Comparison of Methodologies for Limiting Opening Sizes in Forest Harvest Scheduling

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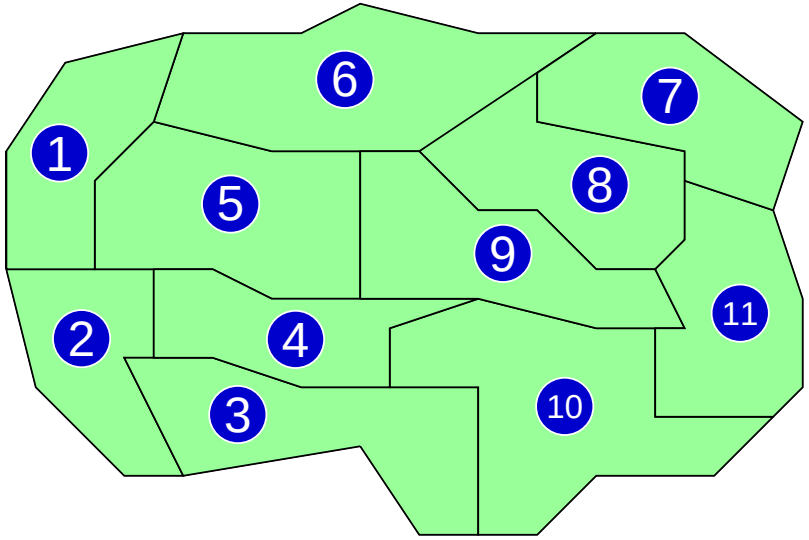
Outline

Obtain Harvest Schedule that Maximizes Profit Subject to Clear Cut Limitations and Side Constraints

- Environmental regulations set Maximum Area Constraints:
  - Reasons include wildlife habitat, scenic beauty, etc.
  - Maximum Clear Cut Area: 40+ to 120+ acres.
  - Thompson et al. 1973, Jones et al. 1991, Barrett et al. 1998, Murray 1999, Boston and Bettinger 2001, Boston and Bettinger 2001, McDill et al. 2002, Bettinger and Sessions 2003. . .

- Side constraints include:
  - Timber Volume Flow Constraints.
  - Average Ending Age.

ARM Includes Aggregation of Cells in the Problem



- Forest composed of small management units (Cells).
- Cluster = Groups of adjacent cells.
- Feasible Cluster = Area-complying clusters.
- Solution is group of non-adjacent feasible clusters.

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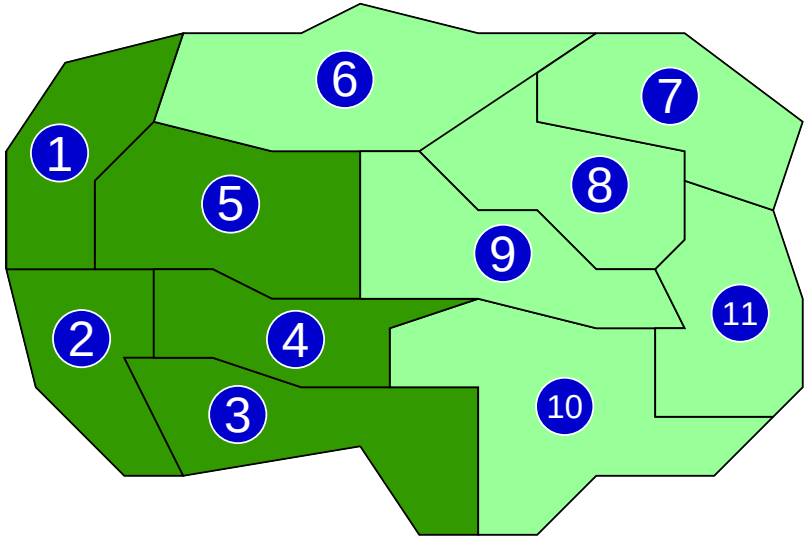

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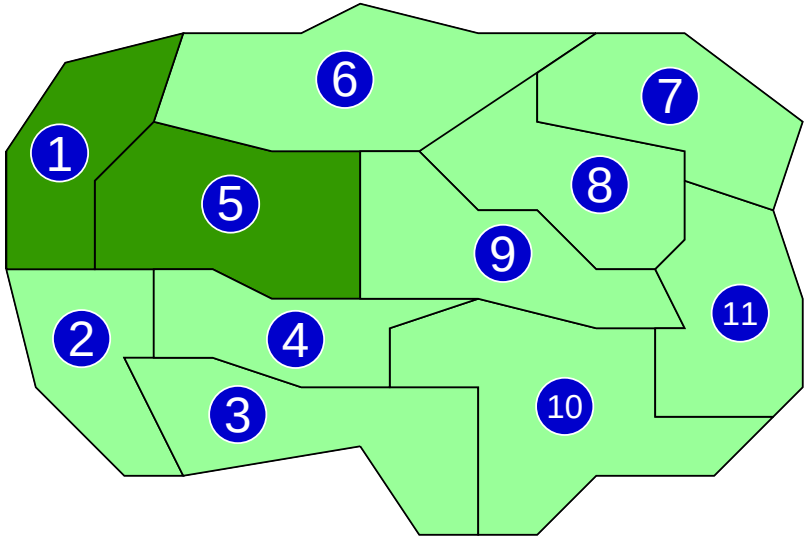

