3. Definition of Study Limits

The first step of a HEP application consists of: 1) defining the study area; 2) delineating cover types; and 3) selecting evaluation species.

3.1 Definition of the study area. Definition of the study area should consider the purposes of the study, significant changes that may occur in existing habitat, and the interrelationships of species within the biological community that presently exist or could exist there in the future.

The study area should include those areas where biological changes related to the land or water use proposal under study are expected to occur. This area should include areas that will be affected, either directly (e.g., engineering structures) or indirectly (e.g., human use trends) by the proposed use. Additionally, the study area should include contiguous areas with significant biological linkages to the area where actual physical impacts are expected to occur. For example, reservoir inundation might affect a stream fishery through both the loss of habitat and the isolation of populations from upstream spawning areas. The study area boundaries may require revision after cover type delineation and selection of evaluation species have been completed.

3.2 Delineation of cover types. A HEP analysis of the study area requires the delineation of cover types. The level of delineation of cover types generally depends on mapping constraints and the detail required in the analysis. It is doubtful that any single cover type classification system would be applicable to all studies in all parts of the country. Therefore, biologists should select a regionally accepted classification system that is compatible with available mapping resources.

Cover types should be delineated on an accurate base map (e.g., U.S. Geological Survey topographic sheet). Maps generated from remotely sensed data (scale 1:20,000 to 1:60,000) usually permit acceptable resolution for terrestrial habitat evaluations. Color infrared photography generally provides the best separation of vegetative structure, which forms the basis for terrestrial cover types. Aquatic cover types should be described by characteristics such as size and temperature. These characteristics have proven to be fairly good estimators of the number (Barbour and Brown 1974; Magnuson 1976) and kinds (Lotrich 1973) of fish species in aquatic systems in restricted geographical areas. Specific definitions of cover type descriptors are provided in 103 ESM.

Cover types serve three basic functions in HEP. First, cover types facilitate the selection of evaluation species (Subsection 3.3). Second, extrapolation of data from sampled areas to unsampled areas can be done with some confidence if the study area is divided into relatively homogeneous areas, thus reducing the amount of sampling necessary. Finally, separation of the study area into cover types facilitates treatment of HEP data (Chapter 4).

3.3 Selection of evaluation species. Evaluation species, both terrestrial and aquatic, form the basis of a HEP analysis. An evaluation species can be a single species, a group of species, species life stage, or a species life requisite. Evaluation species are used in HEP to quantify habitat suitability and determine changes in the number of available HU's. Therefore, a HEP assessment is directly applicable only to the evaluation species selected. The degree to which predicted impacts for these species can be extrapolated to a larger segment of the wildlife community depends on careful species selection.

There are at least two basic approaches to the selection of evaluation species: 1) selection of species with high public interest, economic value, or both; and 2) selection of species to provide a broader ecological perspective of an area. The choice of one approach in lieu of the other may result in a completely different outcome in the analysis of a proposed land use. Therefore, the objectives of the study should be clearly defined before species selection is initiated. If the objectives of a study are to base a land use decision on potential impacts to an entire ecological community, such as a unique wetland, then a more ecologically based approach is desirable. If, however, a land or water use decision is to be based on potential impacts to a public hunting or fishing area, then species selection should probably favor animals with a tangible economic value. In actual practice, species should be selected to represent both economic and ecological views because planning efforts incorporate objectives that have economic, social, and ecological aspects. Species selection always should be approached in a manner that will optimize contributions to the stated objectives of the planning effort.

Most land use decisions are strongly influenced by the perceived impacts of the proposed action on human use. Since economically or socially important species have clearly defined linkages to human use, they should be included as evaluation species in all appropriate land use studies. They must be used if a Human Use and Economic Evaluation (104 ESM) is to be included in the habitat assessment process.

An analysis based only on those species with directly identifiable economic or social value may not be broad enough to adequately describe all of the ramifications of a land use proposal. If it is desirable to increase the ecological perspective of an assessment, the following types of species should be considered:

1) Species known to be sensitive to specific land use actions. The species selected with this approach serve as "early warning" or indicator species for the affected wildlife community.

