Update on Scenario Optimization Tool for CAST

10 July 2018 - Daniel Kaufman

Project Goal: Investigate, develop, test, and implement an optimization system for the Chesapeake Assessment Scenario Tool (CAST) that will facilitate identification of more cost-effective and otherwise optimal approaches to pollutant load reduction for non-federal CBP partners.

Status Summary: Prototyping plan developed & revised based on feedback. Experiments underway. Package evaluations to follow.

Recent Actions

- Feedback
  - Scientific Technical Assessment and Reporting (STAR) group
  - Chesapeake Research & Modeling Symposium
  - Optimization Advisory & Support Committee (OptASC)
- Initial discussions with User Experience (UX) team at CBPO
- Response to STAC Workshop is under review by the Management Board

Overview - Current system

Best Management Practices (BMPs)

Chesapeake Assessment Scenario Tool (CAST)

Loads

Cost

Overview - Current system

Not feasible to exhaustively try potential strategies

Best Management Practices (BMPs)

Chesapeake Assessment Scenario Tool (CAST)

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Overview - Scenario Optimization System

Best Management Practices (BMPs)

Chesapeake Assessment Scenario Tool (CAST)

Loads

Cost

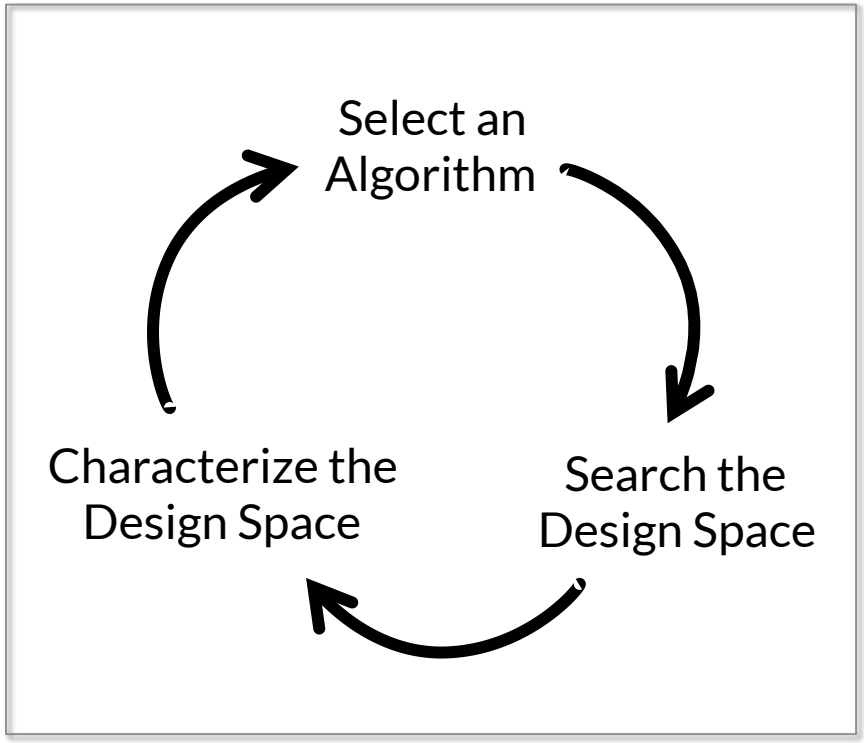
Identify low-cost BMP implementation strategies

Overview

Prototyping Experiments

Next Steps

What is the long view?



Various Possible Approaches

- **Population-based stochastic search**

  (e.g. Genetic algorithm)
- **Decomposing into sub-problems, with multiple algorithms**
  - *Population-based for land use change and/or manure transport*
  - *Greedy algorithm or nonlinear programming for efficiency BMPs*
- **Model training**

