4. Calculating Study Area Habitat Units

A HEP analysis is structured around the calculation of Habitat Units (HU's) for each evaluation species in the study area. The number of HU's is defined as the product of the Habitat Suitability Index (quality) and the total area of available habitat (quantity). This chapter provides some basic guidelines for determining HSI and total available habitat area for evaluation species. Chapter 5 discusses the use of HU's in habitat assessments for both baseline and impact studies.

4.1 Calculating total area of available habitat. The total area of available habitat for an evaluation species includes all areas that can be expected to provide some support to the evaluation species. Total area of available habitat is calculated by summing the areas of all cover types likely to be used by the evaluation species. If the study area is not subdivided into cover types, the total area of available habitat is identical to the entire study area.

The objective of defining total area of available habitat is to delineate only those areas that require HSI determinations. The total area of available habitat will vary between evaluation species if cover type use patterns are different; therefore, HSI's for each evaluation species may apply to different subareas (i.e., available habitat).

4.2 Calculating a Habitat Suitability Index for available habitat. The fundamental step in determining HU's is to estimate or calculate HSI's for each evaluation species. The technique for determining HSI values must be clearly described in a HEP study in order to establish credibility, optimize the usefulness of the analysis in decisionmaking, provide a permanent record of the basis for a decision, and make future improvements in HSI models. Studies by Ellis *et al*. (1979) confirmed that such descriptions increase the repeatability in determining HSI values. Although repeatability does not mean that HSI values will be accurate, repeatability is a prerequisite to improved accuracy.

The recommended method of describing HSI values is through the use of HSI models. An HSI model may be in word or mathematical format but, regardless of the format, the model must clearly describe the rules and assumptions used to calculate an HSI. The process of calculating an HSI involves: 1) establishing HSI model requirements; 2) acquiring an HSI model; and 3) determining HSI for available habitat.

A. Establishing HSI model requirements. Habitat models used in HEP must be in index form. Inhaber (1976) defined an index as a ratio between some value of interest and a standard of comparison. For HEP purposes, the value of interest is an estimate of habitat conditions in the study area, and the standard of comparison is the optimum habitat condition for the same evaluation species. Therefore,

$$\text{Index value} = \frac{\text{Value of Interest}}{\text{Standard of Comparison}} \text{ ; or}$$

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$$HSI = \frac{\text{Study Area Habitat Conditions}}{\text{Optimum Habitat Conditions}}$$

where the numerator and denominator have the same units of measure. The HSI ranges between 0 and 1.0 and, as with any index, is dimensionless (i.e., the units for both the numerator and denominator must be the same and should be specified).

The ideal goal of an HSI model is to produce an index with a proven, quantified, positive relationship to carrying capacity (i.e., units of biomass/unit area or units of biomass production/unit area). This ideal model goal will often be unobtainable; consequently, a more easily obtainable but acceptable goal must be defined. The minimum acceptable goal for an HSI model might be, for example, an index that a recognized expert, knowledgeable about the habitat requirements of a species, believes is positively related to long-term carrying capacity.

The use of an HSI model within HEP places additional requirements on HSI values. The HEP mechanisms for comparing proposed actions and developing compensation plans are based on the assumption that HSI is a linear index; i.e., a change in HSI from 0.1-0.2 is the same magnitude as a change from 0.8-0.9. Even if the HSI model used has a proven, positive relationship to long-term carrying capacity, the relationship must be linear (or transformable to linear). It is not necessary to obtain a model that meets the ideal goal if assumptions concerning the linear relationships of the index to carrying capacity are acceptable.

B. Acquiring HSI models. In acquiring an HSI model for use in HEP, the ideal goal, as stated previously, is to use a model that has been proven to be linearly correlated with a defined measure of carrying capacity (e.g., biomass/unit area or biomass production/unit area). There are two basic categories of models that may be used with HEP: 1) HSI models that directly produce a unitless number between 0 and 1 that is believed (or assumed) to have a positive relationship with carrying capacity; or 2) HSI models with a predictable value of interest (i.e., the numerator is estimated in some specified units, such as lbs per acre).