2) Species that perform a key role in a community because of their role in nutrient cycling or energy flows. These species also serve as indicators for a large segment of the wildlife community, but may be difficult to identify.

3) Species that represent groups of species which utilize a common environmental resource (guilds). A representative species is selected from each guild and predicted environmental impacts for the selected species are extended with some degree of confidence to other guild members.

The procedures for selecting terrestrial and aquatic species described in detail below consider all three types of species with emphasis on guilds. Species of high public interest should be included in the appropriate guild process because in many cases such species do serve as ecological indicators as described above.

A. Terrestrial guild development. The recommended procedure for selecting terrestrial species involves categorizing vertebrate species in an ecological community according to their feeding and reproductive guilds. Feeding guilds are defined in terms of feeding mode (e.g., carnivore, herbivore, or omnivore) and strata locations in the ecosystem where the foods are obtained (e.g., canopy, shrub layer, or surface). Reproductive guilds are defined only in terms of strata locations where reproduction occurs. Figure 3-1 illustrates an example of the possible subdivisions of feeding modes and Figures 3-2 and 3-3 illustrate possible subdivisions for strata locations. Locational descriptors in Figure 3-2 can be used in any terrestrial system and the locational descriptors in Figure 3-3 provide the additional descriptors needed to define guilds for wetland species. For example, a forested wetland may contain location descriptors from both Figure 3-2 and Figure 3-3.

Development of guilds for the selection of species involves several successive steps: 1) construction of matrices that define feeding and reproductive guild cells; 2) selection of species from each cover type that meet guild definitions; and 3) selection of species from each guild to act as study evaluation species. These steps are discussed in the appropriate order below.

(1) Step 1. Construction of matrices. Both a feeding matrix and a reproductive matrix must be constructed for each cover type in a study area. The feeding matrix is created by entering feeding modes horizontally across the top and locational descriptors (strata) down the left side of the matrix (Figure 3-4). The reproductive matrix is constructed similarly, except there is only one reproductive category across the top. The descriptors used to construct the feeding matrix depicted in Figure 3-4 were level

