Why Use a Heuristic Programming Technique?
Marie Lennette, Mason, Bruce and Girard, Inc

I. What are heuristics?

Heuristic programming techniques, usually referred to as heuristics, utilize efficient rules of thumb to search solution spaces quickly. Although not guaranteeing optimal solutions, heuristic methods have the flexibility that allows all of the necessary aspects of a planning problem to be incorporated into the scheduling formulation while still providing near-optimal, realistic solutions. In addition, non-linear decision variables and constraints, such as those necessary to model economies of scale or rates of fire spread, can easily be incorporated into the problem formulation.

II. What are some advantages to using heuristics over other harvest scheduling techniques?

Spatially-explicit modeling
Features that are fundamentally spatial, such as harvest units that span stand boundaries and riparian zones, require discrete variables in order to produce exact solutions. Many non-spatial modeling techniques produce aggregated results that cannot be specifically applied to individual harvest units.

Incorporating spatially-explicit features allows the strategic model to maintain the spatial integrity inherent in a Model I formulation, but also allows for the flexible prescription assignment and easier modeling of multiple outcomes of a Model II formulation.

Strategic vs. Tactical
Heuristic scheduling effectively blurs the line between tactical and strategic planning by satisfying spatial as well as non-spatial constraints concurrently. Modeling tactical constraints at the same time that the model is developing the strategic solution allows for simultaneous recognition of various goals and constraints that may influence the outputs of each other. For example, a true spatial model considers spatial constraints while generating a solution, rather than imposing spatial realities onto a non-spatial solution as a post-processing activity. This allows the model to simultaneously find better allocations for the other
outputs as spatial constraints are imposed, which may generate a better solution that is more easily implemented on the ground.

**Strata vs. Stands**

Due to the nature of forest inventory sampling, prescription development and yield projection, and most strategic-level planning formulations, strata-based planning models are the rule rather than the exception. This is just fine, and in fact may be preferable, especially if the stand-level inventory is not very extensive. However, for those clients that have invested a lot of time and money to obtain reliable stand-level inventories, it doesn’t make sense to lose that information by aggregating stands into strata just to simplify an otherwise cumbersome modeling process.

An advantage of heuristic modeling is that simplification of the planning process isn’t necessary: there is basically no difference in the level of model development and scheduling difficulty between modeling strata or stands. The difference in runtime or the time it takes to construct the model is negligible. And because the spatial scheduling constraint is enforced simultaneously with the development of the strategic solution, there are no second-phase, post-processing, tactical concerns to bind the feasibility and reduce the value of the final solution. If our client has invested a lot of time and effort into their stand-level inventory, we can accommodate it as easily as a strata-based inventory.

**Problem complexity**

Heuristic scheduling techniques are able to handle the ever-increasing complexity of planning issues without sacrificing efficiency or spatial resolution. Even the most complicated planning problems involving spatial habitat constraints and conflicting, multiple-resource goals such as timber revenue, carbon sequestration, and water production can be formulated and solved using heuristics.

Unlike many harvest scheduling formulations, the number of planning periods, polygons, prescriptions, treatment types, constraints, etc. are not limiting factors for most heuristics. In other words, heuristic solution techniques are not limited by typical problem size issues presented by combinatorial optimization problems.

In addition, while the most complex, multi-resource planning problem with numerous spatial constraints on several million acres may take anywhere from 10 to 20 minutes to solve using a heuristic, the majority of problems are processed in a matter of seconds. This means less time waiting for results and more time for evaluating alternatives and their trade-offs.

While heuristic modeling is a powerful planning tool, no one method is always the right tool for every job. Occasionally it is advantageous to use a heuristic, but sometimes it is more appropriate to stick with linear programming or other problem solving techniques.
III. So when should heuristics be used?

Heuristics have a broad application to a range of problems. Although they can be used to solve virtually any planning problem, there are instances where they are more suited to a planning problem than other modeling techniques. Some of the situations where heuristics are particularly advantageous are outlined below.

- When modeling spatially-explicit activities that occur across strata: for example, fire may burn only part of one stratum and then go into another stratum, without regard for following strata boundaries.

- When a project is ongoing and many of the modeling goals and constraints cannot be anticipated at the start, heuristics maintain the flexibility to readily incorporate as-yet unspecified relationships and objectives without having to go back to the beginning and completely change the framework of the model.

- When there’s a need to control the shape of harvest blocks or to maintain a block size distribution. For example, if one of the goals is to create habitat for a species that thrives in edge habitat, the creation of harvest blocks that are elongated may be given priority over more compact blocks in order to maximize the edge effect. Another case may be a management goal of providing a specific distribution of opening sizes on the landscape to meet habitat requirements or for aesthetic reasons.

- When there are other spatial habitat concerns such as minimizing disturbance adjacent to nesting or other sensitive areas, increasing habitat quality as well as quantity, or managing for edge effects and minimizing forest fragmentation.

- When multiple-entry prescriptions are necessary, these are easily incorporated into the model, as well as the coordination of prescription assignment among multiple stands within a harvest unit. For example, perhaps different prescriptions (thinning intensities) may be applied within the same harvest unit (at the stand level), but the entry times need to be coordinated so that the entire harvest unit is treated at the same time. These and other complicated operational realities are easily modeled using heuristics.

- When assessing the variability in stochastic problems which inherently result in a wide variety of outcomes, many runs can be done in a very short amount of time with a heuristic, and the solution space can be explored to determine the approximate extent of the variability.

More generally speaking, if a problem must be over-simplified such that important constraints are ignored in the formulation in order to facilitate modeling with other techniques, perhaps heuristics should be considered.