



Glossary

Adaptive Management (AM) (v1) - Management in the face of uncertainty, with a focus on its reduction (Williams and Johnson 1995).

Adaptive Management (v2) - adaptive management is a flexible decision making process that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. (DOI Technical Technical Guide)

Adaptive Management (v3) - adaptive management is a flexible decision making process that can be adjusted as outcomes from management actions and other events become better understood. When there is uncertainty about the outcomes of management, competing models capture that uncertainty and make predictions about how the system will react. By monitoring the system's reaction to management and comparing the result against the predictions of each of the competing models, we can discern over the long run which of the candidate models produces better predictions and then favor that model in future decisions (adapted from DOI Technical Guide and Kendall 2001).

Adaptive Management (v4) - adaptive management, also known as adaptive resource management, is a structured, iterative process of optimal decision making in the face of uncertainty, with an aim to reducing uncertainty over time via system monitoring. In this way, decision making simultaneously maximizes one or more resource objectives and, either passively or actively, accrues information needed to improve future management. AM is often characterized as "learning by doing." (Wikipedia, August 2008)

Adaptive Management, active - the form of adaptive management that is most like a scientific experiment, with random assignment of treatments and a full range of experimental treatments and controls.

Adaptive Management, passive - a form of adaptive management in which many of the requirements of a scientific experiment are not met, but the overall process is still approached with learning as a major objective

Adaptive Resource Management (ARM) - see adaptive management

Adaptive Stochastic Dynamic Programming (ASDP) - goes one step beyond stochastic dynamic programming by incorporating epistemic uncertainty

Affective (psychology) - relating to or resulting from emotions or feelings rather than from thought.

Aleatory Uncertainty - dependent on chance or luck - an inherent variation associated with the physical system or the environment; also referred to as variability, irreducible uncertainty, and stochastic uncertainty, random uncertainty.

Algorithm - a logical arithmetical or computational step by step procedure that, if correctly applied, ensures the solution of a problem.

Alternatives. Different management actions that are available. This element requires explicit articulation of the alternatives available to the decision maker. The range of permissible options is often constrained by legal or political considerations, but structured assessment may lead to creative new alternatives.

Alternative Branch - a branch emanating from a decision node representing one available alternative.

Alternative Dispute Resolution (ADR) - is a term that encompasses a spectrum of processes that can be used to resolve claims or disputes. These processes provide alternatives to traditional judicial or administrative adjudications where a judge is responsible for resolving the dispute for the litigants. ADR processes are voluntary, give the parties greater control over the outcome of their dispute, and are generally more flexible and less contentious and allow for more creative solutions.

Alternative Hypothesis - see Null hypothesis

Ambiguity - uncertainty arising from the fact that a word can have more than one meaning and it is not clear which meaning is intended, the lack of clear goals and objectives.

AHP (Analytical Hierarchy Process). One of several specific methods of analyzing tradeoffs when a decision contains multiple objectives. AHP involves structuring multiple choice criteria into a hierarchy, assessing the relative importance of these criteria, comparing alternatives for each criterion, and determining an overall ranking of the alternatives. AHP involves a relatively complex mathematical procedure, so a computer package has been developed to support the method.

Anchoring - the tendency to be influenced by initial estimates - people will be drawn to the guesses made by others, and will defer their judgments to people they believe have greater authority

Assumption - something taken to be true without proof or demonstration

Assessment - obtaining a range of outcomes (usually over an 80% range of uncertainty: "10-50-90" for a particular uncertainty from an informed expert acceptable to the decision maker or decision board.

Assumptions Analysis - see sensitivity analysis.

Attribute (criteria) - a quantitative measure of performance associated with a particular criterion according to which an alternative is to be evaluation. Attributes fall into three categories 1) natural; 2) constructed; and 3) proxy.

Bayes' Net - a Bayes Net is a system model that is specifically designed to propagate uncertainty from the input to the outcomes.

Bayes' Theorem - a result in probability theory that relates conditional probabilities. It can be seen as a way of understanding how the probability that a theory is true is affected by a new piece of evidence.

Bayesian Analysis - provides a mechanism for combining knowledge from subjective sources with current information to produce a revised estimate of a parameter.

Bayesian Belief Networks (BBN) - (also called probability networks, influence networks, and belief networks). Graphical models that represent relationships among uncertain variables, in which probabilities may be estimated subjectively and updated using Bayes' theorem.