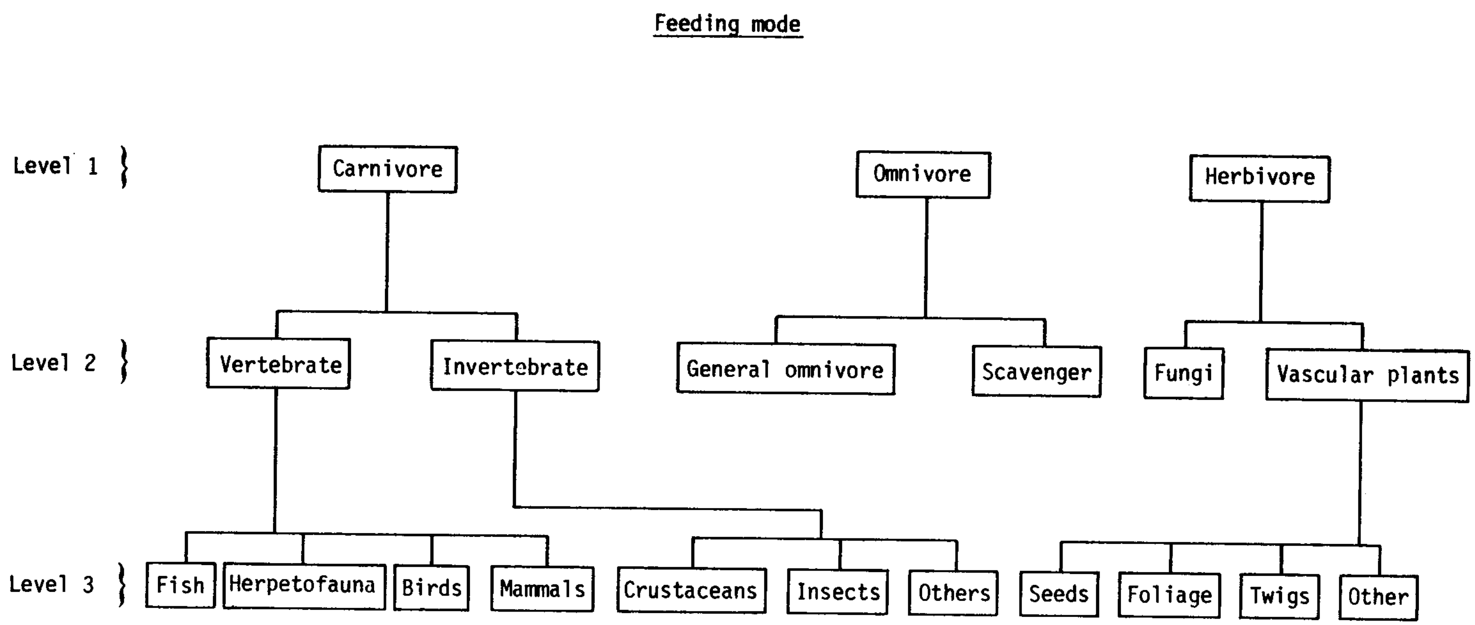

Figure 3-1. An example of the development of feeding mode descriptors through various levels (1-3) of detail.

