, and W. Seitz. 1981. Estimating wildlife habitat variables. FWS/OBS-81/48. USDI Fish and Wildlife Service, Washington, D.C. 111 pp.

Joint Federal-State-Private Conservation Organization Committee. G. Hickman, chairman. 1974. Ecological planning and evaluation procedures. USDI Fish and Wildlife Service, Washington, D.C. 269 pp.

New England Research, Inc. 1980. Investigation of the relationship between land use and wildlife abundance. Contract Report, 80-62, V. U.S. Army Corps of Engineers, Ft. Belvoir, Va. 146 pp.

Pettinger, L. R., A. Farmer, and M. Schamberger. 1979. Quantitative wildlife habitat evaluation using high-altitude color infrared aerial photographs. Paper presented at the Pecora IV Symposium on Application of remote sensing data to wildlife management. 10–12 October 1978. Sioux Falls, S. Dakota. 11 pp.

Schamberger, M. 1979. Habitat evaluation. Water Spectrum 11(2): 26–34.

______, and A. Farmer. 1978. The Habitat Evaluation Procedures: Their application in project planning and impact evaluation. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 43: 274–283.

Schamberger, M. L., and H. E. Kumpf. 1980. Wetlands and wildlife values: A practical field approach to quantifying habitat values. Pages 37–46 *in* V. S. Kennedy, ed. Estuarine perspectives. Academic Press, N.Y.

Schamberger, M., C. Short, and A. Farmer. 1979. Evaluating wetlands as wildlife habitat. Pages 74–83 *in* P. E. Greeson, J. R. Clark, and J. E. Clark, eds. Wetlands functions and values: The state of our understanding. Amer. Water Resour. Assoc., Minneapolis, Minn.

Short, C., and M. Schamberger. 1979a. Evaluation of impacts on fish and wildlife habitat and development of mitigation measures. Pages 331–335 *in* Proceedings: The mitigation symposium: A national workshop on mitigating losses of fish and wildlife habitats. General Technical Report RM-65. USDA Forest Service, Fort Collins, Colo.

______. 1979b. Habitat analysis methodology as applied to plains riparian habitats. Pages 47–54 *in* Proceedings: 31st annual meeting, Forestry Committee, Great Plains Agricultural Council. 18–21 June 1979. Fort Collins, Colo.

Short, H. L., and K. P. Burnham. 1982. A technology for structuring, evaluating, and predicting impacts on wildlife communities. Special Scientific Report-Wildlife 244. USDI Fish and Wildlife Service, Washington, D.C. 34 pp.

U.S. Fish and Wildlife Service. 1976. Habitat Evaluation Procedures: For use by the Division of Ecological Services in evaluating water and related land resource development projects. Mimeo report. USDI Fish and Wildlife Service, Washington, D.C. 30 pp.

______. 1980a. Habitat as a basis for environmental assessments. 101 ESM. USDI Fish and Wildlife Service, Division of Ecological Services, Washington, D.C.

______. 1980b. Habitat Evaluation Procedures (HEP). ESM 102. USDI Fish and Wildlife Service, Division of Ecological Services, Washington, D.C.

______. 1980c. Human Use and Economic Evaluation (HUEE). 104 ESM. USDI Fish and Wildlife Service, Division of Ecological Services, Washington, D.C.

______. 1981. Standards for the development of Habitat Suitability Index models. 103 ESM. USDI Fish and Wildlife Service, Division of Ecological Services, Washington, D.C.

White, W. M., chairman. 1971. Action report: Conservation and enhancement of fish and wildlife in the national water resources program. U.S. Bureau of Sport Fisheries and Wildlife, Washington, D.C. 50 pp.