(1) Existing habitat models. HSI models are under development by the USFWS[2] and several reservoir models are now available in Aggus and Morais (1979). Models have been described that can be converted

[2]Contact USFWS, Western Energy and Land Use Team, 2625 Redwing Road, Fort Collins, Colorado 80526.

to HSI format. The Aquatic Systems and Instream Flow Group has developed a method of assessing change in fish habitat potential in streams in response to change in stream flow or channel configuration (Bovee 1978; Stalnaker 1978; Stalnaker 1980). This method involves modeling habitat within selected stream reaches. Training and technical assistance in the use of this method is available from the Aquatic Systems and Instream Flow Group. Terrestrial habitat models that predict population densities based on statistical methods have been developed by Russell et al. (1980).[3] These models use conditional probability statements derived through habitat observations in areas of both high and low population densities.

Tested and scaled regression models relating habitat variables to population measures are available for reservoir fishes (Jenkins 1976; Leidy and Jenkins 1977; Aggus and Morais 1979) and some stream fishes (Binns and Eiserman 1979) and should be reviewed for potential HEP applications. In addition, certain species data bases are being developed by the U.S. Forest Service and other agencies and may be useful in HSI modeling.

If there are existing models, judgment may be required in adapting them for specific applications. Almost all models are developed around a specific set of assumptions that may or may not apply to a specific application area. An existing habitat model may be constructed around habitat variables (e.g., % canopy cover or tree height) that do not relate to habitat suitability in all regions of the country where the species occur.

The use of existing habitat models in HEP requires that model outputs be in a 0 to 1 index form. Models that output a measure of habitat suitability that are not a 0 to 1 index should be converted to an HSI as follows:

$$HSI = \frac{\text{Model Output (Study Area Habitat Conditions)}}{\text{Optimal Habitat Conditions}}$$

For example, the output of the model developed by the Aquatic Systems and Instream Flow Group is weighted useable area (WUA) for appropriate instream habitat types (spawning, fry, juvenile, adult). This information is displayed for selected stream reaches at monthly intervals (Stalnaker 1980). Suitability indices for each habitat type may be calculated as follows:

[3] The use of these models may require assistance from the Colorado Cooperative Wildlife Research Unit, Colorado State University, Fort Collins, Colorado.

$$SI_i = \frac{\text{Weighted Useable Area (WUA) of the Stream Reach Modeled}}{\text{Wetted Surface Area of the Same Stream Reach}}$$

where i = instream habitat type

SI_i = suitability index for a given stratified stream segment described by the representative reach samples.

These SI values must be aggregated into an HSI value. The physical habitat simulation model (PHABSIM) developed by the Aquatic Systems and Instream Flow Group can be used to predict WUA changes in stream environments under proposed alterations of streamflow or channel geometry. This model output can then be used to calculate future HSI values. The Instream Flow Group is currently preparing a detailed illustration of the application of the IFG Incremental Methodology in a HEP analysis.

The output of the model described by Russell et al. (1980) is a population density estimate. This estimate can be converted to an HSI as follows:

$$HSI = \frac{\text{Population Density Estimates (Model Output)}}{\text{Maximum Observed Population Density}}$$

(2) Development of HSI models. If an HSI model must be developed, 103 ESM should be consulted for full details of the model building process. The following discussion is a summary of the modeling process and is meant to be an aid to understanding how an HSI model may be constructed.

The general steps in the construction of a model are: 1) establish a model goal; 2) define the habitat variables that are related to the model goal; and, 3) define model relationships that combine measurements of the variables to achieve model goals.