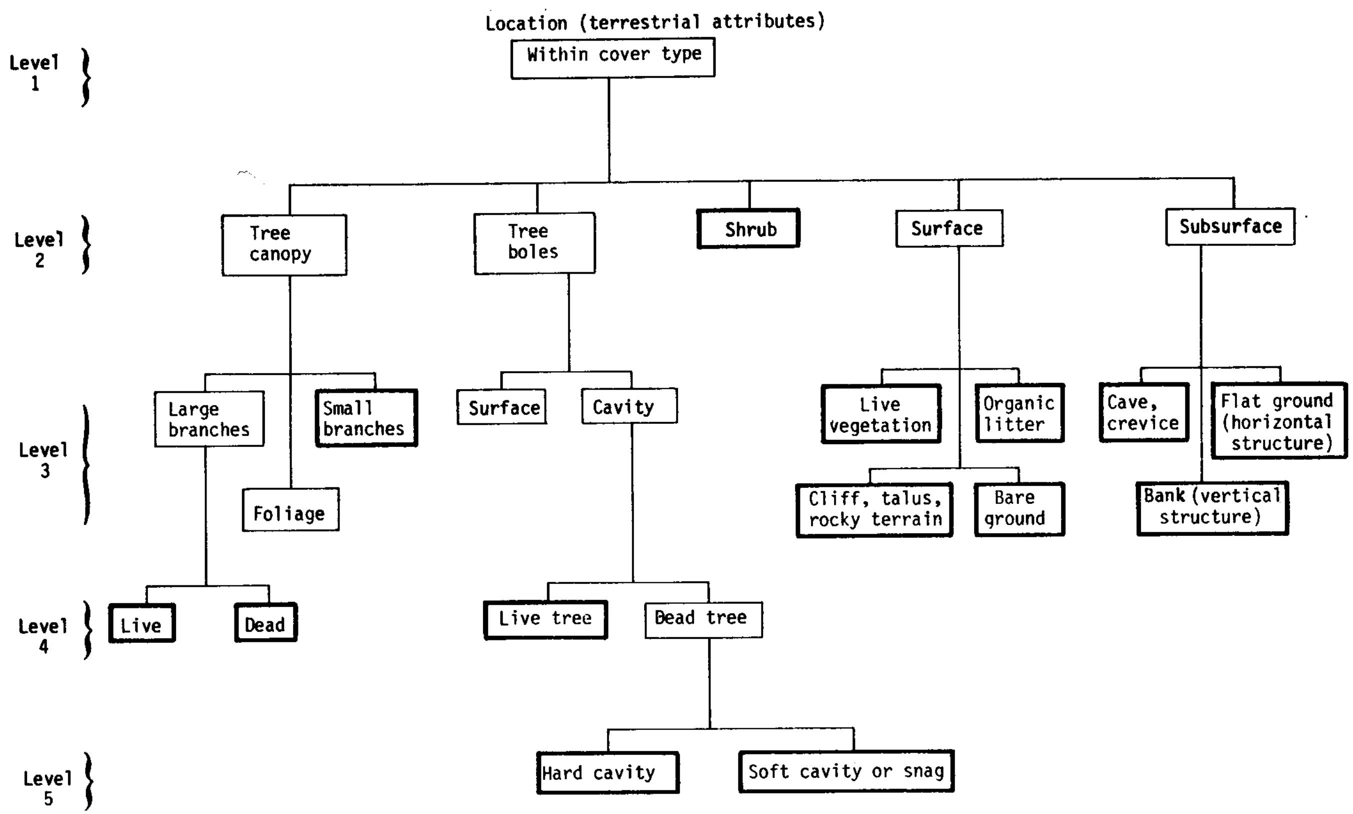

Figure 3-2. An example of terrestrial locational descriptors for selection of evaluation species through guilding.

Location (wetland descriptors)

