4. Carrying Capacity and Habitat as a Basis for Impact Assessments

The concept of carrying capacity integrates the habitat and population themes in a time dimension and, in doing so, provides a potential basis for impact assessments. The purposes of this chapter are to define and discuss the estimation of carrying capcity, and then evaluate the utility of incorporating the concepts presented in this document into a practical method for assessing the impacts of man's actions on fish and wildlife resources.

4.1 Definition of carrying capacity. Strictly speaking, carrying capacity is a population concept with the underlying theme of numbers of animals supported by some unit of area. In population ecology terms, it is "the density of organisms (i.e., the number per unit area) at which the net reproductive rate (R_o) equals unity and the intrinsic rate of increase (r) is zero" (Pianka 1974:82). Pianka goes on to explain that carrying capacity is "an extremely complicated and confounded quantity, for it necessarily includes both renewable and nonrenewable resources, as well as limiting effects of predators and competitors, all of which are variables themselves." Carrying capacity is the "K" in various versions of the Verhulst-Pearl logistic population-growth equation. Defined in this context, carrying capacity is the population density at an upper asymptotic level of population growth. After a population reaches this level it may fluctuate around K due to chance events. The asymptotic density is maintained by density-dependent environmental factors.

Wildlife resource managers often are more liberal in their perceptions of carrying capacity than are population ecologists and may use the term in a variety of contexts (Edwards and Fowle 1955). When confusion occurs, it can be traced to a lack of user definition and not to the integrating role of this useful concept. Giles (1978) has recently attempted to alleviate confusion by suggesting that carrying capacity be defined for a population with a user-specified quality of biomass (e.g., specified sex and age ratios). With this approach, carrying capacity is the quantity of the specified population for which a particular area will supply all energetic and physiological requirements over a long, but defined, period of time.

4.2 Estimation of carrying capacity. Carrying capacity (K in the Verhulst-Pearl logistic population growth equation) may be estimated empirically with regression techniques described by Watt (1968) and Poole (1974). These regression techniques require that population densities be recorded for various stages of population growth. The technique is based on observed population densities, thus it does not provide the ability to predict future changes in carrying capacity. For that latter reason, and others discussed in 101 ESM 3, population estimation is not a viable technique for impact assessment purposes.

Another technique for estimating carrying capacity is the traditional resource inventory. With this technique, carrying capacity is estimated based on how well the habitat will meet the known physiological and behavioral needs of a species. Ecologists working with ungulates have historically based carrying capacity estimates on caloric and nutritional values of foods provided by the habitat. Examples of the data and calculations required are described by Moen (1973) and Mautz (1978). Others, including avian ecologists, have considered structural aspects of the habitat as important determinants of carrying capacity (Elton and Miller 1953). Carrying capacity estimates based on the resource inventory approach will nearly always be estimates of "potential," because the limiting effects of other species (competitors and predators) are difficult to explicitly include in the calculations.

4.3 Application of habitat concepts to impact assessments. Structural and physical features of habitat are measurable and because vegetational succession is predictable to a certain extent, future habitat values can be projected with some confidence. However, numbers of individuals fluctuate naturally over time and often independently of structural and physical features of available habitat. These fluctuations can be difficult to measure or predict and are often caused by epizootic diseases, excessive departures from normal weather patterns, or other stochastic events not directly related to habitat. More common however, are the effects of predation and competition on numbers of individuals utilizing a particular habitat (Wagner 1969; Partridge 1978). For example, predator-prey studies by Rogers et al. (1980) indicated that, in similar habitat, white-tailed deer densities were higher in the buffer zones between wolf pack territories than in the center of individual territories.

In regard to competition, avian ecologists are making rapid advances in deciphering the influence of competition on animal numbers. For example, a recent study (Williams and Batzli 1979a,b) indicated that the presence or absence of one particular species within a guild of bark foraging birds affected whether or not other guild members would use a particular habitat segment, how they would use it, and in what numbers. The implications of these studies and others are directly applicable to the objectives of impact assessment. Numbers of species and numbers of individuals often may change for unpredictable reasons, but habitat potential remains unchanged. Because of its relative stability, it is this habitat potential which should be documented by the wildlife manager interested in ecologically valid impact assessment.

Two factors support impact assessments based on habitat potential. First, the time scale for predictions can come close to matching the time span over which impacts will occur. For many impact studies performed by the USFWS involving long-term modifications of land use, the most useful information for decisionmaking is the long-term trend in fish and wildlife resources. Predicted short-term (e.g., seasonal or annual) fluctuations in populations may have little influence on a land use decision. Secondly, the degree to which a predicted impact is considered significant is partially a function of socioeconomic preferences for the species involved. When recommendations for land use decisions are based on habitat potential it is possible to maximize the number of future management options, recognizing possible future changes in socioeconomic preferences.

4.4 Limitations of the habitat approach. The habitat approach, like any approach used for impact assessments, has limitations which define the limits of application and identify potential problem areas where good professional judgement is required. Performing impact assessments with a habitat approach, as described herein, basically limits application of the methodology to those situations in which measurable and predictable habitat changes are an important variable. Many impact studies (e.g., harvest management and predator control) cannot be adequately performed solely with a habitat approach but require other analytical capabilities.

The habitat approach presents a relatively static view of the ecosystem and forces a long-term "averaging" type of analysis. Although this is described as a positive attribute in earlier sections of this document, there is no assurance that wildlife populations will exist at the potential levels predicted by habitat analyses. A habitat approach may not include all of the many environmental or behavioral variables that often limit populations below the habitat potential. Moreover, socioeconomic or political constraints imposed by man may prevent the actual growth of certain species populations to their potential levels.