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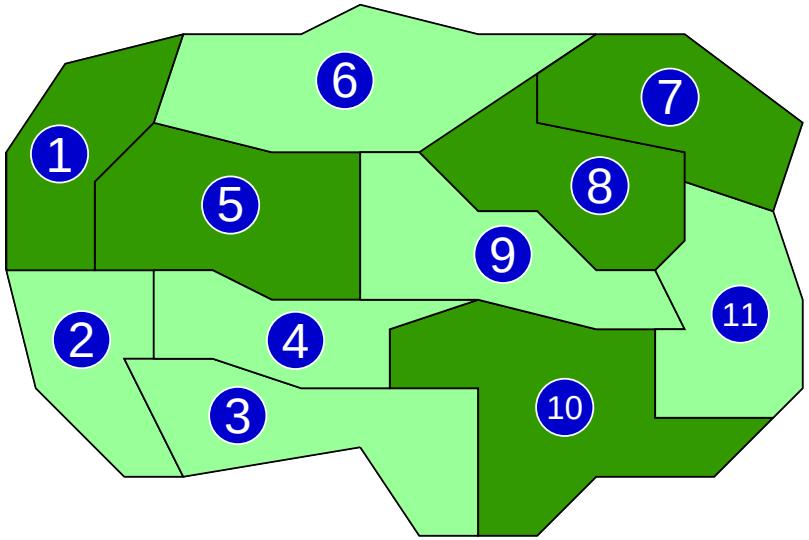

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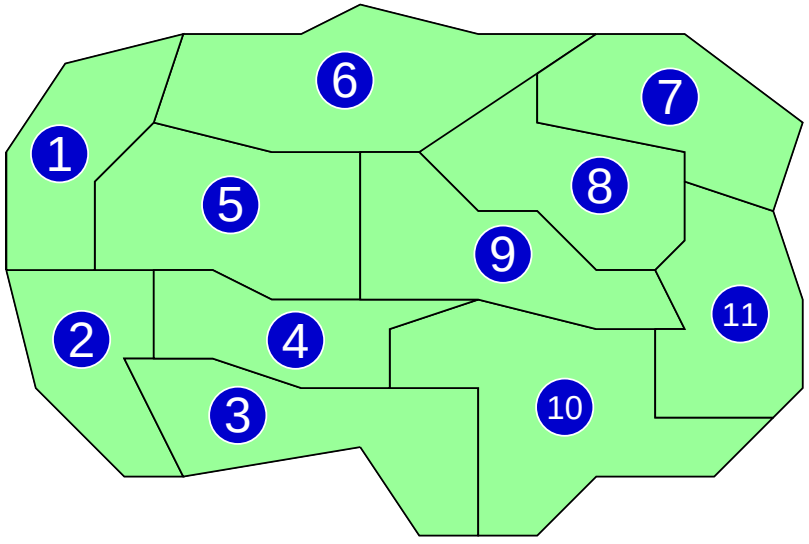

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- Cover/Path Constraints forbid harvesting (Minimal) Infeasible Clusters. (McDill et al. 2002)
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  - Crowe et al. 2003 *Clique* Constraints.
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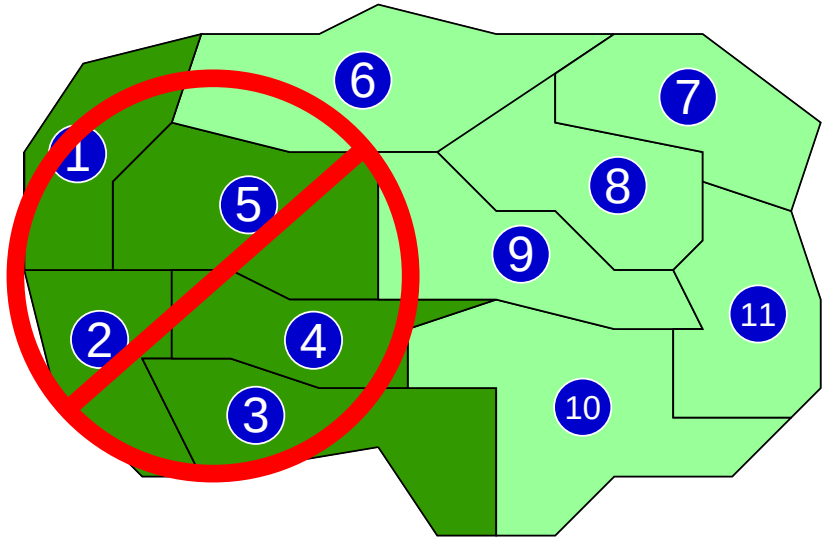

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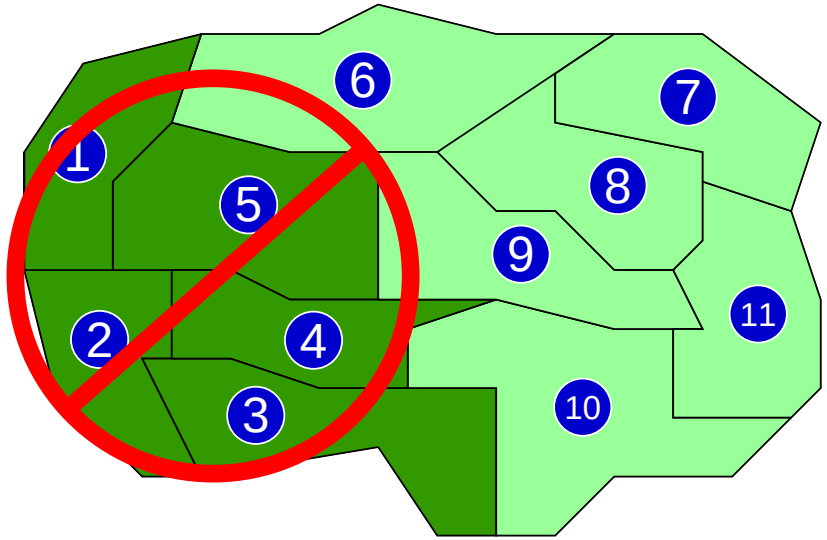