Belief - the degree to which a proposition is judged to be true, often reported on an interval (0,1) or percent scale creating an analogy with 'chance'.

'Bounded Rationality' - perception and uncertainty limit the ability of people to achieve goals. People construct simple models to deal with these difficulties. The key idea is that people 'satisfice' rather than optimize.

Calibration - the likelihood that the expert's probabilities correspond with a set of repeated experimental results, the probability that the difference between the expert's judgment and the observed values have arisen by chance.

Calibration Curves - expert judgments plotted against reality.

Calibration of Models - adjusting model parameters, structures and assumptions so that they fit available data an intuition, i.e., refinement of ideas.

Carrying Capacity - the maximum number of individuals that a given environment can support indefinitely, usually determined by the organism's resource requirements.

Cause-consequence Diagram - another name for a logic tree.

Causal Web - an epidemiological model showing the linkages between a set of factors that may lead to a specific condition, which is usually the outcome of a chain of causes, rather than a single cause, that acted together, often in complex ways. Causal webs are developed to provide a framework for thinking about the relationships between these causes and for developing strategies for controlling, managing, and/or preventing the condition.

Central Tendency - the tendency of the values of a random variable to cluster around the mean, median, and mode.

Chance - the frequency of a given outcome, among all possible outcomes of a random process, or within a given time frame.

Claim - as assertion or proposition, usually the end result of an argument, but neither necessarily certain or true.

Clairvoyant - a being having the ability to see the future with perfect clarity. Useful for structuring uncertainties and assessing the value of information (S).

Clairvoyance Test - a test for determining clarity; when a question can be answered or a statement can be said to be true or false relying solely on facts - not interpretation or inference - it passes the clairvoyance test.

Closure - see consensus, negotiation.

Coefficient of Variation - a measure of the relative variation of a distribution independent of the units of measurement; the standard deviation divided by the mean.

Cognitive Availability - the tendency to judge the probability of an event by the ease with which examples are recalled.

Conceptual Model/Diagram - verbal models, diagrams, logic trees, or sets of mathematical equations representing components in a system, including input and output, flows, cycles, system boundaries, causal links, and so on.

Conditional Probability - the probability of occurrence of an event given the occurrence of another conditioning event.

Confidence - the degree to which we are sure that an estimate lies within some distance of the truth.

Confidence Interval - in the long run, someone who computes 95% confidence intervals will find that the true values of parameters lie within the computed intervals 95% of the time.

Conflict (or Dispute) Resolution - is a process of shared discussion until (if it works) parties agree on a solution.

Conflict Assessment/Situation Assessment/Conflict Analysis - a pre-negotiation procedure conducted by a neutral third party to gather information and make recommendations on whether to proceed with some ADR or consensus-building process, and if so, to assist with appropriate process design. The objective is generally to identify key issues and stakeholders, analyze the

Consensus Building - seeks to bring all relevant stakeholders together on a face-to-face basis, assisted by facilitators, to engage in collaborative problem solving

Consequences - The results of different management actions, in terms that are relevant to the management objectives. Often, we predict the consequences of the alternative actions with some type of model. Depending on the information available or the quantification desired, consequences may be modeled with highly scientific computer applications or with professional judgment elicited carefully and transparently. Ideally, models are quantitative, but they need not be; the important thing is that they link actions to consequences.

Consensus - a means of achieving closure in which the experts agree that a particular position is "best"

Constraint - a limitation imposed by external conditions

Context - the setting of the problem at hand

Contingent Valuation - a method for valuing intangibles in cost-benefit analysis. It uses questionnaires and/or interviews to elicit preferences and demand functions for environmental goods and services.

Contraction (of info-gap models) - the nominal value v is the only possible value in the absence of uncertainty.

Convergence - behavioral consensus techniques in which participants agree to negotiate to resolve conflict.

Co-optation - a means of achieving resolution in which experts acknowledge that the conflict is 'resolvable', and sound argument, consensus, or negotiation may bring closure.

Cost-benefit Analysis - examination, usually in economic terms, of the advantages and disadvantages of a particular course of action.

Credibility - the believability of detail in a narrative or model (acceptance of ideas based on the skill of the communicator, the trust placed in a proponent).

Criterion - a particular perspective according to which decision alternatives may be compared, usually representing a particular interest, concern, or point of view.

Cumulative Probability - a cumulative probability distribution gives the probability, p , that the random variable X will be less than or equal to some value x . It sums the value of the probability distribution from left to right.

