For the purposes of strategy development, we used expert elicitation to evaluate the consequences of alternative strategies. Expert elicitation can provide important information for decision making when sufficient data from research or monitoring is not complete or available (U.S. Environmental Protection Agency 2011, Drescher et al. 2013). We followed published best practices for expert elicitation to obtain experts' judgments on likely outcomes for conservation benefits and costs along with uncertainty in those judgments if alternative strategies were implemented (Gregory et al. 2012, Drescher et al. 2013). The general modified-Delphi process was to (1) carefully and systematically achieve a common understanding among experts of the questions being asked, (2) elicit a first round of judgments, (3) discuss the rational for those judgments, and (4) repeat the steps as necessary until experts finalized their judgments.

The decision problem was to identify the management approach that would best achieve the conservation objectives. The alternative management approaches were defined by the effort allocated to a set of specific management actions. Further, the team aimed to identify which species and locations would be most likely to benefit from the implementation of the best management approach.

The alternative management approaches do not emphasize any one set of management actions to the exclusion of another. For example, habitat management will continue if population management is emphasized, and stressors will continue to be identified, studied, and ameliorated. Rather than selecting one type of management action to the exclusion of another, the purpose of strategy development is to optimize allocation among a large array of management actions through a selected approach.

Strategy development included the following steps:

1. Determine conservation objectives and specify performance measures for each objective.
2. Identify a comprehensive set of management actions (Appendix 4) and formulate broad actions and approaches that address threats and factors limiting species recovery.
3. Predict the consequences on species and habitat and estimate the costs of implementing each management approach within management units of the UTRB.
4. Identify the management approach that best achieves the conservation objectives of maximizing conservation benefit while minimizing costs.
5. Prioritize species for focused management based on level of imperilment[1], likely conservation benefit (as predicted from step 3), and species-specific management cost.
6. Prioritize locations for general habitat management based on diversity (richness) of imperiled species and feasibility of habitat improvement at each location.

Goals and Objectives

The goal of the Strategy is to maximize conservation and recovery of imperiled aquatic species and the UTRB ecosystem upon which they depend. Ecosystem conservation is implicit because to recover imperiled species ecosystems must be included. Objectives were outlined and used to guide the strategic planning process (Figure 6). A distinction is made between objectives that are

[1] The degree of imperilment is relative amongst species considered in the Strategy and a lower degree of imperilment should not be construed to suggest any specific determination regarding any pending listing/delisting action.

fundamentally important (i.e., fundamental objectives) and those that are means to achieving the fundamental objectives (i.e., means objectives). Fundamental objectives were to: (1) maximize imperiled species persistence and viability and (2) maximize operational efficiency (Figure 6). The species persistence and viability objective was considered separately for fishes and mussels to allow for faunal group-specific differences when considering conservation actions. Maximizing habitat quality and maintaining genetic diversity were treated as means objectives that would contribute to population persistence. The operational efficiency objective was defined as minimizing management costs so that the relative cost-benefits of conservation actions could be analyzed.