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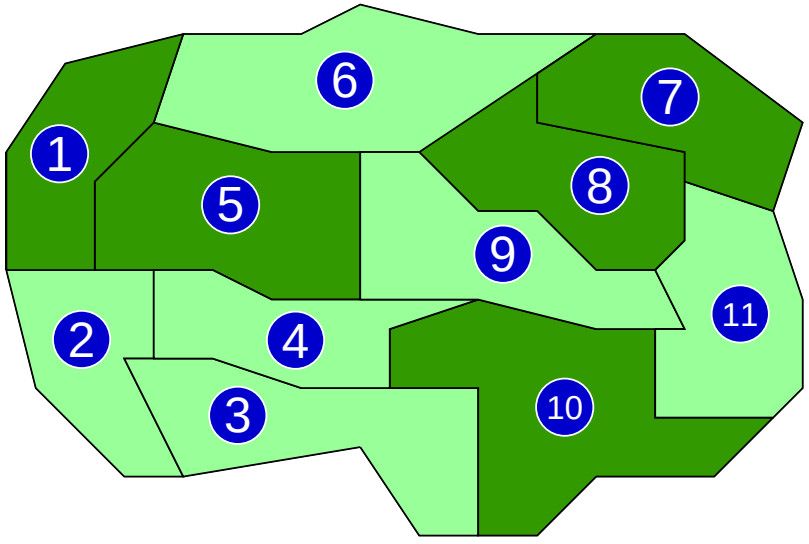

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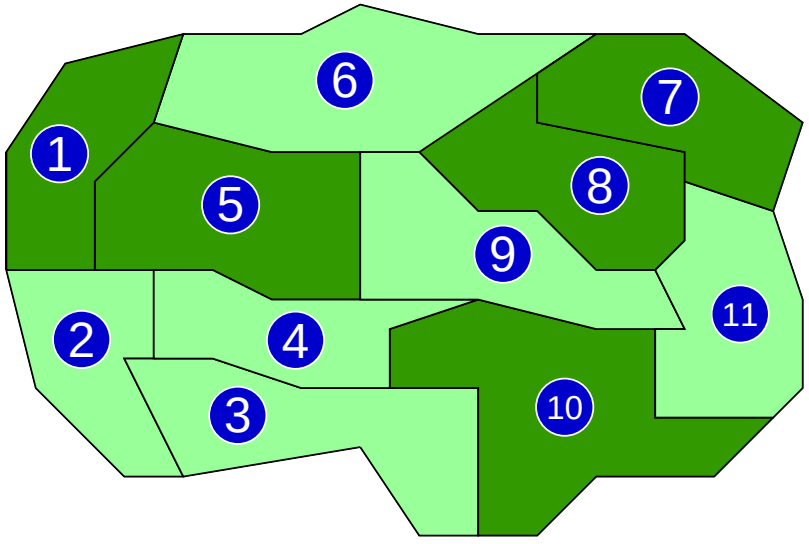

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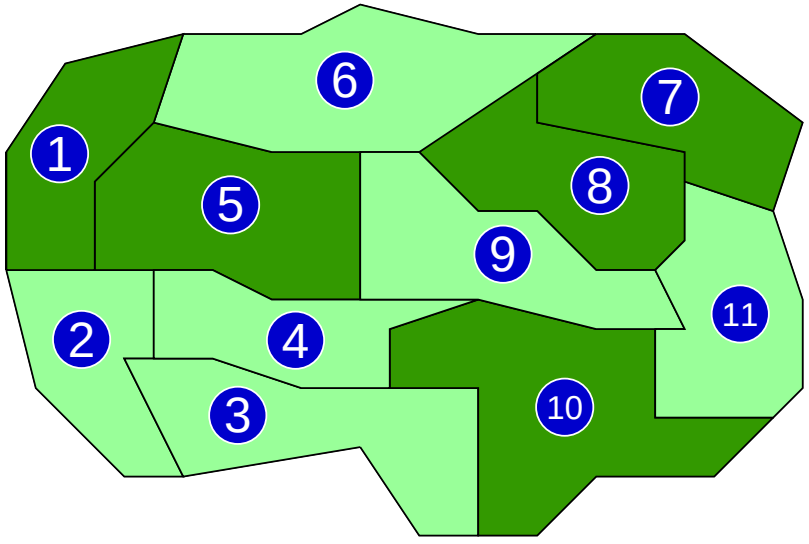

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Cluster Approach Easily Allows for Extra Modeling Requirements

- Fixed Harvesting Costs:
  - Modify objective coefficients in cluster approach.
  - Not clear how to do in cell approach.
- Average area clear-cut constraints:
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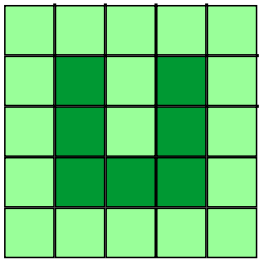
Control Over Clusters Creation Allows to Restrict Clear Cut Shapes and Gives Heuristic

- Easy to forbid inconvenient cluster shapes:
  - U shaped clusters.
  - Long and thin clusters.
  - etc.



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  - Often fixed costs hard to quantify.
  - Imposed for economic reasons.

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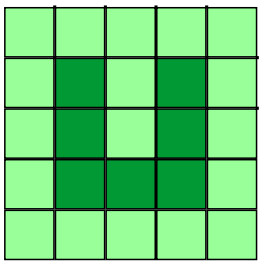

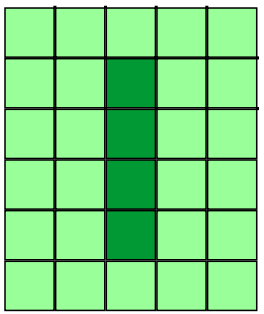

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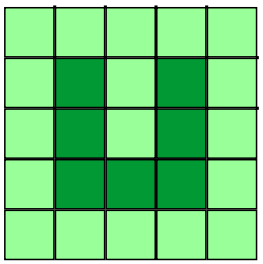