Cumulative Probability Distribution - a chart with probability on the y-axis and value on the x-axis, which describes the entire range of probable outcomes resulting from a course of action. The chart is always read from right to left, stating the probability Y and the value as X or less.

Decision - a choice between two or more acts, each of which will produce one of several outcomes, a conscious, irrevocable allocation of resources with the purpose of achieving a desired outcome, a judgment on an issue under consideration; the act of making up one's mind or reaching a conclusion, a verdict reached or a judgment announced.

Decision Aiding - an alternative approach to stakeholder participation using a structured process based on constructive, multi-attribute techniques and value-focused thinking.

Decision Analysis - is a methodology and set of probabilistic frameworks for facilitating high quality, logical discussions; illuminating difficult decisions, and leading to clear and compelling action by the decision maker.

Decision Analysis Cycle - a systematic approach for solving problems; *structuring* a problem to capture the essentials, *evaluation* to gain insight, and *agreement* with the world to make something happen.

Decision Hierarchy - a method to organize decisions into those that are policy or constraints, those which are the focus of the analysis, and others which are required for implementation.

Decision Maker - person or team with the responsibility and authority to allocate resources and implement the decision.

Decision Making (descriptive) - how people actually do make decisions.

Decision Making (prescriptive) - a rational framework for how people should make decisions, and techniques to aid them doing so.

Decision Node - a point in a decision tree where a decision must be made.

Decision Tables - tables that link acts, states, and outcomes. The acts refer to the decision alternatives, the states refer to the relevant possible states of the system, and the outcomes refer to what will occur if an act is implemented in a given state.

Decision Tree - a sequential graphical representation of decisions and uncertainties which represent all paths the decision maker might follow through time. There are four basic elements from which a decision tree is constructed: decision nodes, alternative branches, probability nodes, and outcome branches.

Decomposition - thinking about and describing the different parts of your problem.

Delphi (method, technique) - a form of behavioral aggregation that consists of questionnaires, elicitation, aggregation of results, review of combined results by experts and iteration of feedback until consensus is achieved.

Demographic Variation - the chance events in the births and deaths of a population.

Demographic Stochasticity (with reference to risk assessment) - the variation in the average chances of survivorship and reproduction that occur because of the demographic structure of populations made up of a finite, integer number of individuals; random sampling of distributions for variables which must logically take a discrete integer value.

Density Function - (see probability function)

Density Dependence - this is when survival or fecundity is a function of the difference between the total number of adults and the carrying capacity of the environment, creating a feedback between population size, and the rate at which the population grows.

Dependency of a Variable (statistical) - implies that variation in one variable contributes to or causes the values in another variable.

Detectable Effects Sizes (d) - if data x are not statistically significantly different from H_0 (the null hypothesis), and the power to detect effect d is high, then x constitutes good evidence that the actual effect is not greater than d . Conversely, if data x are not statistically significantly

different from H_0 , and the power to detect effect d is low, then x constitutes poor evidence that the actual effect is not greater than d .

Deterministic Model - a model in which there is not representation of variability.

Deterministic Sensitivity - if a parameter is changed by a small amount in the region of the best estimate, it is the magnitude of change we see in model output, relative to the amount of change in the parameter.

Diminishing Return - the utility resulting from any small increase in wealth is inversely proportional to the quantity of goods already possessed.

Discontinuity - (Context-specific definition not available) 1. Lack of continuity or cohesion. 2. gap. (Merriam-Webster Online Dictionary)

Dispersal (with reference to PVAs) - the movement of individuals among spatially separate patches of habitat, including all immigration and emigration events.

Dispute Resolution (see conflict resolution)

Dominated Alternative. - An alternative in which all objectives are better met by other possibilities under consideration.

Dynamic Programming (DP) - is a method (that bears some resemblance to linear programming) for solving problems where temporal dynamics are important.

Efficiency Frontier. In a multiple-objective setting, the boundary at which no objective can be better achieved without some sacrifice relative to another objective. The optimal solution is located on the efficiency frontier, but where on the frontier depends on how the tradeoffs among objectives are valued.

Empirical - derived from or relating to experiment and observation rather than theory.