Figure modified from Red Cedar Tech., WP-1022

Prototyping Experiments

Search Space Investigations

Fine-tuned sub-problem

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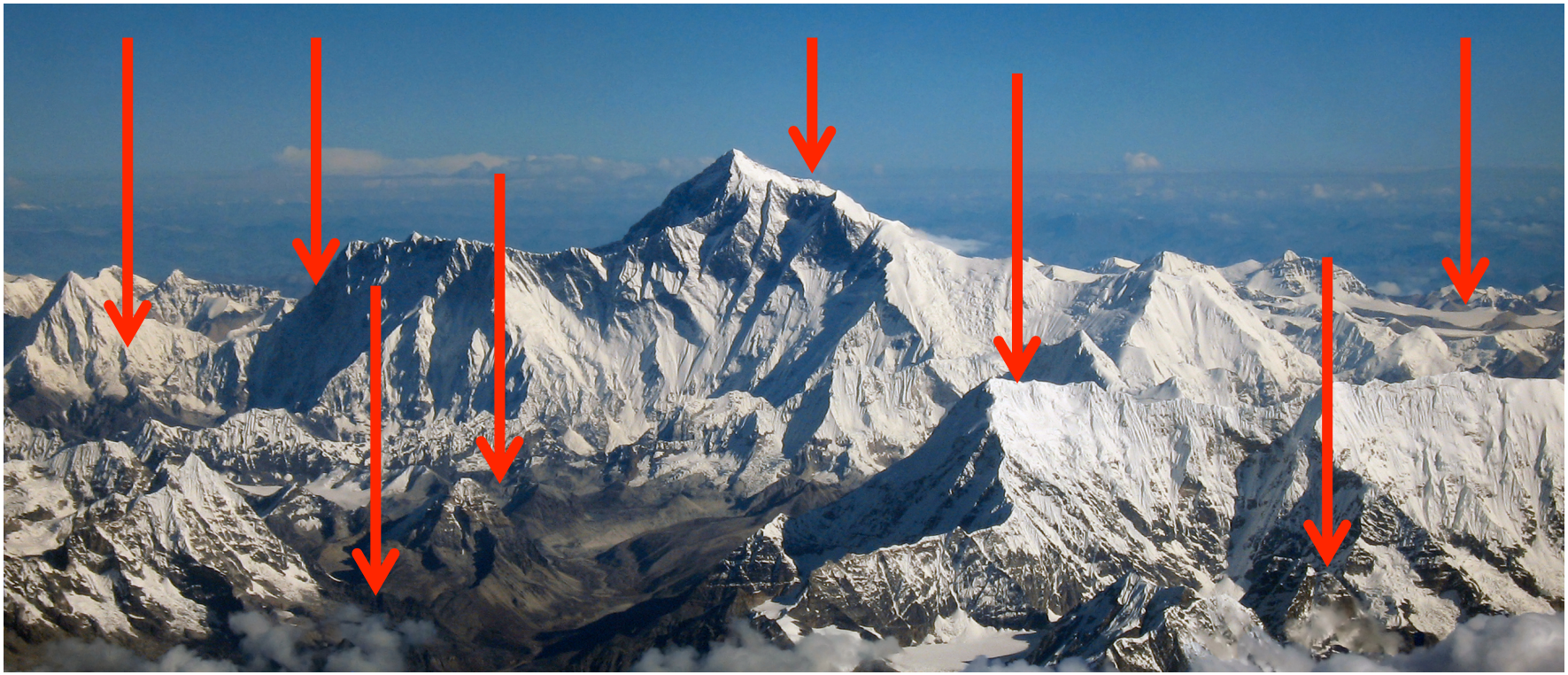