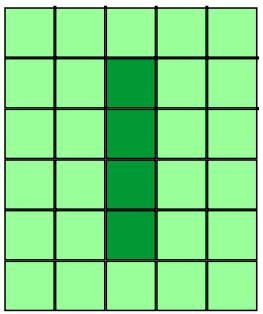

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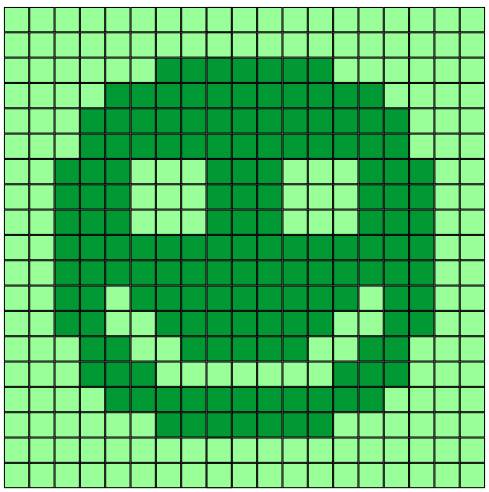

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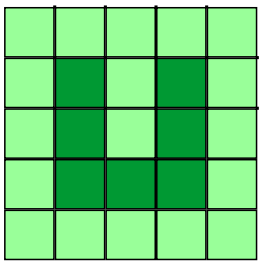

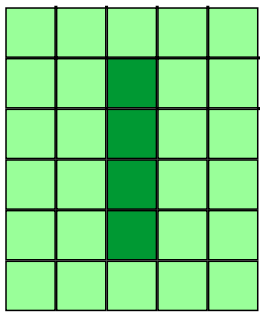

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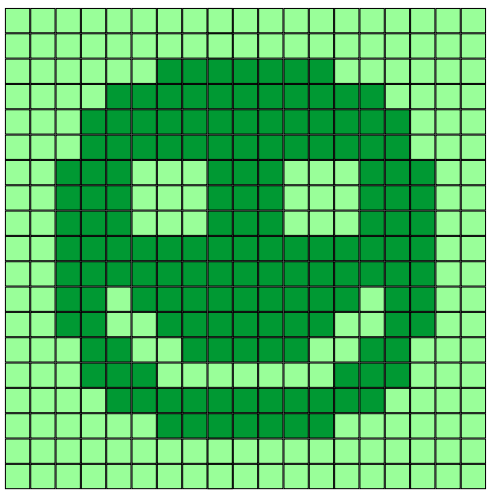
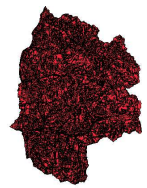


Description of Forest Instances

- El Dorado
  - 1,363 nodes and 3,609 arcs.
  - Node areas 10-116.35 acres. Max area 120.
  - Feasible clusters ≤ 7 nodes, cliques ≤ 4 nodes.

- Shulkell
  - 1,039 nodes and 2,065 arcs.
  - Node areas 0.31-277.64 acres.Max area 40.
  - Feasible clusters ≤ 13 nodes, cliques ≤ 4 nodes.

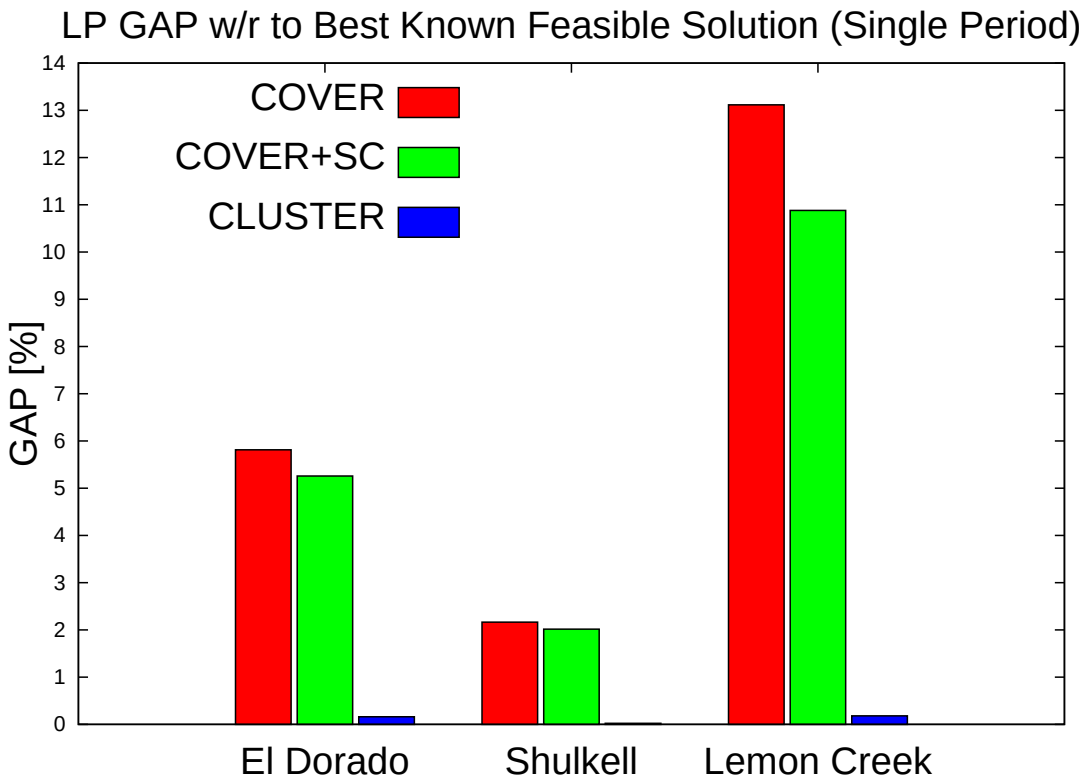
- Lemon Creek (Partial URM)
  - 6,624 nodes and 18,048 arcs.
  - Node areas 7.01 and 242.53 acres.Max area 40.
  - Feasible clusters ≤ 5 nodes, cliques ≤ 4 nodes.