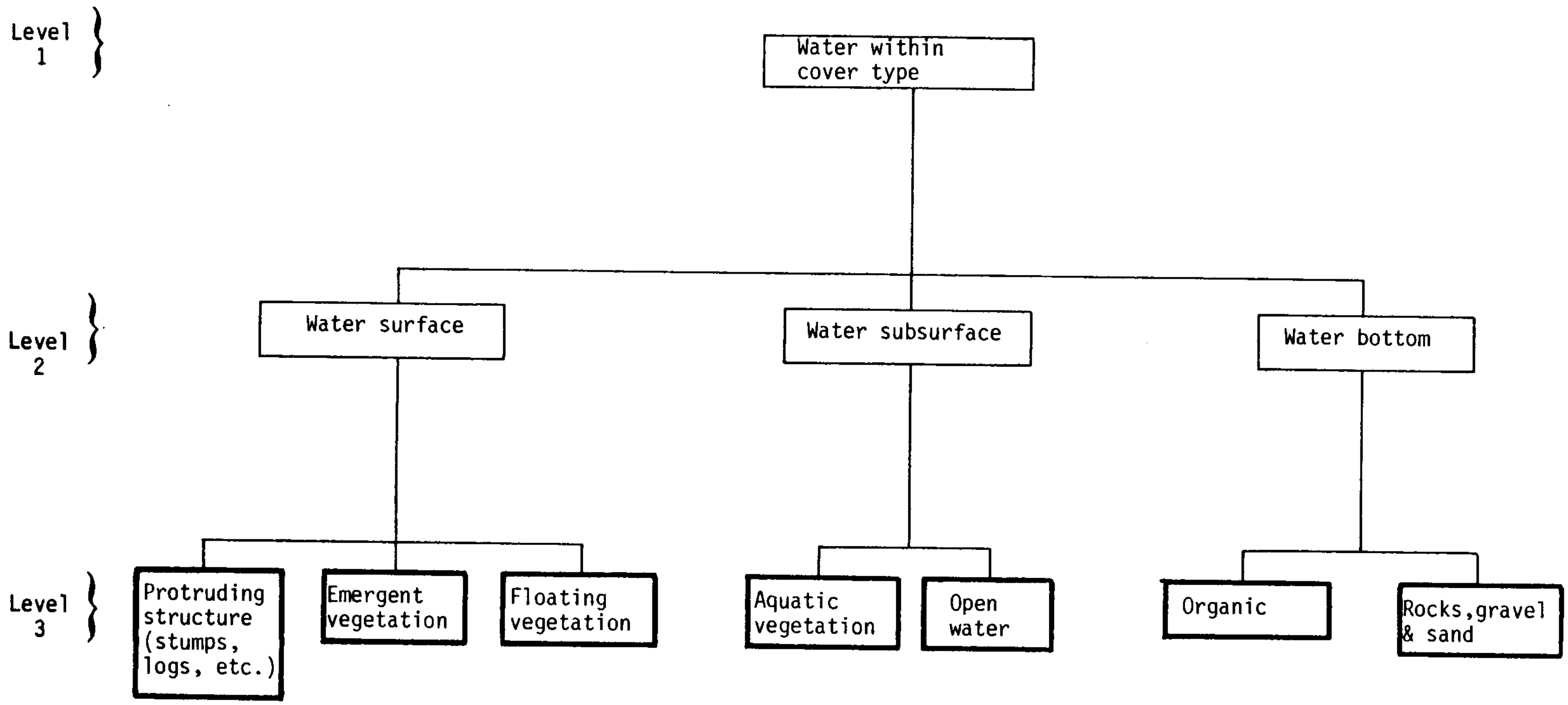

Figure 3-3. Terrestrial locational descriptors for guilding at various levels of detail (wetland descriptors).

Cover type: Deciduous forest	Feeding mode					
	Vertebrate carnivore	Invertebrate carnivore	General omnivore	Scavenger	Herbivore (fungi)	Herbivore (vascular plants)
Tree canopy		Hairy woodpecker				Fox squirrel Gray squirrel
Tree boles		Hairy woodpecker	Pileated woodpecker Carolina chickadee			
Shrub layer						White-tailed deer Eastern cottontail Eastern woodrat
Terrestrial surface	Bobcat Red-tailed hawk Red-shouldered hawk Barred owl	Nine-banded armadillo	Gray fox Raccoon			White-tailed deer Eastern cottontail Eastern woodrat Golden mouse Fox squirrel
Terrestrial subsurface						

Figure 3-4. An example of terrestrial feeding guilds in a deciduous forest in the south-central United States.

2 locational (Figure 3-2) and level 2 feeding (Figure 3-1) descriptors. The reproductive matrix shown in Figure 3-5 was constructed using locational descriptors from the levels indicated by bold-line squares in Figure 3-2.

The descriptors used to construct these matrices were selected to produce guild cells similar to those contained in the wildlife species data base being developed by Short, 1980. Extensive literature reviews indicated that these descriptors result in guilds which contain species similar in terms of habitat utilization for impact assessment purposes. Descriptors at other levels of detail can be used for a HEP analysis.

The guilding concept is somewhat arbitrary because no two species are precisely the same in terms of habitat utilization and responses to land use changes. The best level of detail for guilding for a particular study allows the maximum generalization about species similarities while maintaining acceptable homogeneity within the individual guilds. There will always be a compromise between the number of guild cells and the degree of similarity between species in any guild. The number of guilds that should be identified is constrained by the time and funds available for a study. More detail in the guild descriptors results in the identification of a greater number of potential evaluation species. The matrices in Figures 3-4 and 3-5 contain 44 cells collectively. If one species were selected to represent each cell for each cover type in a study area, there would be a large number (44 times the number of cover types) of potential evaluation species. However, in practice the number of actual species would be lower for several reasons:

1) Nonapplicable cells. There may be several cells for which no species can be identified. For example, there may be no identifiable species that feeds on fungi in the tree canopy.

2) Nonapplicable strata. Some cover types may not contain all the strata identified. For example, grassland cover type matrices will not include feeding or reproductive guilds that are defined by tree canopy and tree bole strata.