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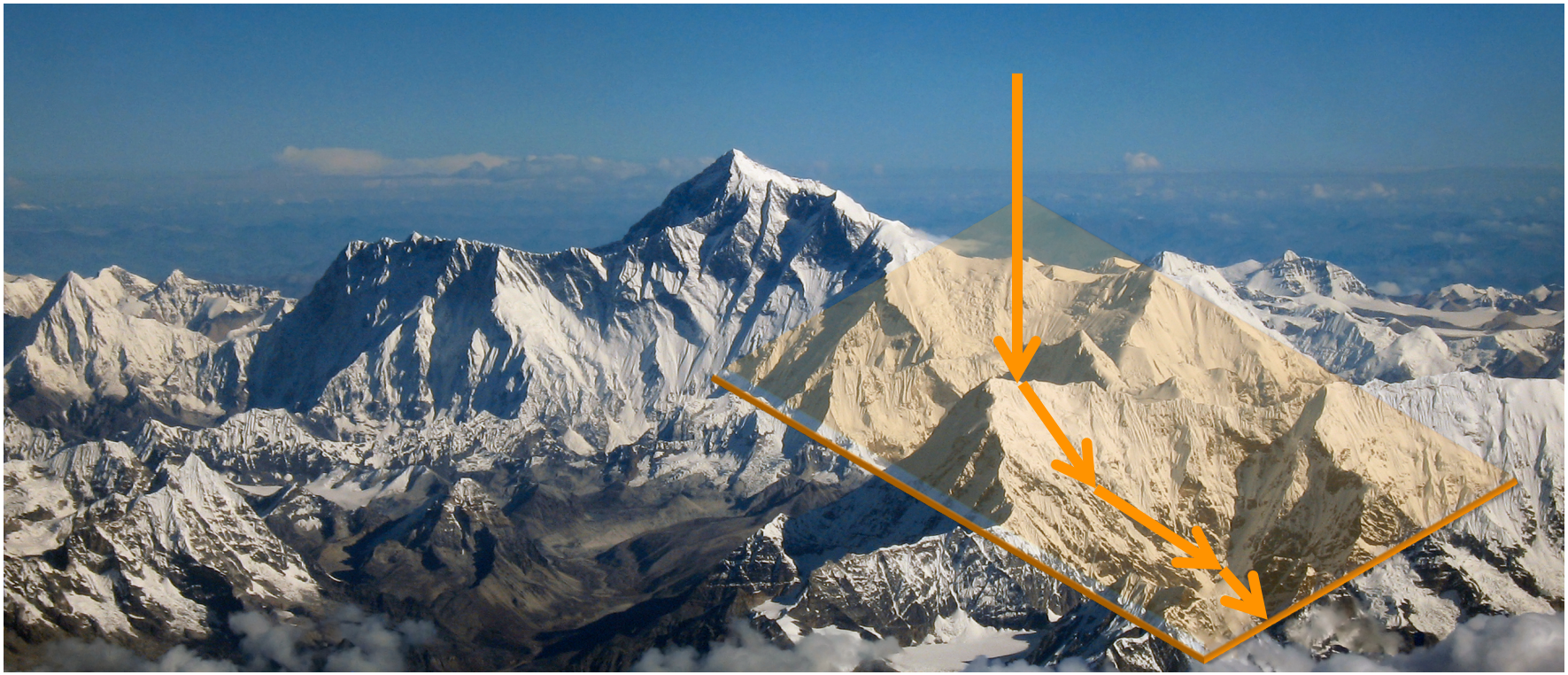
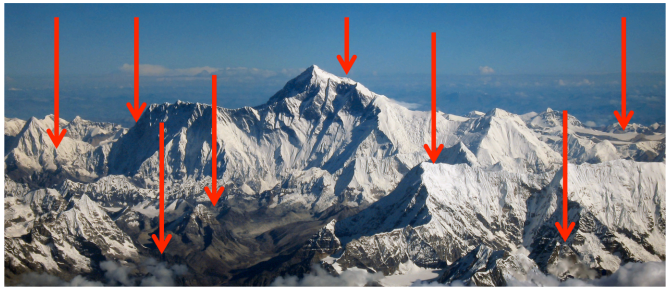
Search Space Investigations

Fine-tuned sub-problem



Experiments –
(1) Search Space Investigations

- Sampling, stochastic and targeted
- Insight for appropriate algorithms
- Produce a scenario comparison tool



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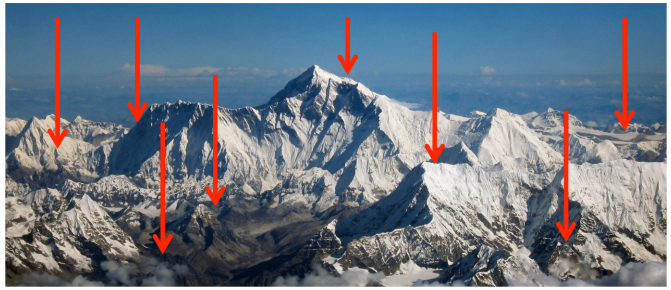

Preliminary graphical interface design

- metadata
- decision variable selection
- constraints

- Documented
- Cloned on CBP cloud server
- Percent bounds for most BMPs

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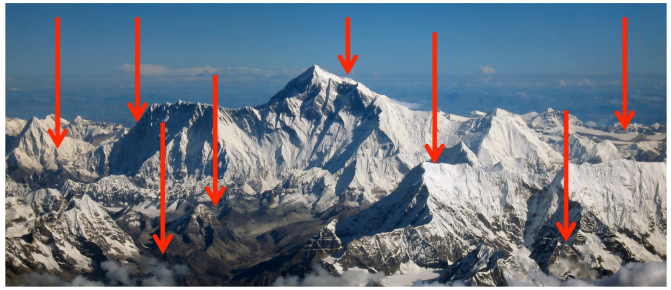