- 3 and 5 period instances with volume and ending age constraints. Solved with CPLEX 9 for 10,000 seconds. 0.01% GAP considered Optimal

Cluster Approach LP is Tighter that Cell Approach LP

- Theorem: LP of Cluster Formulation is Stronger than LP of Cell Formulation with Cover Constraints



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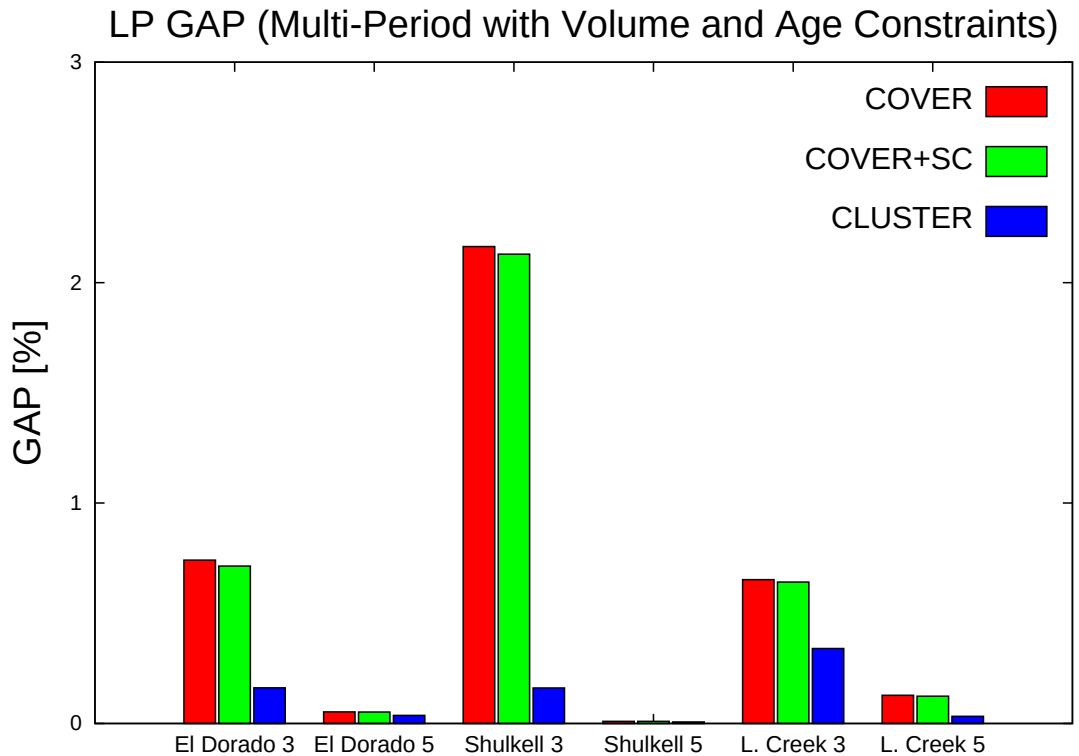
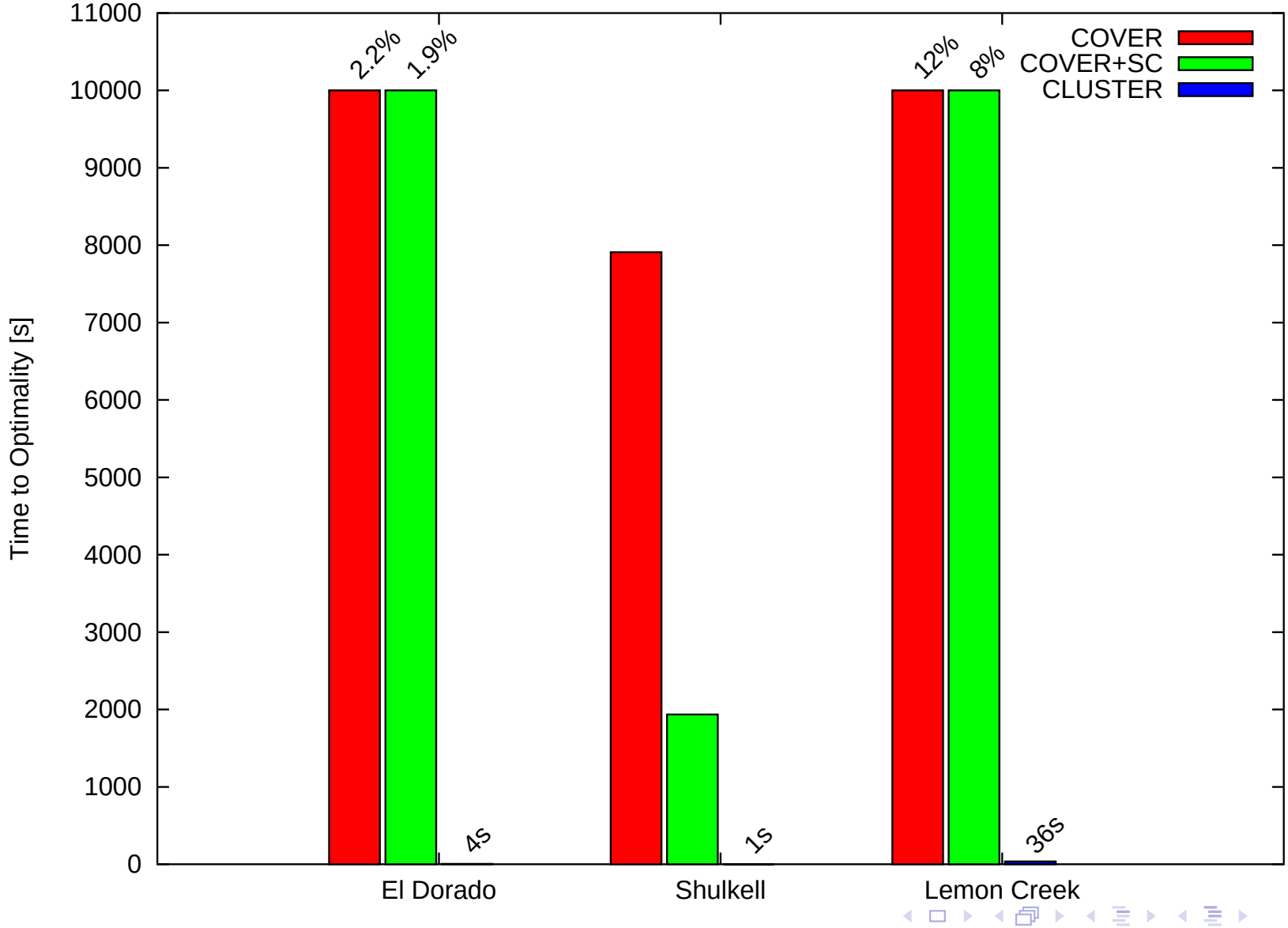
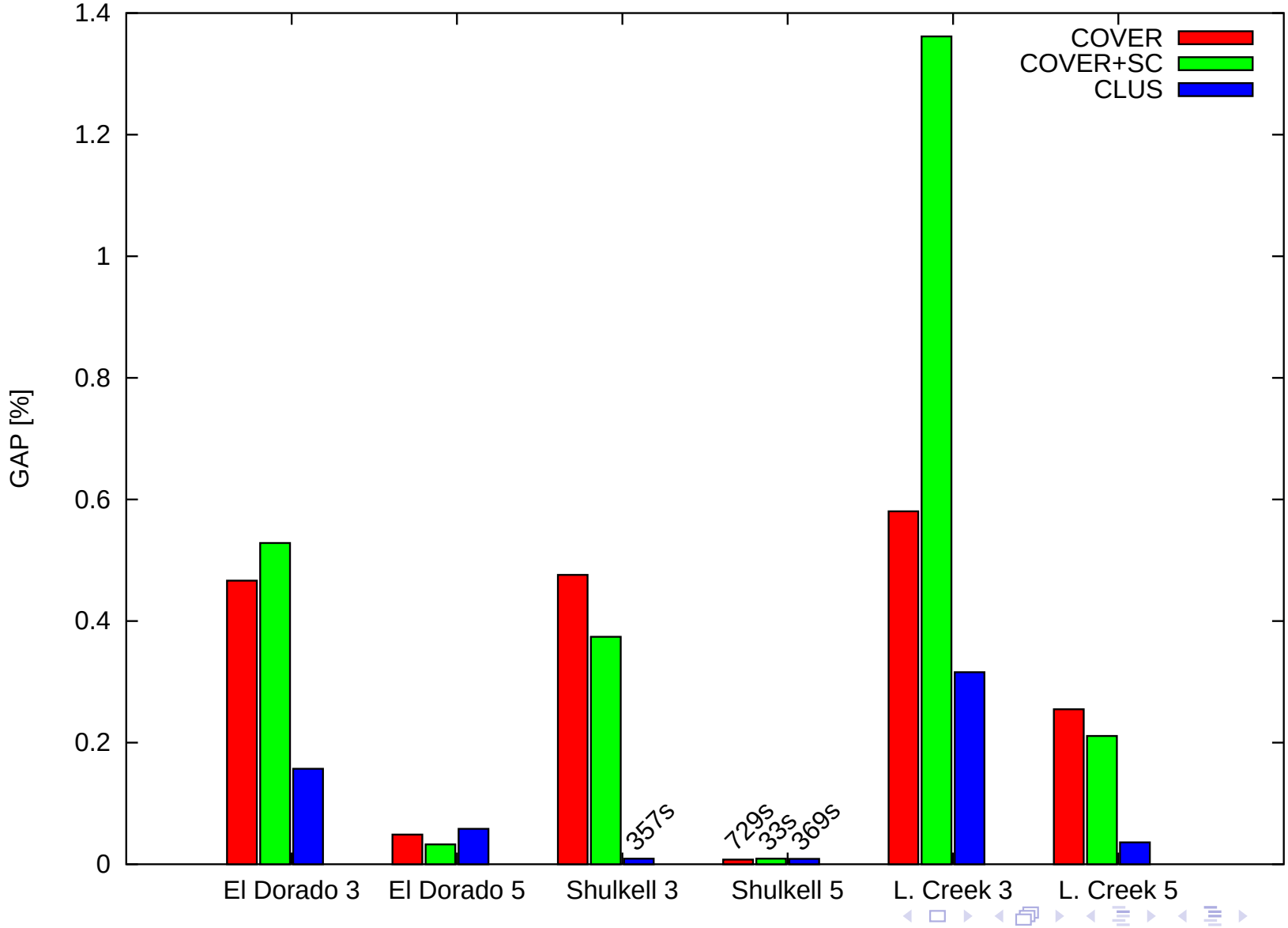