Model goals include two general aspects: 1) output specifications and 2) a definition of potential variables the field biologist is able to measure. The ideal output for an HSI model is a measure of habitat suitability per unit area (e.g., biomass or biomass production/unit area). In order to provide a rapidly applicable assessment tool, habitat models for use in HEP should be based on easily measured physical, chemical, or vegetative variables. After reviewing the literature about the evaluation species, the proper variables to measure can usually be identified. States *et al.*

(1978) described variables commonly measured in aquatic and terrestrial systems, noted why variables were important, and discussed references on how to measure them.

The relationship between model variables can be defined in word or mathematical format. In word format, a definition of optimum habitat is developed through a written description of the best condition of habitat variables. A description of the habitat in the study area, based on the same variables, is developed and compared to the word model to determine the HSI. The data and logic used to determine the HSI must be described.

A mathematical format is a more rigorous approach and requires that the logic of the HSI calculation be mathematically defined. HSI values are determined by mathematical functions that combine habitat variable measurements. A mathematical format allows clearer statements of model relationships but is not necessarily any less subjective than a model in word format. The mathematical functions need not be complex, but should consider the biological interactions of variables.

Ideally, an HSI model should be calibrated to the desired output goal. Significant assumptions are required concerning the attainment of model output goals (e.g., number of animals/hectare) until the model has been tested and scaled by comparing it to a defined measure of habitat suitability.

C. Determining HSI for available habitat. After a habitat model is obtained, the model must be used in HEP to obtain an HSI for the available habitat. The HSI for available habitat is a function of the suitability of all cover types used by the evaluation species. The HSI for available habitat is calculated in one of several ways; the choice depends on the structure of the model. Figure 4-1 displays the various routes to calculating an HSI for available habitat. These routes are dependent on the structure of the model and can be defined by answering three questions about the model structure: 1) Does use of the model produce suitability indices (SI's) for the available habitat from individual cover type suitability indices?; 2) If cover type suitability indices are calculated, does the available habitat for the species consist of more than one cover type?; and 3) If the available habitat consists of more than one cover type, is interspersion between cover types important for the species?