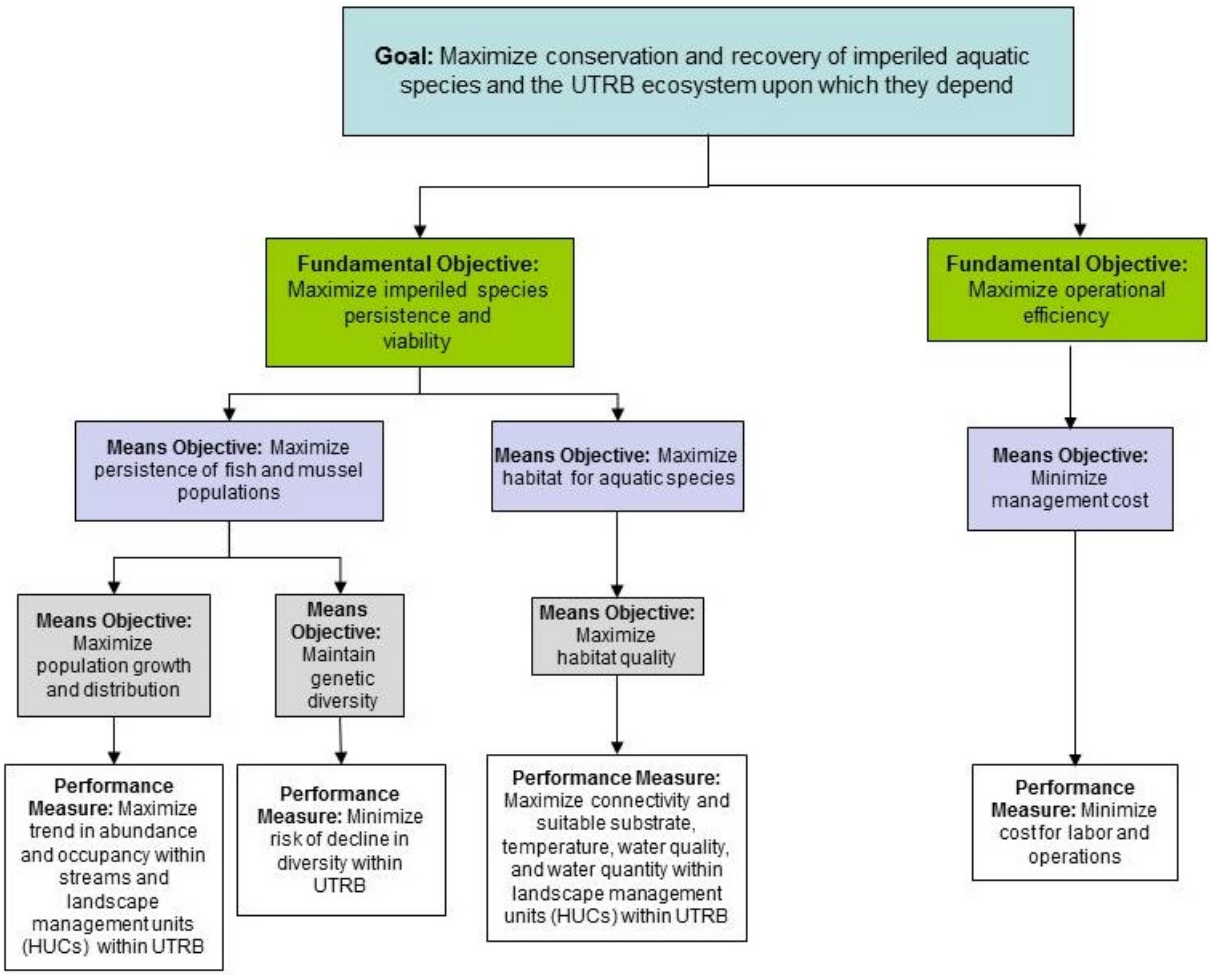

Figure 6. Hierarchy organizing the general goals and fundamental objectives for strategic decisions for conservation of imperiled aquatic species in the UTRB.

In SDM processes, performance measures are used to compare how well actions and approaches are likely to perform with respect to management objectives. These measures should not be arbitrary but should be easily recognized as relevant to the objectives (Keeney 1992, Game et al. 2013). In this application of SDM, the performance measures for the species persistence objective were trend in abundance, number of habitat units occupied (distribution), and risk of decline in genetic diversity. The performance measure for habitat quality was based on the

presence of the following habitat elements: connectivity and suitable substrate, temperature, water quality, and water quantity. The performance measures for operational efficiency were based on management cost as measured by staffing levels and operational costs.

Alternative Management Approaches

Formulation of alternative management approaches was guided by identifying primary threats and ecological factors that currently limit imperiled species population growth, distribution, and viability. The limiting factors considered were predation, invasive species, physical habitat, host fishes (mussels only), flows, water quality (dissolved oxygen, temperature, contaminants), lack of dispersal/fragmentation, disease, and depensation due to low density (Allee effect). Experts[2] ranked the top three limiting factors for imperiled fishes and mussels. A rank of 1, 2, and 3 received 30, 20, and 10 points, respectively, and then the points were summed for each factor separately for fishes and mussels. The summed scores were standardized between 0 and 100 for least to most important, respectively (Table 3). Depensation, contaminants, and lack of dispersal/fragmentation were among the top three limiting factors for both fishes and mussels.

Table 3. Ranking of factors that could limit the persistence of imperiled fishes and mussels in the UTRB.

Potential Limiting Factors	Standardized Score for Fishes	Standardized Score for Mussels
Depensation (Allee effect)	88	100
Water quality – contaminants	100	89
Lack of dispersal/fragmentation	88	78
Physical habitat	50	33
Host fish	0	22
Flows	13	11
Predation	0	0
Invasive species	0	0
Water quality – dissolved oxygen	0	0
Water quality – temperature	0	0
Disease	0	0

Two broad approaches were considered to address the limiting factors: population management emphasis and habitat management emphasis. Population management emphasis addresses low population size (depensation) and lack of dispersal/fragmentation by increasing extant populations (augmentations) and establishing additional populations (reintroductions/ introductions) through propagation and release of cultured individuals and translocated adults into suitable habitat. Habitat management emphasis addresses water quality, physical habitat, and flows by protecting or restoring occupied and unoccupied habitat within the historical range of imperiled species. These two approaches—population management emphasis and habitat management emphasis—were compared to a status quo management approach, which is a continuation of the management actions currently being implemented by USFWS.

An inventory of management actions (Appendix 4) was taken along with associated costs (Appendix 5). Management approaches were defined by the relative level of effort or agency resources committed to implementing management actions (Table 4). The three alternative approaches considered did not indicate exclusive reliance on either habitat or population management emphasis actions. Instead the alternatives represented different shifts in the types of management actions that would be emphasized (Table 4). For example, a high level of effort

[2] Brian Evans, Catherine Gatenby, Roberta Hylton, Cindy Schulz, and Peggy Shute.