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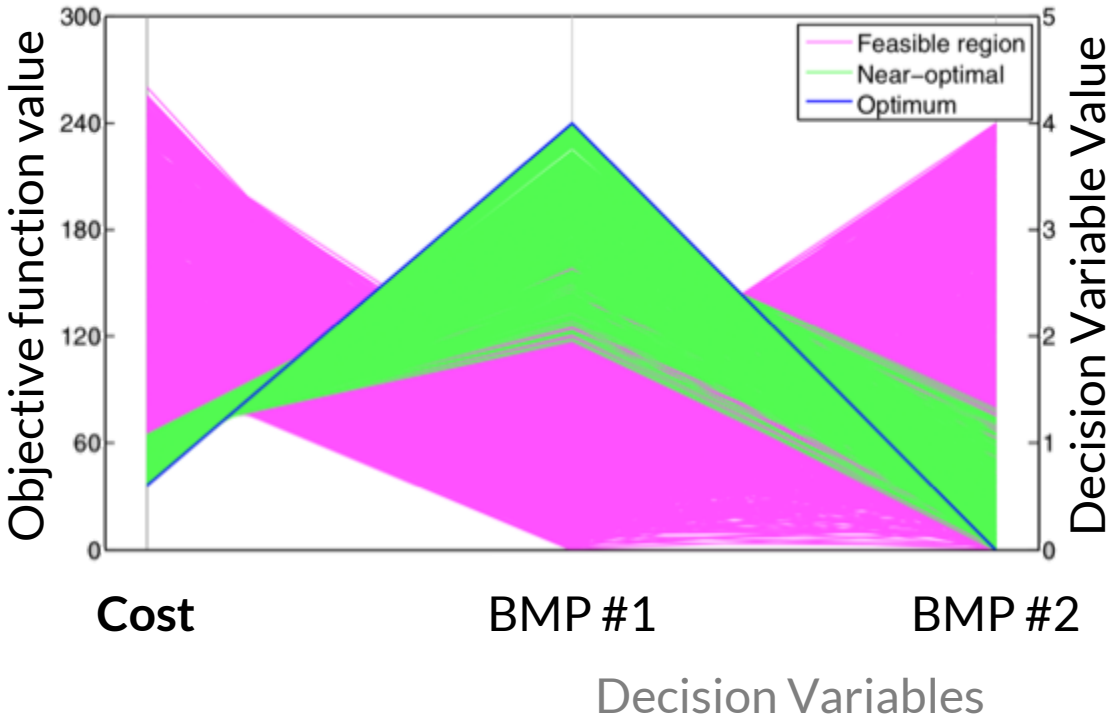
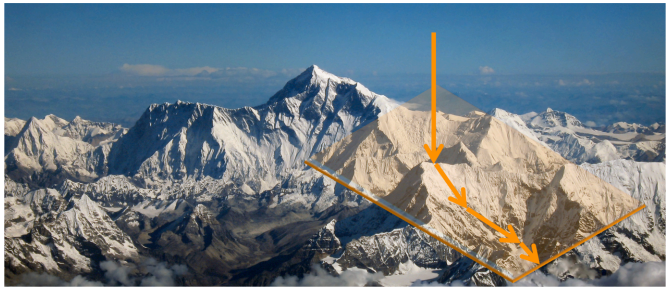


Figure modified from Rosenberg, 2015

Experiments –
(2) Fine-tuned sub-problem

- Guide explorations of increasing complexity
- Solutions for select BMPs



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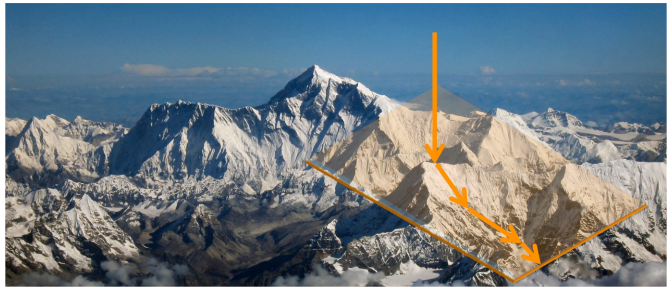
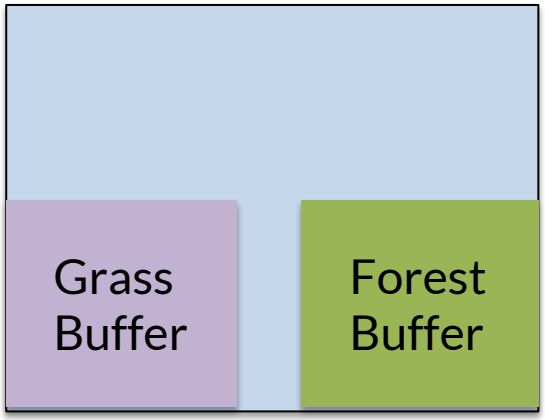