Environmental Conflict Resolution (ECR) - third-party assisted conflict resolution and collaborative problem solving in the context of environmental, public lands, or natural resources issues or conflicts, including matters related to energy, transportation, and land use. ECR processes can be applied during a policy development or planning process, or in the context of rulemaking, administrative decision making, enforcement, or litigation and can include conflicts between federal, state, local, tribal, public interest organizations, citizens groups and business and industry where a federal agency has ultimate responsibility for decision-making.

Environmental Variation - variation in climate, landscapes, and other unpredictable influences that lead to uncertainty about the effects of management.

Epistemic Uncertainty - reflects incomplete knowledge, including measurement error, natural variation, model uncertainty; and subjective judgment.

Estimation - the aggregation of field data into measures of resource attributes. Examples include means, variances, and correlation coefficients computed with sample data. Multiple estimators are always available for any resource attribute, and the choice of which particular estimator to use is based on statistical features such as bias and precision.

Experimentation - the imposition of treatments on subjects or experimental units for the explicit purpose of learning about treatment effects by observing outcomes. Ideally experimentation involves random allocation of treatments to experimental units, replication of treatments, and the use of controls for comparative purposes.

Experimental Management - the use of management interventions for the purpose of understanding the effects of management. Interventions are used as experimental treatments, ideally (but infrequently) in the context of randomization, replication, and experimental control.

Even Swap - to adjust the consequences of different alternatives to render them equal for a given objective (and then that objective becomes irrelevant)

Event Tree - a form of logic tree, an event tree begins with a triggering event and follows all possible outcomes to their final consequences (event tree analysis).

Evidence - direct experimental observation of cause and effect, probability or frequency.

Expected Utility - the magnitude of an anticipated gain, discounted by the chance that the outcome will be achieved.

Expected Value of Information - the difference between the current state of knowledge and what might be learned from a given strategy.

Expert - someone who has knowledge, skill, experience, training, or education about an issue at an appropriate level of detail and who is capable of communicating their knowledge. See also substantive expertise and normative expertise.

Exponential Distribution - the time between random, successive events, sometimes called the negative exponential distribution

Fault Tree - a form of logic tree, linking chains of events to the outcome (fault tree analysis)

Fecundity (with reference to PVA's) - the number of offspring born per adult, and alive at the time of the next census.

First Prototype - see Rapid Prototyping

Fixed Probability - method of asking a series of questions to elicit points on a distribution in which values of the variable that bound specified quantiles were elicited. Answers to these questions approximate points on a cumulative density function (a 'cdf'). The assessor concentrates on medians, quartiles, and extremes (such as the 1% and 99% limits).

Fixed Value - method of asking a series of questions to elicit points on a distribution in which the assessor asks experts to judge the probability that the variable lies within a specified interval. The answers approximate points on a probability density function (a 'pdf').

Frequentist Statistics - see probabilities as relative frequencies (as opposed to Bayesian statistics).

Fundamental Objective. One of the ultimate goals of the decision. An objective that we care about for its own sake, or which is an end in itself. See also *Means Objective*.

Heuristic - a rule of thumb.

Hierarchical Holographic Model (HHM) - an approach that recognizes that more than one conceptual model is possible for any system, and tries to capture the intuition and perspectives embodied in different conceptual and mathematical models of the same system.

Hypothesis - a suggested but unconfirmed assertion or explanation of observed patterns. Hypotheses can take many forms, for example, a hypothesized magnitude of a resource attribute or a mathematical relationship between attributes. Hypotheses are tested by comparison against field data.

Incertitude - lack of knowledge about parameters or models (including parameter or model uncertainty).

Indicators - biological entities whose interactions with an ecosystem make them especially informative about communities and ecosystem processes.

Indifference - indifference between two opportunities means they are equally desirable or indistinguishable in terms of value to the decision maker.

Influence Diagram - a visual representation of the functional components and dependencies of a system. Shapes (ellipses, rectangles) represent variables, data, and parameters. Arrows link the element, specifying causal relations and dependencies, a graphical representation of decisions and uncertainties which shows what is known and uncertain at the time of each decision and the dependence and independence of each uncertainty on all other decision and uncertainties.

Irrelevant Objective. An objective with an equal or near equal outcome in all alternatives. If one occurs, the objective can be removed from the analysis. This does not mean the objective is not important to the decision-maker, just that it does not provide any power to discriminate among the alternatives.

Intractable - hard to manage; unruly or stubborn; hard to work, manipulate, cure [and] treat.