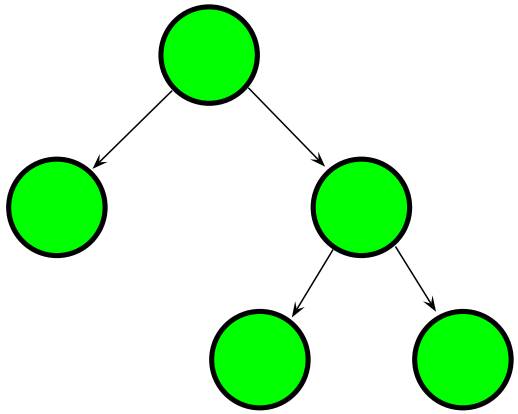
Performance of IP for Single Period Problems



Performance of IP for Multiperiod Prob. w Side Const.

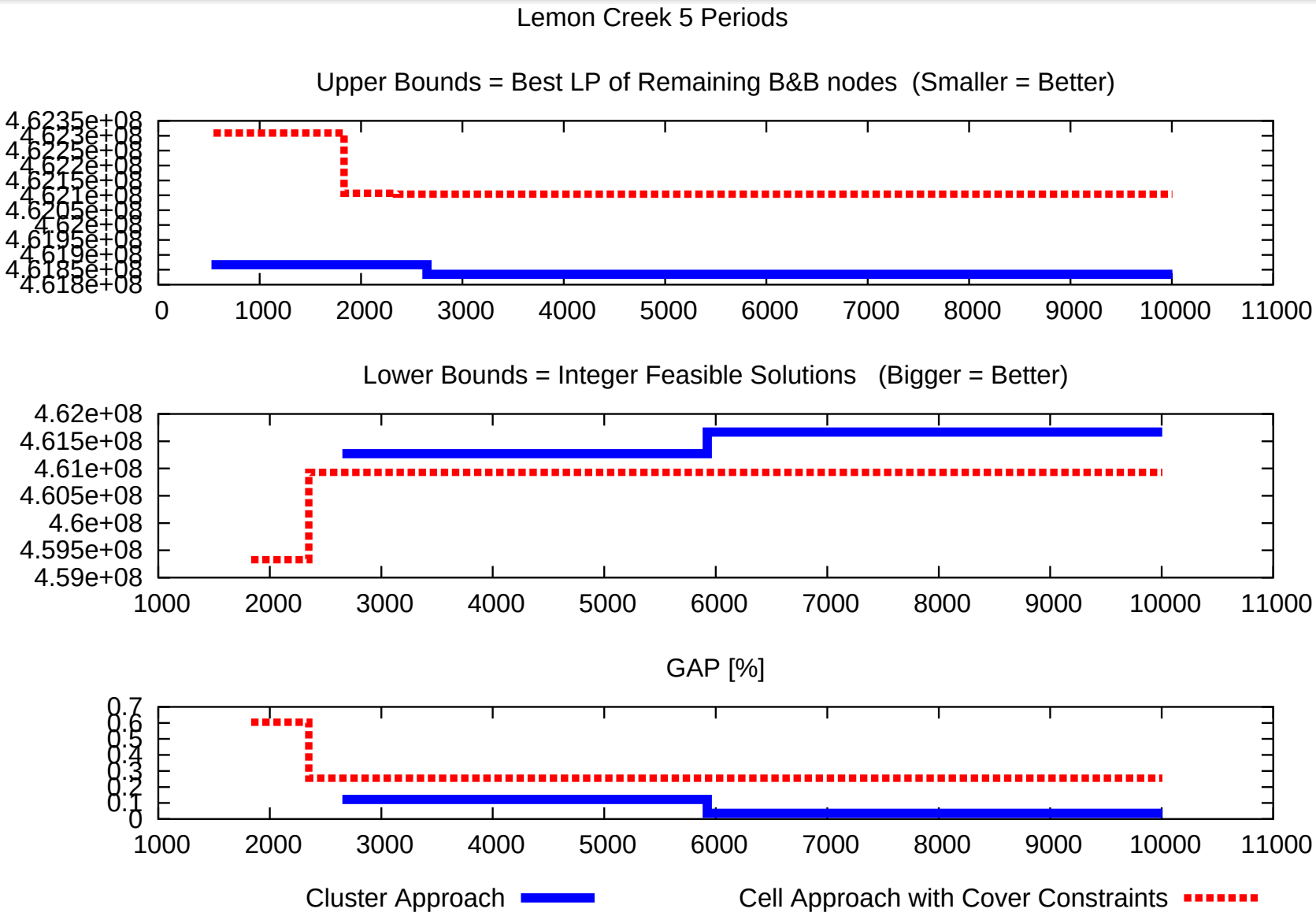


Why are Tight LP's Good for Solving IP's



- Solving IP's, Two Aspects:
  - Lower Bounds: Integer Feasible Solutions
  - Upper Bounds: Best LP of unprocessed nodes. Used to prove optimality or validate GAP.

Details of IP for Multiperiod Prob. w Side Const.



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  - Models problems which cell approach can not.
  - Tighter LP bounds (both theoretically and practically).
  - One period instance sub-problem solves much better.
- Advantages of the Cell Approach.
  - Better at finding good feasible solutions quickly.
  - Linear Programming Relaxation solves very fast.
- Which approach should be used? Both very effective!
  - For quickly finding solutions within a very small gap?
  - For solving to optimality?
  - For validating a heuristic?
  - The Important Question: What is the target time/gap?
- More real forest instances needed. (FMOS)
- Slides available at http://www.isye.gatech.edu/∼jvielma/.

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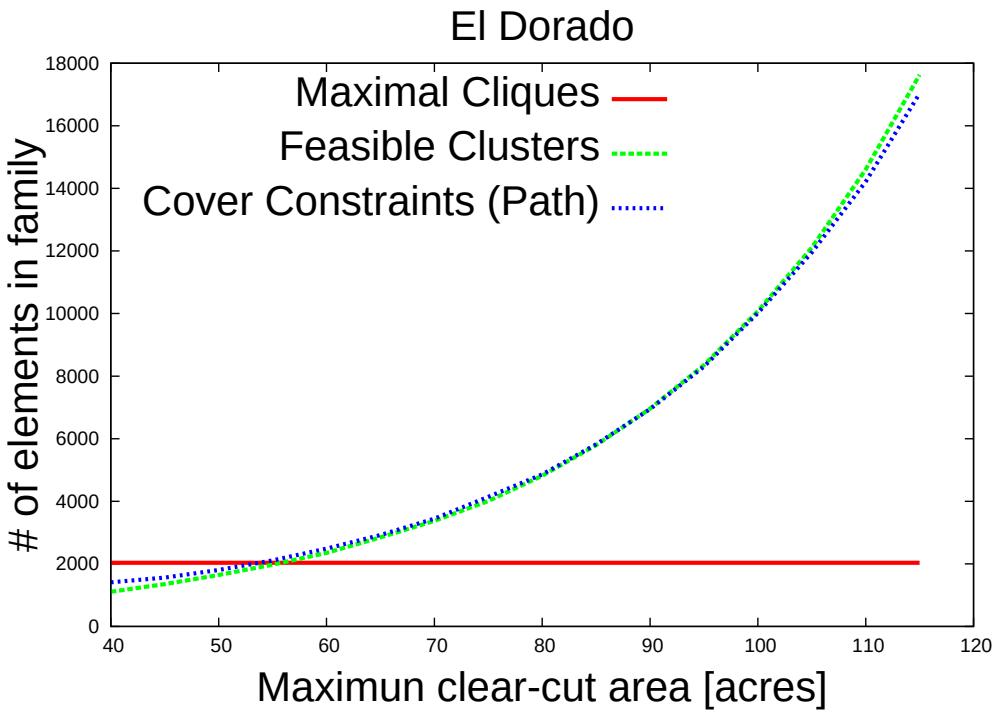