Mutually Exclusive
(aka Additive)



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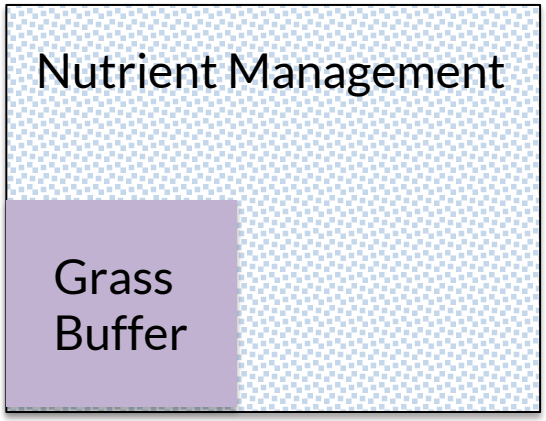

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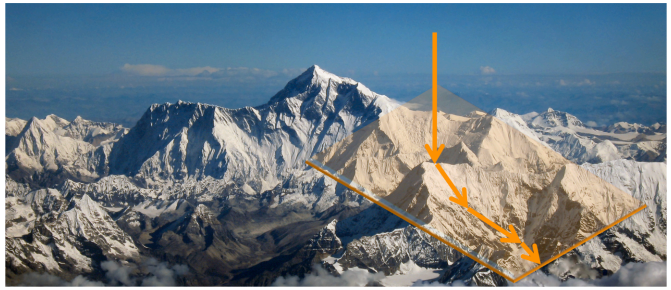

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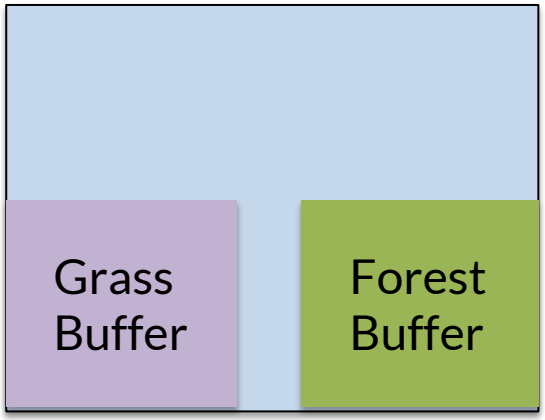

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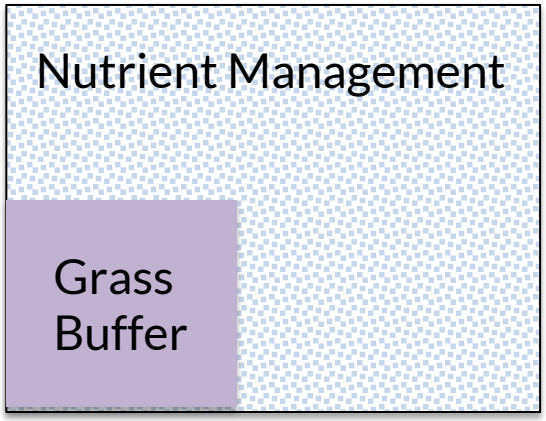

An example formulation
(for 1 land river segment)

1 linear objective
1167 variables
52 constraints
- 3 nonlinear
- 49 linear
- 52 inequality

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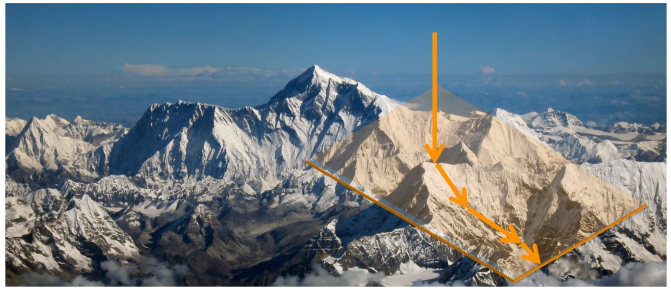

