**OBJECTIVES**

By the end of this module, you should be able to:

* Recognize the many guides of portfolio problems
* Understand the key challenges in solving a portfolio problem

**THOUGHT EXERCISE**

* Think of a time when someone asked you to do a “prioritization” – personal or professional. Jot down a few of the specifics.
* Discuss briefly with your neighbor. Can you figure out what the underlying decision was for each of your examples?

**PORTFOLIO PROBLEMS COME IN MANY GUISES**

* Knapsack problems.
* How do you choose a collection of objects to achieve as much value as possible while remaining within certain constraints?
* Classic example. Given a number of different items, each with a mass and a value, determine which items to include in a knapsack so that the total weight is less than a given limit, and the total value is as large as possible.
* It may be that the value of a given objective depends on whether another object is included in the sack (what’s the point of having a corkscrew if you don’t have a bottle of wine?).
* In staffing an office, how many employees and in which job series and grades should you have to maximize the function of the office, while remaining within a budgeted salary cap?
* What suite of recovery actions will maximize the probability of persistence of a listed species, subject to the budget and capacity of the management partners?
* Allocation problems.
* Resources are being allocated to a number of different activities, each of which can contribute to the overall objective(s). What allocation produces the greatest value?
* FWS provides funding annually to 18 National Fish Habitat Partnerships. How should the funds be allocated to the different partnerships to best achieve the goals of the National Fish Habitat Action Plan? (See Gallagher et al. 2012)
* Within a Fish Habitat Partnership, how should the received funds be allocated among permanent staff and sponsored projects?
* How much staff time should be allocated to each bull trout Section 7 consultation that comes through the office (see Converse et al. 2011)
* “Prioritization” problems.
* Usually, these problems appear as requests to produce a prioritized list of items. But the hidden decision problem is to identify an optimal portfolio of those items to fund or implement
* The regional office asks for a prioritized list of invasive species. The ultimate decision is how to allocate funding to projects that address one or more invasive species; the decision is actually the portfolio of actions (or species) to fund.
* A Joint Venture seeks to prioritize research topics. If this is tied to a request for proposals, the decision is to select the portfolio of research proposals that collectively best reduces uncertainty to inform JV decision making.

What are the common features among these problems?

**ALTERNATIVES IN PORTFOLIO PROBLEMS**

The alternatives in portfolio problems are complex collections; they are the *alternative sets* of action elements. It’s tempting to focus on the action elements themselves (the individual species, the individual research projects) as the alternatives, but they are not. The alternatives are the possible collections. Often it is quite difficult to enumerate all the possibilities.

* Portfolios of like elements
* If you have five research proposals to select among, the 31 possible portfolios are: 1, 2, 3, 4, 5, 1&2, 1&3, 1&4, 1&5, 2&3, 2&4, 2&5, 3&4, 3&5, 4&5, 123, 124, 125, 134, 135, 145, 234, 235, 245, 345, 1234, 1235, 1245, 1345, 2345, 12345
* When allocating a fixed budget among four different programs, each program can receive between $0 and the total budget, subject to the sum of the allocations adding up to the total budget.
* Strategy table of unlike elements
* Suppose a recovery plan can contain 1 of 6 levels of habitat restoration, 1 of 5 levels of take reduction, 1 of 3 levels of disease prevention, and 1 of 2 levels of monitoring. There are 180 possible combinations of all these elements, hence 180 alternatives.

**OBJECTIVES IN PORTFOLIO PROBLEMS**

* Objectives associated with the elements of the portfolio. The individual elements may have inherent value that needs to be added up.
* Objectives associated with the collection of elements in the portfolio. There may be certain properties of the set that are desirable. For example,
* At least one project within each program receives funding.
* None of the research projects are redundant with each other.
* Constraints. Often there are constraints that limit which potential portfolios are admissible.
* Budget constraint. No portfolio that costs more than the budget is admissible.
* No set of projects that requires more staff time than the capacity of the office is admissible.

**EVALUATION OF THE CONSEQUENCES**

The alternatives are the portfolios of items; thus, the consequence analysis is of those portfolios.

* Some of the performance has to do with the value of the individual elements
* Each invasive species that is eradicated contributes a specific amount to the native biodiversity and ecosystem integrity
* Each acre of habitat adds to the carrying capacity for the population of interest
* Some of the performance has to do with the interaction of the elements
* Some interactions are synergistic—when the two elements occur together, their value is more than the sum of their individual values
* Some interactions are antagonistic—when the two elements occur together, their value is less than the sum of their individual values
* Some of the performance has to do with the entire set of elements in the portfolio

**SOLVING PORTFOLIO PROBLEMS**

1. Enumerate all the possible portfolios
2. Eliminate inadmissible portfolios (by considering the constraints)
3. Develop an automated method for evaluating any given portfolio
4. Search across all admissible portfolios for the best performance

* Brute force: evaluate every single portfolio
* Various search algorithms (combinatorial optimization, constrained optimization). The Excel “Solver” is amazingly powerful for this purpose.

**DISCUSSION**

With your neighbor, share some more examples of problems you think fit into this class. What insights are gained by thinking of them as portfolio problems?

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**MODULE DEVELOPED BY:**

Michael C. Runge, *USGS Patuxent Wildlife Research Center*

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