Table 2-1
Summary of Strengths and Weaknesses at Different Levels of Biological Scale for 1) Ecological Risk Assessments (ERA) of Stressor Impacts and 2) NRD Injury Quantification

Level of Organization	Examples	ERA Strengths	ERA Weaknesses	NRD Injury Quantification Issues
Individuals	Mortality Growth Reproduction Bioenergetics Behavior Biomarkers Morphology Disease	High mechanistic understanding in certain instances; relatively inexpensive analyses; often high stressor specificity; good understanding of background conditions; biological markers can give excellent indicators of exposure.	Requires a species by species approach; little known ecological relevance; weak relationship with ecological effects; individuals may be relatively unimportant to overall population demography; effects of multiple stressors unclear; often not representative of ecological services.	Individual by individual analysis of injury has been the basis of most NRDA injury determinations over the past decade. Easiest and quickest approach to establishing injury and scaling restoration; may require some understanding of local regional population for modeling. Counting individuals is likely to underestimate total injury to the system because it does not place those organisms in context. Gravid or pregnant females are already contributing to the next generation. Individuals lost that are part of depressed populations may result in too low a population density for continued survival of the species in that region. **ADDITIONAL PERSPECTIVE:** Not recommended for quantifying injury or service losses. May be useful as ancillary information to help determine causal relationships.
Populations	Density Age structure Reproductive rate Recruitment Genetic structure Spatial distribution Migration/ Immigration Invasive species	Fundamental units of ecological systems; large database on sensitivity to specific stressors; excellent statistical and deterministic models available for population assessments; T&E legislation; focus of ERA; populations are the foundation of ecological services such as silviculture, fisheries & social icons (e.g., salmon in the Northwest).	Requires species by species approach; quantitative sampling difficult for some species; population densities may be highly variable; spatial structure can be difficult to ascertain; population of interest can be difficult to define.	Critical that population of interest is clearly defined; examples exist where this has been done, e.g. specific runs of salmon, herring. Baseline typically is unknown; extent of datasets may depend on importance of resource. Difficult to show cause and effect relationships to a specific stressor. Generally requires long-term studies that may be cost-prohibitive for NRD settlement purposes. May depend on required accuracy of injury and type of population. **ADDITIONAL PERSPECTIVE:** Fundamental assessment method for quantifying injury and service losses. Recommended approach for most species.

Communities	Species diversity, Species richness, Dominance, Community composition, Habitat structure and function	High ecological relevance; may control ecosystem processes; strong theoretical background in disturbance ecology; variety of statistical approaches available for terrestrial, freshwater and marine systems; USGS GAP program has cataloged a number of communities and habitats and mapped some areas in great detail.	Arbitrary spatial and temporal scale; taxonomic difficulties for some groups; difficult to demonstrate causal relationship between stressors and community responses; assumption of community equilibrium not always valid; historical data for many sites are not available. Data analysis tools (multivariate statistics etc) may be not readily available to some practitioners.	Community is not well-defined for mobile species (most vertebrates) that are often the focus of NRDA injury studies; Many feedback loops within a community making causal relationships difficult to demonstrate; Difficult to establish baseline and return to baseline; generally requires long-term studies that may be cost-prohibitive for NRD settlement purposes. The community of interest in this case is straightforward to identify by understanding the habitat of the species of interest. For many vertebrate species there are descriptions of habitat--loss of habitat corresponds to a loss of community function that can reduce the numbers of the population of interest. **ADDITIONAL PERSPECTIVE:** Recommended for quantification of injury to some biotic groups. Most applicable to benthic macroinvertebrates and fishes. Potentially useful for small mammals and birds.
Ecosystems	Nutrient cycling Energy flow Decomposition Primary production Secondary production Spatial structure	High ecological relevance; responses are closely related to ecosystem services, especially nutrient cycling, climate, and the overall spatial structure of habitats. Remote sensing data are available for much of North America and the coastal regions; serves as an appropriate scale for examining the interactions of natural and human systems (urban areas and wildlands).	High variability; relative insensitivity; functional redundancy; low specificity to stressors; limited understanding of background conditions & underlying mechanisms; little agreement over which ecosystem processes are most important; relatively expensive analyses & often requires extensive computing resources; confounding factors make determination of causality problematic; data analysis tools are being developed & data	Same issues as listed for community, only generally more internal feedback loops that result in a relatively higher degree of homeostasis; determining causal relationships to stressors and establishing baseline is problematic; generally requires long-term studies that may be cost-prohibitive for NRD settlement purposes. Homeostasis is no longer a recognized feature of ecological systems in most current models. Ecological systems are now generally recognized to be dynamic, patchy, and non-linear. The number of interactions may also lead to a system more vulnerable to rapid change. **ADDITIONAL PERSPECTIVE:** Not recommended for quantifying injury because of high costs, scientific complexity, lack of available tools, and interpretive difficulties.

			are often @ different scales of spatial & temporal resolution.	
Habitat	Habitat equivalency factors; Habitat suitability index models; GAP habitat criteria from remote sensing. Habitat can also be classified as to type (rocky intertidal, tidal, marine, etc.	Critical to the preservation & maintenance of populations & individuals. In certain circumstances the amount of available habitat can be used as a surrogate for estimating the size of a population within a geographic region. Habitat classification should be specific to the type of species being protected, restored or for which compensation is being sought. Habitat can be mapped with current remote sensing and geographic information system tools, and in some areas the information is widely available.	The habitat requirements of the species under consideration should be known. In some instances the mapping data may not be available. Presence of habitat does not mean that the species is in the area.	Habitat analysis has been the basis of many NRD Assessments, primarily based on the Habitat Equivalency Analysis (HEA) methodology. HEA is a useful tool for NRD application and settlement of cases. HEA addresses the type and scale of restoration and services to compensate for interim loss of resource. HEA input parameters are generally readily estimated, e.g. duration and extent of injury, reduction in quality and quantity of services normally provided by injured resources, recovery period, relative service levels of replacement resources. HEA provides a means for calculating compensation in lieu of determining dollar-value for habitat services. **ADDITIONAL PERSPECTIVE:** Recommended for quantifying injury and service losses when the release directly affects habitat quality and/or quantity, such as vegetation structure.