Minimize:

(total cost) $$\sum_{\substack{Segments,\\ BMPs,\\ Loadsources}} \text{cost} * \text{BMPacres}$$

Subject to:

(Target load) $$\text{PercentLoadChange}[\text{segment}, \text{pollutant}] \geq \text{TargetLoadChange} \left(\text{e.g. } 25\%\right)$$

(Availability) $$\sum_{\substack{BMPs\\ in\\ Groups}} \text{BMPacres} \leq \text{AvailableAcres}$$

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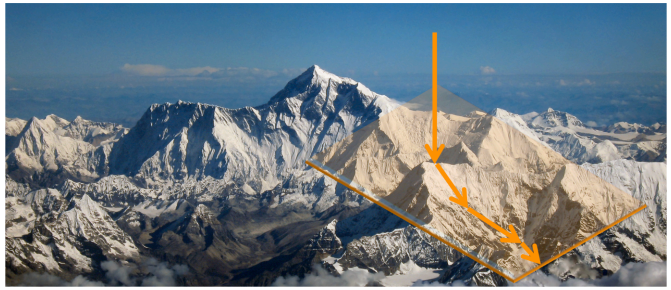
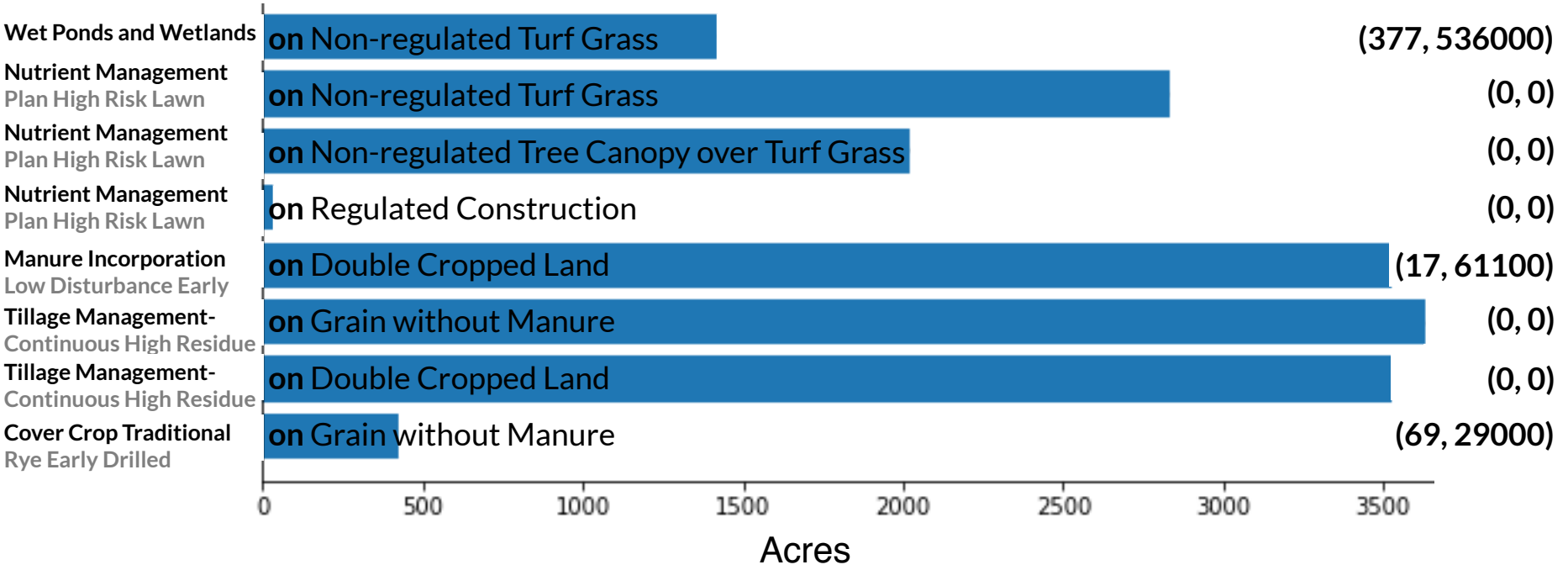


Example Results (6% Reduction Constraints)