Joint Fact Finding - is a procedure for involving those affected by policy decisions in the continual process of generating and analyzing the scientific and technical information used to inform those decisions. Joint fact finding and conflict resolution both focus on stakeholder participation and communication.

Kaizen Process - is a Japanese term promoting a rapid improvement process. The philosophy implies that small, incremental changes routinely applied and sustained over a long period result in significant improvements. A *kaizen* strategy aims to involve workers from multiple functions and levels in the organization in working together to address a problem or improve a process. The team uses analytical techniques, such as value stream mapping and "the 5 whys", to identify opportunities quickly to eliminate waste in a targeted process or production area. The team works to implement chosen improvements rapidly (often within 72 hours of initiating the *kaizen* event), typically focusing on solutions that do not involve large capital outlays.

Likelihood - the extent to which a proposition or model explains available data (the relation between hypothesis and evidence). *See also* maximum likelihood.

Linguistic Uncertainty (verbal imprecision) - arises because language is not exact, including vagueness, context dependence, ambiguity, indeterminacy and underspecificity.

Linked Decision. A decision that is connected to another antecedent or subsequent decision. Finding the optimal solution to a linked decision requires anticipating the consequences to future decisions.

Logic Trees - diagrams that link all the processes and events that could lead to, or develop from, a hazard. They are sometimes called cause-consequence diagrams. *See also* fault tree and event tree.

Management by Experiment - an approach to management that recognizes management interventions as experiments, by means of which understanding can be enhanced as management proceeds through time.

Management Action - an action affecting a managed system, taken as a result of a management decision. In the context of natural resources, management actions typically influence the status of resources or the processes that control resource dynamics.

Management Alternative - a potential management action. In sequential management, a management action is selected at each point in time from an identified set of management alternatives. The set of management alternatives constrains and influences the choice of a management strategy.

Management Decision - a decision to take a management action. In adaptive management, decision making typically is driven by management objectives, with active stakeholder involvement. Adaptive decision making takes into account both the current status of resources and the level of understanding about them.

Management Option - used interchangeably with management alternative.

Management Strategy - a prescription of management actions pursuant to management objectives. In the context of adaptive management, a management strategy describes time-specific management actions to be taken, conditional on current resource status and the level of

- understanding about resource dynamics. Management strategies often are expressed in terms of resource thresholds, on either side of which a different action is to be taken.
- Means Objective* - An objective that is not sought for its own sake, but as a means of achieving a more fundamental objective.
- Measurable Attribute* - A metric used to assess achievement of an objective.
- Measurement Error* - error caused by imprecise and inaccurate instruments and operators.
- Median* - the point that divides an ordered set of data into two equal parts.
- Mediation* - a facilitated negotiation process, in which a skilled impartial third party with no interest in or control over the outcome of the case, assists the parties in working together to solve problems and reach their own mutually acceptable solutions to issues.
- Metapopulation* - a set of local populations which interact via individuals moving between local populations.
- Metric* - a standard of measurement.
- Minimum Expected Population Size* (in PVA) - the average minimum population size from a set of forecasts, summarizing the chances of a population falling below a lower threshold within a specified time period.
- Minimum Viable Population* - the smallest isolated population having an acceptable chance of surviving for the foreseeable future.
- Mixing or Averaging Probabilities* - probabilities associated with belief may be combined as weighted linear combinations of opinions.
- Model* - any representation, whether verbal, diagrammatic, or mathematical, of an object or phenomenon. Natural resource models typically characterize resource systems in terms of their status and change through time. Models imbed hypotheses about resource structures and functions, and they generate predictions about the effects of management actions, an explicit approximation of reality, typically expressed as a series of mathematical relationships.
- Model Averaging* - combines the predictions of a set of plausible models into a single expectations in which individual weights reflect the degree to which each model is trusted.
- Model Uncertainty* - uncertainty arising from the fact that, often, many alternative assumptions and models could be constructed that are consistent with data and theory, but which would generate different predictions.
- Monitoring* - sampling and analysis to determine compliance with a standard or deviation from a target or prediction, or to measure the state and response of the system to management strategies.
- Monte Carlo Analysis* - uses statistical distributions to represent different kinds of uncertainty, combining them to generate estimates of risk.
- Motivational Bias* (strategic bias) - biased assessments that arise because the results benefit the people who make the assumption.
- Multi-attribute Utility Theory* - a utility-based criterion theory for decision making in which a utility function that incorporates the outcomes of all important attributes is used in place of economic value.
- Multicriteria Decision Analysis* - measures preferences by eliciting and ordering judgments from people affected by a decision.
- Multicriteria Mapping* - takes the philosophical position that risks are socially constructed and (mostly) difficult to measure and uses the preferences of individuals to explore alternative management options.
- Multiple-objective Tradeoff Analysis* - A set of techniques for choosing among alternatives when there are multiple competing objectives. The various methods include ways of reducing the