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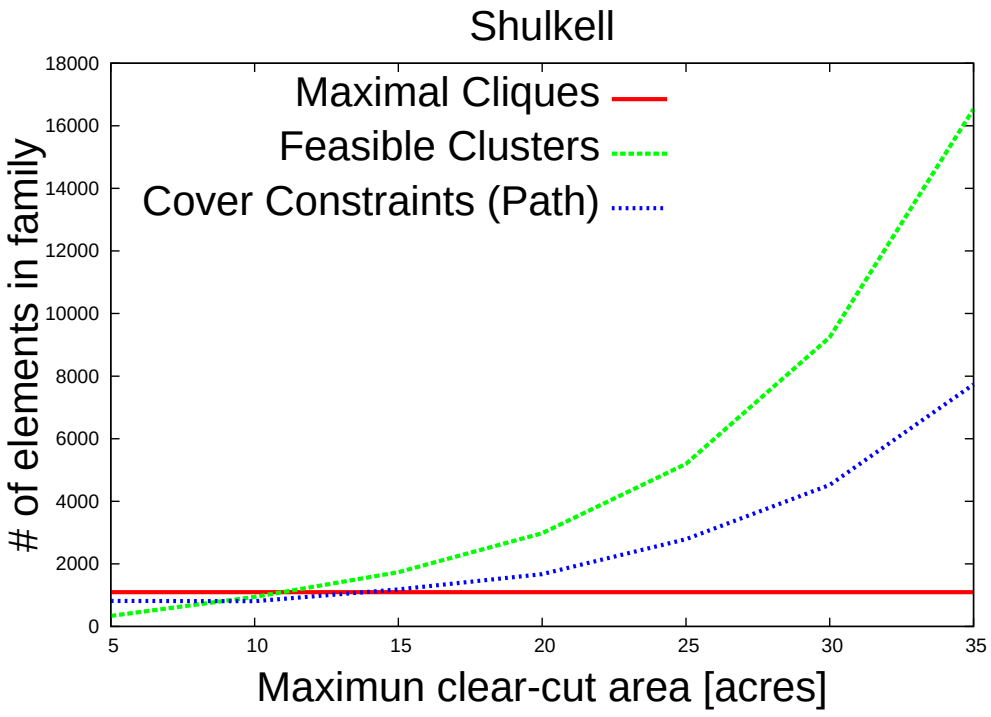

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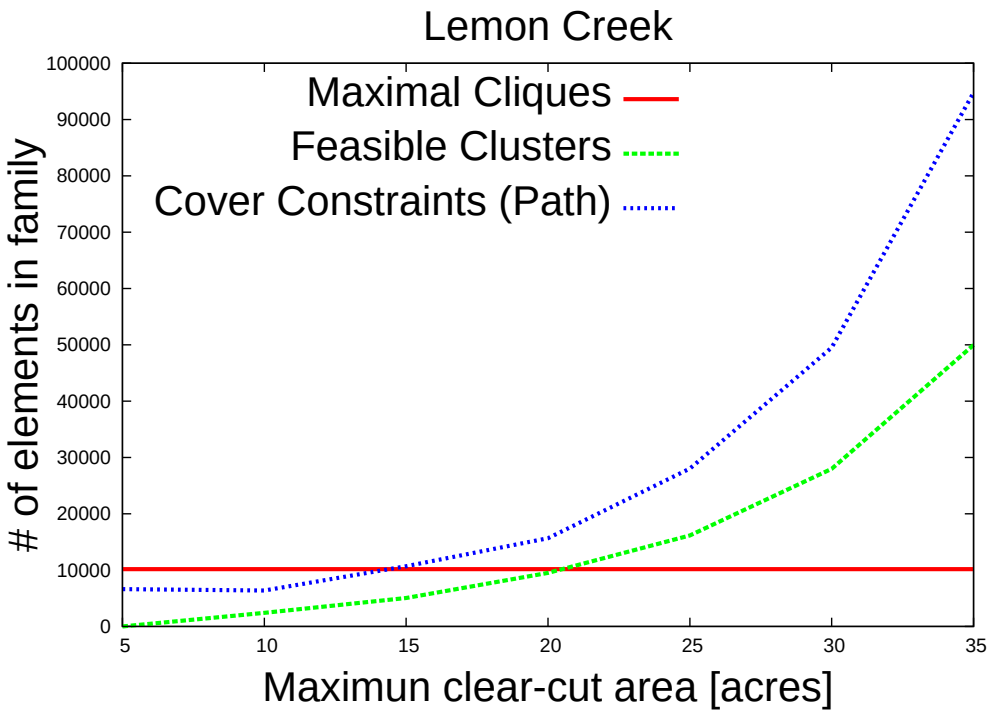

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