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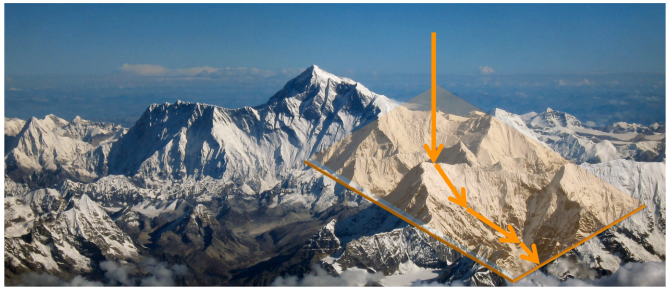

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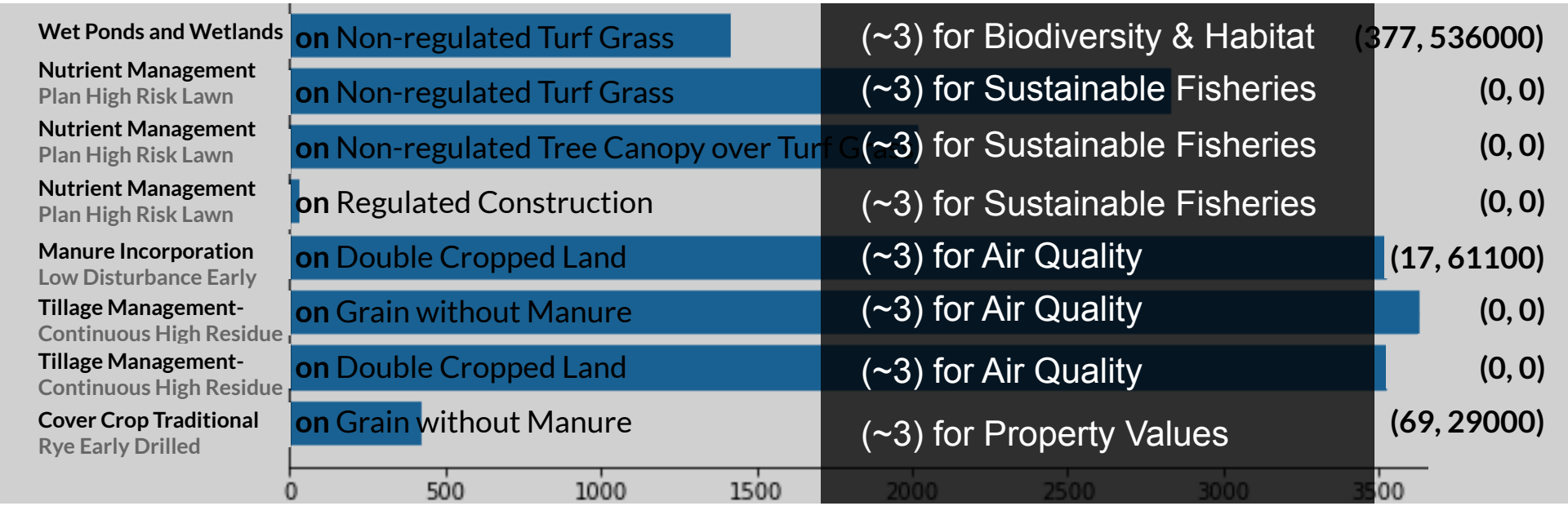

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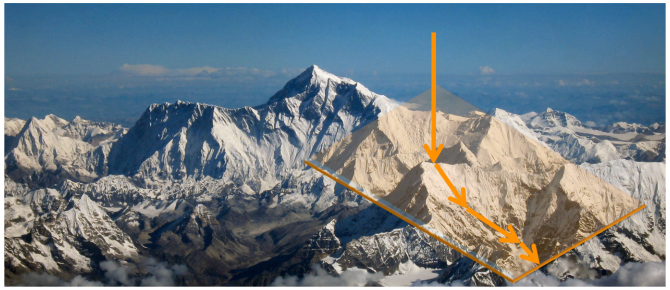