- number of alternatives (by identifying dominated alternatives), reducing the number of objectives (by finding irrelevant objectives), and negotiating the remaining tradeoffs (often through weighting the objectives).
- 'Negative' or Null Hypothesis* - an a priori assumption that there is no effect of a treatment or impact of an activity.
- Negotiation* - a means of achieving closure in which an arranged resolution is reached that is acceptable to the participating experts and that is 'fair' rather than correct.
- Nesting* (of info-gap models) - a family of nested sets of possible values of the uncertain entity.
- Neutral Third Party* - facilitator/mediator - impartial third party neutral who can be used in a variety of situations to help to keep the parties talking, listening, operating consensually, and moving forward towards meeting their objectives to their mutual satisfaction. Where the parties seek an agreement, the facilitator assists the parties in working together to achieve a mutually satisfactory resolution or a "good outcome" that is fair, based on an efficient, credible process, implementable, grounded in best information and sound technical merit, and meets the parties' interests to maximum extent possible.
- Node, e.g., Decision Node.* A point in a flowchart or decision tree where a choice must be made
- Normal Distribution* - parameters that result from the sum of a larger number of independent random processes.
- Normative Expertise* - the ability to communicate, including interpersonal skills, flexibility, and impartiality.
- Normative Theories* (of rational consensus) - expert judgment takes the form of degrees of belief about facts and in order to estimate an uncertain quantity, an analyst may combine the distributions provided by more than one expert. There is an underlying assumption that there is a fact and the job of the experts is to estimate it.
- Objectives* - An explicit statement of a desired outcome, typically expressed in subject-verb-object sentence structure. Objectives (even those that are stated in scientific terms) are always a reflection of values, so setting objectives falls in the realm of policy and should be informed by legal and regulatory mandates as well as stakeholder viewpoints. A number of methods for stakeholder elicitation and conflict resolution are appropriate for clarifying objectives.
- Odds ratio* - expresses the probability of one outcome relative to the probability of its opposite.
- Outcome* - the subsequent events that determine the ultimate desirability of pursuing a particular alternative.
- Outcome Branch* - a branch emanating from a probability node representing the possible outcome and its probability of occurrence.
- Outranking* (multicriteria decision analysis) - methods used when preferences cannot be expressed as a unique numerical function, when at least one criterion is not quantitative or when compensating gains and losses among criteria are not clear.
- Partial Observability* - uncertainty about the effectiveness of management due to an inability to precisely monitor the status of a population.
- Partial Controllability* - uncertainty about the effectiveness of management due to differences between the intended versus the actual ability to deploy the management action.
- Population Viability Analysis (PVA)* - the use of population models to estimate extinction risk and to compare management options in terms of risk of decline of a population or metapopulation.
- Possibility* - the set of things (events, outcomes, states, propositions) that could be true, to which some (nonzero) degree of belief or relative frequency might be assigned.

Posterior Probabilities - estimates of the prior probabilities (probabilities, distributions) are combined with Bayes' theorem to give posterior probabilities, the updated degrees of belief that the hypotheses are true.

Power (statistical) - the probability of detecting a given true difference between two 'populations' (data sets) when using a statistical test.

Precautionary Principle - where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

Preference - the decision maker's attitude toward the value, timing, and uncertainty of outcomes.

Preference Matrix - the result of pairwise comparisons of preferences between criteria. The elements of the first (dominant) eigenvector of the matrix can be used as the weights for each criterion.

Prior Probabilities - represent the probability that the data would be observed, if the various hypotheses were true. It requires the experts to specify their subjective belief in a distribution, prior to the analysis, even if no data are available.

ProACT - an approach to decision making consisting of eight core elements starting with identifying the Problem, Objectives, Alternatives, Consequences, and Trade-offs - then moving on to clarify and evaluate uncertainty, risk tolerance, and linked decisions. Described in detail in *Smart Choices: a practical guide to making better life decisions* by J.S. Hammond, R.L. Keeney, and H. Raiffa.

