A whole bunch of stuff on multi-objective planning and approaches to descision support. SA, MCA, Fuzzy logic and Bayesian.

We chose a simulated annealing approach as the primary modeling framework imbedded in the decision support tool. We use an existing, well vetted and freely available third party software called Marxan (Ball and Poisingham 2001) that implements a simulated annealing algorithm. The model is used to approximate a close to optimal configuration of high priority watersheds while achieving land management preferences (for example, avoiding sub-basins with a high relative vulnerability to climate change).

This spatial simulated annealing analysis selects discrete fourth field sub-basins defined by a wide array of presence, abundance and persistence of aquatic species as well as vulnerabilities to climate change, aquatic invasives and watershed condition across the study area to achieve goal proportions for each species specified by the user through the decision support tool (DST). Goal proportions are based on the underlying data specific to each species. The goal therefore represents a proportion of the total number of units for any given species. For example, if data for a given species is collected in terms of presence / absence at the sub-basin scale, a goal of 50% would represent the 50% of all sub-basins where that species exists. For a description of the units for each species please see the data dictionary.

An objective function is calculated based on meeting these goal proportions while minimizing costs associated with selecting sub-basins in poor health or that are highly vulnerable to aquatic invasives or are at risk effects of climate change. This technique iterates through a million possible priority configurations and recalculates the objective function after each run. Initially, the algorithm *temperature* is high, allowing a wide range of possible priority configurations whether or not the objective function improves. As progress is made through the one million iterations, the *temperature* cools and only changes that improve the objective function are accepted. This process helps to avoid local minima in the early rounds and finds progressively more efficient solutions in later iterations.

The objective function can be expressed as follows:

$$\min Z = \sum_{n=1}^{P} C \times \sum_{n=1}^{p} B$$

Where:
p: Planning unit (4th field huc)
C: costs for any given unit *p (e.g.*
BLM: Boundary Length Modifier used to clump reserves
B: Boundary of selected units

The resulting priority sub-basins represent an approximation of the optimum configuration of watersheds given user specified preferences for specific species.