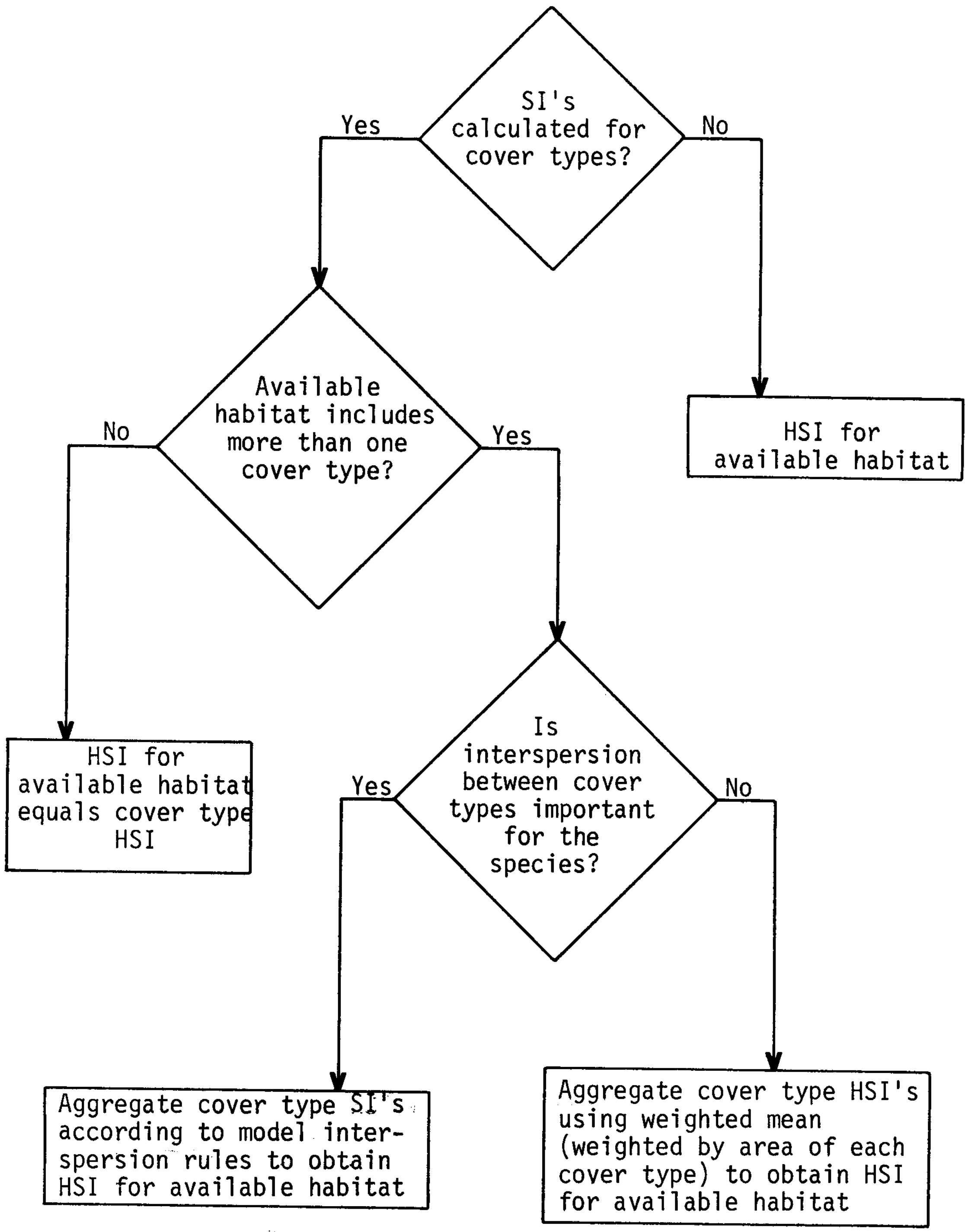

Figure 4-1. Options for calculating HSI for available habitat.

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In response to the first question in Figure 4-1, if the habitat model does not produce cover type suitability indices then all pertinent habitat variables, including interspersion, will be combined in one relationship. Examples of models of this type are provided by Russell et al. (1980). Different calculations are necessary if cover type suitability indices are produced by the model. Models that provide suitability indices for evaluation species by cover type are being developed by the Habitat Evaluation Procedures Group (USFWS, Fort Collins, Colorado) and are described in more detail in 103 ESM.

Each cover type within the available habitat is assigned a suitability index for only those resources provided by the cover type (e.g., food, reproductive cover). The indices applied to individual cover types are not necessarily habitat suitability indices because they may only apply to part of the species' habitat needs.

A second question is necessary if the model produces cover type indices: Does the available habitat for a species include only one cover type? If all habitat needs are met by one cover type, then the HSI for available habitat is equivalent to the cover type suitability index. If the available habitat consists of two or more cover types, then methods are required to aggregate cover type indices into an HSI for available habitat. The aggregation methods are defined by the third question in Figure 4-1. If interspersion between cover types is important, then the model should aggregate cover type HSI's into one HSI value. For example, optimum habitat conditions for species A might be a 2:1 ratio of cover type A (that provides suitable food) to cover type B (that provides suitable cover), with the added requirement that only those portions of the cover types which are within 300 m of each other should be considered as optimum habitat. If a species occurs in more than one cover type, but interspersion between cover types is not important (i.e., all habitat needs are provided by each cover type), then a different aggregation method is required. This latter aggregation method is a simple weighted mean of the suitability indices for the cover types (weighted by the area of each cover type).

All models have specific data requirements that influence data collection tasks. If a model is structured to compute cover type suitability indices, then data must be collected for each cover type. Baseline habitat conditions typically will be based on field data collection at several selected sites within each cover type. HSI's for future years typically will be based on a predicted average value of the habitat variables within each cover type, without the use of field sample sites. Spatial variables (interspersion of cover types) are best computed from maps. The same basic data collection options can also be used for other model types by sampling in the field to compute mean values of variables or estimating areawide average values of variables.