Probability - the statistical frequency (or relative frequency) with which an event is expected to occur, or the degree of belief warranted by evidence; see also belief, chance, confidence, credibility, cumulative probabilities, likelihood, plausibility, possibility, risk, posterior probabilities, prior probabilities, tendency), a number between zero and one (inclusively) representing the degree of belief a person attaches to the occurrence of an event.

Probability Density Function - the distribution of relative frequencies of different kinds of events (outcomes).

Probability Networks - see Bayesian networks.

Probability Node - a point in a decision tree where an uncertainty will be resolved; often called a chance node.

Problem - a question or situation that presents doubt, perplexity or difficulty; a question offered for consideration, discussion, or solution.

Problem Definition. The first step in a structured analysis of a decision, in which the nature and scope of the decision is clarified. It helps to ask some of the following questions: Who is the decision maker? What specific decision has to be made? What are the spatial scope of the decision? When does the decision have to be made? Will the decision be iterated over time?

Process Model - a mathematical representation of a conceptual model, such as a population model, an expert system, a logic tree, or any other quantitative model.

Prototype - an original type, form, or instance that is a model on which later stages are based or judged.

Public Participation - deliberation on the issues by those affected by the decision.

Quantiles - a point in the ordered data set below which a specified percentage of the data lie.

Quartiles - the point below which 25%, 50% or 75% of the data of an ordered set lie. The third quartile is the interval between the first and third quartiles and it encloses 50% of the data.

Range (statistical) - the interval between the smallest and largest values of an ordered set.

Rapid Prototyping - an approach to structured decision making that involves quickly framing a simple prototype of the decision problem then stepping back to assess its basic structure and major components. Rapid prototyping is very useful for quickly validating objectives, evaluating model components, and setting parameters for sensitivity analysis with a minimum investment of time. The rapid prototype concept comes from engineering (quickly building a trial version of a new device or machine to see if it will work), and is useful for structured decision analysis and biological model building in natural resource management.

Regret - the difference between the result of the best action and the result of the action taken.

Relative Criteria - Measurable attributes for objectives that can be valued on a continuous scale, or a discrete, ordinal scale. In this way, the objective can be partially achieved. See also *Threshold Criteria*

Relative Risk - the chance of an event in an exposed population relative to the chance in the unexposed population, i.e., the change in risk experienced by a group, relative to the risk they would have experienced had they belonged to the reference class.

Risk - the chance, within a time frame, of an adverse event with specific consequences.

Risk Analysis - evaluation and communication of the nature and extent of uncertainty.

Risk Assessment - the analytical side; completion of all stages of the risk management cycle, a marriage of risk analysis methods, adaptive management, decision tools, monitoring and validation.

Risk Aversion - when people prefer to have a smaller reward with greater certainty, than a larger reward with less certainty.

Risk Tolerance - How the decision maker evaluates alternatives in the face of uncertainty. Identifying the uncertainty that impedes decision-making, then analyzing the risk that uncertainty presents to management is an important step in making a good decision. Understanding the level of risk a decision-maker is willing to accept, or the risk response determined by law or policy, will make the decision-making process more objectives-driven, transparent, and defensible.

Robust Decisions - decisions that provide a satisfactory outcome, despite uncertainty, thereby avoiding unacceptable outcomes.

Robust Satisficing - a strategy that maximizes the reliability of an adequate outcome.

Satisficing - an alternative to optimization for cases where there are competing, multiple objectives in which one gives up the idea of obtaining a "best" solution. In this approach one sets lower bounds for the various objectives that, if attained, will be "good enough" and then seeks a solution that will exceed these bounds. The satisficer's philosophy is that in real-world problems there are too many uncertainties and conflicts in values for there to be any hope of obtaining a true optimization and that it is far more sensible to set out to do "well enough" (but better than has been done previously).

Scale - The standard of reference on which a measurable attribute is valued. A *natural scale* is one which directly measures a property of the attribute (e.g., acres, dollars). A *constructed scale* is a relative scale that identifies and describes meaningful levels of the attribute (e.g., best, better, satisfactory, worst, with clear definitions for each). A *proxy scale* is a natural scale for a related attribute that is thought to be closely correlated with the desired attribute (e.g., population size as a proxy for extinction risk).

Scenario Analysis - an approach to creating alternatives for problem formulation, constructed and communicated with a story line in which events unfold through time through a series of imagined causes and effects.