3) Land use changes being studied. It may be possible to ignore certain guild cells and still select species most likely to be impacted by land use changes. A given study need only

Cover type: Deciduous forest	Reproductive
Tree canopy	
Small branches	Red-eyed vireo
Large live branches	Fox squirrel, gray squirrel, red-tailed hawk, red-shouldered hawk
Large dead branches	
Tree boles	
Live tree cavity	Fox squirrel, gray squirrel, raccoon, hairy woodpecker, Carolina wren, barred owl
Dead hard cavity	Raccoon, barred owl, pileated woodpecker, hairy woodpecker, Carolina wren
Dead soft cavity	Raccoon, barred owl, pileated woodpecker, Carolina chickadee, hairy woodpecker, Carolina wren
Shrub	White-tailed deer, gray catbird, indigo bunting, mourning dove
Surface	
Live vegetation	White-tailed deer, eastern cottontail, eastern woodrat, bobwhite, turkey
Organic litter	
Cliff, talus, rocky terrain	
Bare ground	
Subsurface	
Cave, crevice	Eastern woodrat, bobcat, gray fox
Flat ground	Eastern woodrat
Bank	Eastern woodrat, gray fox, nine-banded armadillo

Figure 3-5. An example of terrestrial reproductive guilds in a deciduous forest in the southcentral United States.

consider those strata impacted by a particular land use change. For example, only the terrestrial surface and shrub layers may need to be analyzed if a land use proposal involves increased livestock grazing.

Given the above variables that influence the relationship between the number of guilds and the number of evaluation species, it is difficult to provide rigid guidelines for matrix construction. However, as a general rule, construct initial feeding and reproductive matrices with a combined number of guilds approximately four to five times the desired number of evaluation species. The matrices may be reconstructed at different levels of detail if either: 1) the actual number of species is too large; or 2) the guild categories are too general for study purposes.

(2) Step 2. Selection of species to meet guild descriptors. After the matrices have been developed, the next step is to categorize species into the guilds. The public interest species should be included in the guilds. Some judgment is required in determining the number of species that should be considered. In some cases, there may be several hundred vertebrate species in a study area. Various screening mechanisms can be used to reduce the list of candidate species. For example, habitat evaluation data bases, such as those under development by the USFWS and other agencies, might be consulted as a prescreening mechanism to identify those species for which adequate habitat information is available from which to develop habitat models. As a general guideline, enough species should be entered into the matrix to represent a reasonable cross-section of feeding and reproductive guilds. For very general descriptors, a small number of species might be sufficient to provide at least one species in each guild. Figures 3-4 and 3-5 contain examples of species categorized according to feeding and reproductive guilds.

(3) Step 3. Selection of species from each guild. If more than one species has been entered into any guild, at least one should be selected to represent the guild. This within-guild selection can be arbitrary or according to a ranking scheme. Suggested ranking criteria include anticipated sensitivity to proposed land use impacts, community role in nutrient cycling or energy flow, geographic range, cover type utilization, and the availability of habitat data. Each criterion may be subdivided into several categories for purposes of numerical weighting. For example, the data availability criterion might be subdivided and weighted as follows:

	Weight
Species-habitat relationships well known	4-5
Species-habitat relationships partially known	2-3
Species-habitat relationships not well known	1

As an example of within-guild selection, the two deciduous forest omnivores that feed on tree boles (Figure 3-4) are ranked according to: 1) availability of habitat information; and 2) perceived sensitivity to land use impacts (for example, a timber management practice). Habitat relationships for both the pileated woodpecker and the Carolina chickadee are reasonably well understood; the score for each would be 2.5. However, the pileated woodpecker is perceived to be more sensitive to the proposed timber management practice and would be rated at 4.0; the more tolerant Carolina chickadee would be rated at 1.0. The overall score for the pileated woodpecker (6.5) is higher than the overall score for the Carolina chickadee (3.5) and, therefore, the pileated woodpecker would be the first choice for an evaluation species to represent the omnivore- tree bole guild in deciduous forest. The ranking process may place a high value on an economically or socially important species; in such cases, the species will provide both economic and ecological perspectives. However, be cautious when selecting a game species to represent a guild because in many cases game species are "generalists" that adapt readily to change. Generalist species may not adequately represent other guild members in a habitat evaluation.