<u>Continuing Analyses</u>

Invert the model, with load reduction as objective

Sensitivity Analyses

- Marginal Costs
- Gradient at the optimum

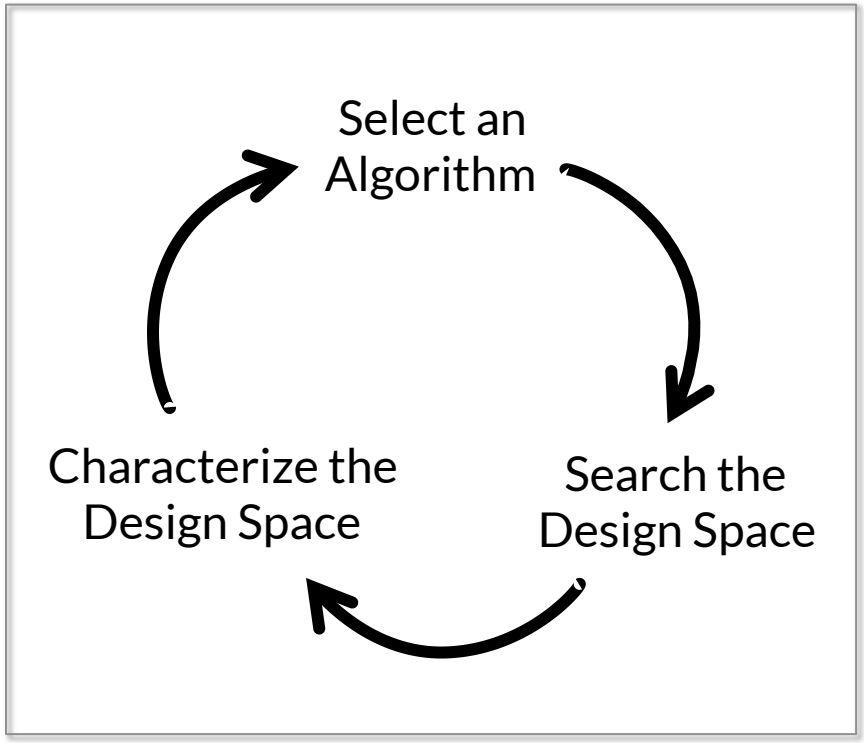
Solver efficiencies, robustness to configurations

Overview

Prototyping Experiments

Next Steps

After prototyping experiments…



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Near-term Milestones

Date	Optimization Task
Summer 2018	Analyses of sampling experiments & sub-problem formulation
End of Summer	Scenario generator interfacing with CAST architecture update
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Winter 2018	Beta testing of version 0.1, constraints & user interface

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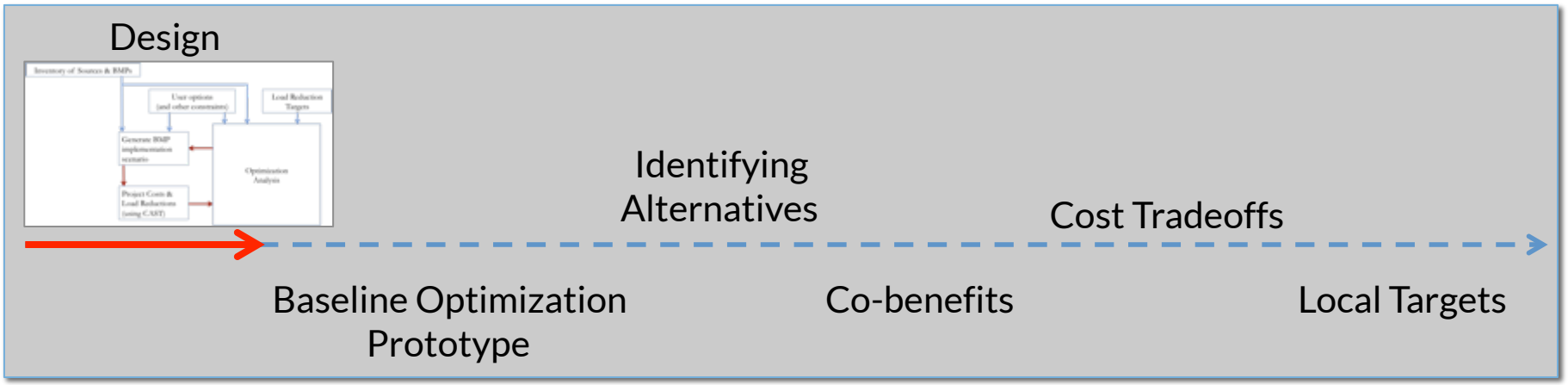

Will be shaped by feedback!

Actively searching for ways to engage local decision makers at county and municipal scales for their guidance and feedback on optimization design.

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