Scenarios - shared, agree mental models, internally consistent descriptions of possible futures created in structured brainstorming exercises.

Sensitivity Analysis - Measuring the impact of uncertainty on the preferred alternative or the expected performance, in order to understand the robustness of a proposed solution to the existing uncertainty. Often this is done to determine which uncertainties are critical, and perhaps allow resolution of that uncertainty prior to making the decision.

SMART (Simple Multi-attribute Ranking Technique) - One of several specific methods of analyzing tradeoffs when a decision contains multiple objectives.

Stochastic Dynamic Programming (SDP) - is similar to dynamic programming but incorporates uncertainty due to stochastic events.

Stakeholder - individuals and organizations (e.g., managers, scientists, private citizens, nongovernmental organizations) with a vested interest in a shared experience. Interests can include an expectation of received benefit, a perceived threat, a prior investment of time and/or resources, or values shared with others associated with the enterprise. Active engagement of stakeholders promotes the successful implementation of adaptive management.

Stochastic Dynamic Programming - a Markov chain that gives the transition probabilities among possible states, maximizing the chances of a desired outcome.

Stochastic Model - a model in which at least some of the parameters are drawn from statistical distributions, or in which there is some other explicit recognition of uncertainty.

Strategic Habitat Conservation (SHC) - is an approach to habitat conservation focused on providing landscapes capable of sustaining trust species populations at prescribed levels. This approach is founded on a science-based, adaptive, iterative process of biological planning, conservation design, conservation delivery, and monitoring and research.

Structural Uncertainty - a lack of understanding about biological mechanisms that limits the effectiveness of management.

Structured Decision Making (SDM) - is an approach to decomposing and analyzing decisions to identify solutions that achieve the desired objectives, in a manner that is explicit and transparent. Based in decision theory and risk analysis, SDM is a concept that encompasses a very broad set of methods, not a prescription for a rigid approach for problem solving. SDM provides clear roles for stakeholders and scientists when working on problems at the interface of science and policy. Key SDM concepts include making decisions based on clearly articulated fundamental objectives, dealing explicitly with uncertainty, and responding transparently to legal mandates and public preferences or values in decision making; thus, SDM integrates science and policy explicitly.

Subjective Belief - personal judgment in the truth of a proposition.

Threshold - the limiting value of a resource attribute that triggers a change in management actions. Management strategies often include thresholds, such that one action is specified for resource values less than the threshold and a different action is specified for a larger resource values.

Threshold Criteria - Measurable attributes for objectives that are valued on a binary scale (yes/no) and must be fully met, as opposed to objectives that one would like to fully achieve but for which partial achievement carries some value. *See Relative Criteria.*

Tractable - easily led, taught, or managed; docile; manageable; [and] governable.

Tradeoffs - In a multiple objective setting, gains in one objective that come at the cost of losses in another objective. In most complex decisions, it is not possible to perfectly achieve all objectives; the best we can do is choose intelligently between less-than-perfect alternatives.

Numerous tools are available to help determine the relative importance or weights among conflicting objectives and to then compare alternatives across multiple attributes to find the 'best' compromise solutions.

Trial and Error - an informal way to learn by experiencing a single event (or series of events) and changing future decisions based on that experience.

Type I, Type II Errors - monitoring systems should: (1) tell us there *is* a serious problem when one exists (thus avoiding overconfidence, called 'false negatives' or type II errors) and (2) tell us there *is not* a serious problem when there isn't one (thus avoiding false alarms, called, 'false positives' or type I errors)

Uncertainty - Because we rarely know precisely how management actions will affect natural systems, decisions are frequently made in the face of uncertainty. Uncertainty makes choosing among alternatives far more difficult. A good decision-making process will confront uncertainty explicitly, and evaluate the likelihood of different outcomes and their possible consequences.

Utility - a measure of the total benefit or cost resulting from each of a set of alternative actions (decisions), a scale of preferences among outcomes.

Utility function - a continuous representation of utilities. Calculations depend on a probability associated with each state.

Utility-based Criteria - decisions based on the valuation of outcomes; for example, probabilistic benefit-cost, maximizing multi-attribute utility, or maximizing/minimizing chances of extreme outcomes.

Validation/verification (of model) - comparing independent field observations with predictions, i.e., testing ideas.

Variability - naturally occurring, unpredictable change, differences in parameters attributable to 'true' heterogeneity or diversity in a population.