B. Aquatic guild development. Aquatic guilds can be developed to aggregate species into groups with similar habitat requirements. The guild structure can have several levels, and the number of descriptors within a level can vary. Guilds may be based on: 1) feeding habits (Leidy and Jenkins 1977); 2) reproductive habits (based on Balon 1975; Balon *et al*. 1977); 3) tolerance and response to temperature (Hokanson 1977); 4) preferred habitat; or 5) tolerance to the results of a potential habitat alteration, such as turbidity-siltation. In some studies, the user may find it useful to further divide the guild into several levels. For instance, Balon (1975) presents a detailed reproductive guild classification that would provide more resolution for delineating species into groups by their similar reproductive strategies. The various descriptors in the matrix need not be mutually exclusive. For example, a species such as smallmouth bass is commonly found in both riverine and lacustrine habitats and can be classified under both categories.

After the descriptors have been established, the aquatic species are listed and categorized by guild descriptor. The guild matrix presented in Figure 3-6 is one of several possible guild structures and serves only as an example. The number of levels and descriptors for the guild

Evaluation Species or Life Stage	Habitat preferences: Lacustrine: Small (< 50 ha)	Medium (50-200 ha)	Large (> 200 ha)	Near Shore	Off Shore	Riverine: Small (< 5 m wide)	Medium (5-30 m wide)	Large (> 30 m wide)	Low Velocity (pools, eddies)	High Velocity (riffles, runs)	Summer temperature optima: Cold (< 20° C)	Cool (20-28° C)	Warm (> 28° C)	Reproductive considerations: Simple Spawners a/	Complex Spawners b/	Temperature Range (C)	Season (Jan = 1, Dec = 12)
Smallmouth bass	X	X	X	X		X	X	X	X			X			Rb	13-20	5-7
Channel catfish	X	X	X	X	X		X	X	X				X		C	21-30	5-7
Sunfishes	X	X	X	X		X	X	X	X				X		PRg	>21°	5-8
Threadfin shad			X		X			X	X	X			X	P		>21°	4-8
Spotfin shiner								X		X		X		P		>15°	5-8

a/ Simple Spawner - B = buoyant or semi-buoyant, drifting eggs; P = eggs deposited primarily on plant materials, R = eggs deposited primarily on rocky-sandy substrates, PR = eggs deposited on either rocky-sandy substrate or plants.

b/ Complex Spawner - C = constructs or uses naturally occurring cavities as nests and guards nest, Rb = constructs nest in or on rocky substrate, Pg = constructs nest in or on plant materials and guards nest, PRg = constructs nest with either inorganic or organic materials and guards nest. Mg = constructs mound-shaped nest and guards nest.

Aquatic species matrix. Figure 3-6. Aquatic species matrix must be adapted to fit study needs. For example, if the stream bottom type is important, descriptors such as mud, sand, gravel, or rubble bottom could be added to the matrix.

It is most desirable to list all species in the study area and then select a species from each guild. However, in many cases time and budget constraints may require that a preliminary screening occur to reduce the number of species before attempting to place them in the guilds. Taxonomic classification at the family level has ecological significance and can provide a first level screening to reduce the number of species. The user should select at least one species in the study area from each taxonomic family and place them in the guilds. Species of high public interest should also be placed in the guilds so that the final list of species contains those of high public interest and species representing ecological diversity. An "x" is placed in the matrix cells in which each species belongs (Figure 3-6).

Evaluation species are selected by choosing one or more species from the matrix. When several species occur in one guild and the user determines that only one or two members of that guild are required for the evaluation, criteria must be developed to select species from within the matrix (See Steps 1-3 in Section 3.3A). Criteria such as availability of quantifiable habitat information, degree of public interest in the species, or other criteria can be used to make the final selection.

C. Compiling study area list of evaluation species. A composite list of species for the study area will contain every species chosen to represent their matrix in all cover types and species chosen for economic or social importance. If the number of evaluation species on this list exceeds study constraints, the list can be reduced by: 1) developing a more generalized matrix, and; 2) deleting entire cells from the existing matrices. Matrix cells can be deleted from consideration based on rating criteria as discussed in Step 3 [3.3 A(3)] of the terrestrial guilding process.