Optimization Tool Development

March 6, 2018

Daniel Kaufman

Description: The project goal is to facilitate cost-effective reductions of nutrient loads entering the Chesapeake Bay from the watershed by developing an optimization module for the Chesapeake Assessment Scenario Tool (CAST).

Status (Phase 1): developing an optimization plan

Overview

Motivation:

Of all possible types and combinations of feasible Best Management Practices (BMPs), which mix(es) of BMPs will allow us to meet the target loads at the lowest total cost?

Tools:

- **Chesapeake Assessment Scenario Tool (CAST)**
- **Scenario Optimization Module**

Outline

- CAST and optimization
- The vision: a “scenario optimization module”
- What is the current phase of development?
- How will a prototype tool utilize info from CAST?
- Next steps and moving forward

Chesapeake Assessment Scenario Tool (CAST)

A "web-based nitrogen, phosphorus and sediment load estimator"

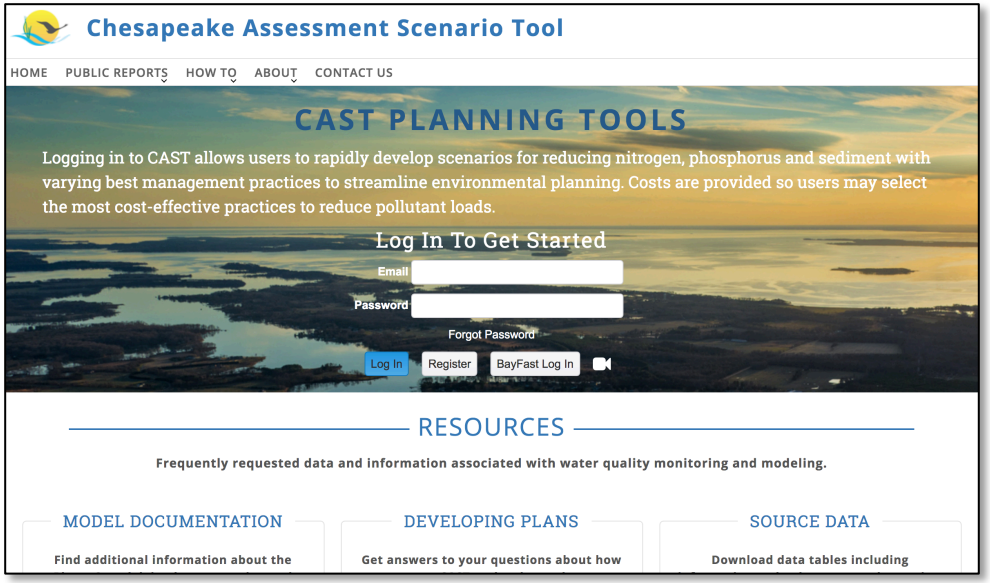
Originally developed in 2011, but has undergone substantial changes over the years

Users specify:

- **A geographical area (e.g. a county)**

  (& other restrictions, such as "agencies")

- **Best Management Practices (BMPs) to apply on that area**



Chesapeake Assessment Scenario Tool (CAST)

A "web-based nitrogen, phosphorus and sediment load estimator"

Originally developed in 2011, but has undergone substantial changes over the years

Users specify:

- **A geographical area (e.g. a county)**

  (& other restrictions, such as "agencies")
- **Best Management Practices (BMPs) to apply on that area**

CAST provides:

- **Estimates of nitrogen, phosphorus, and sediment load reductions** (e.g. by sector, load source, delivery edge)
- **The cost of the scenario.**

Chesapeake Assessment Scenario Tool (CAST)

A "web-based nitrogen, phosphorus and sediment load estimator"

Originally developed in 2011, but has undergone substantial changes over the years

Users specify:

- **A geographical area (e.g. a county)**

  (& other restrictions, such as "agencies")

- **Best Management Practices (BMPs) to apply on that area**

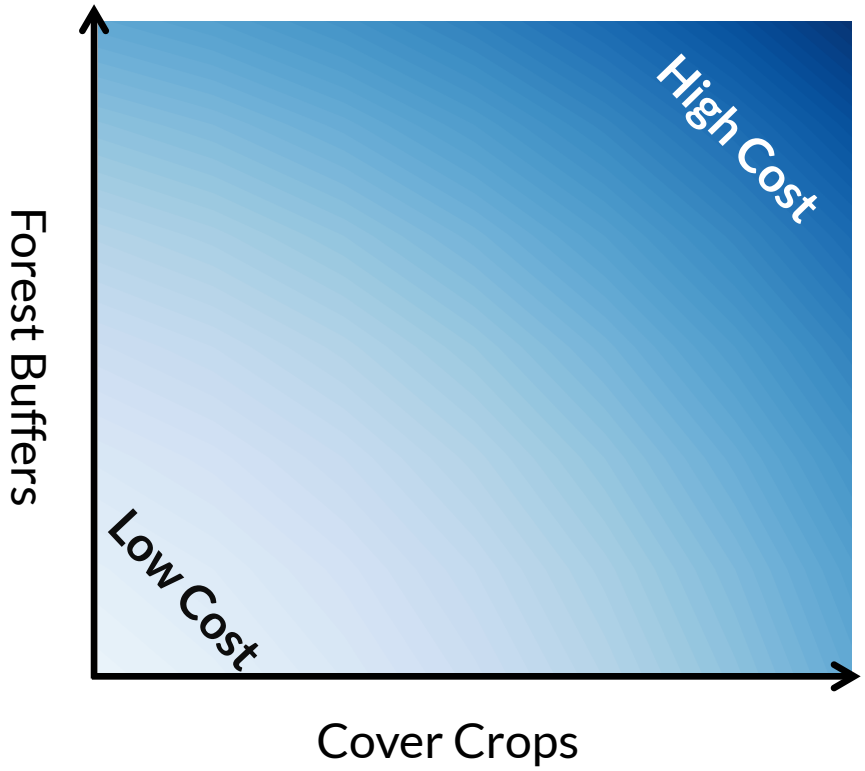
Load Sources
Cost profiles

BMP effects on
• loads • other BMPs

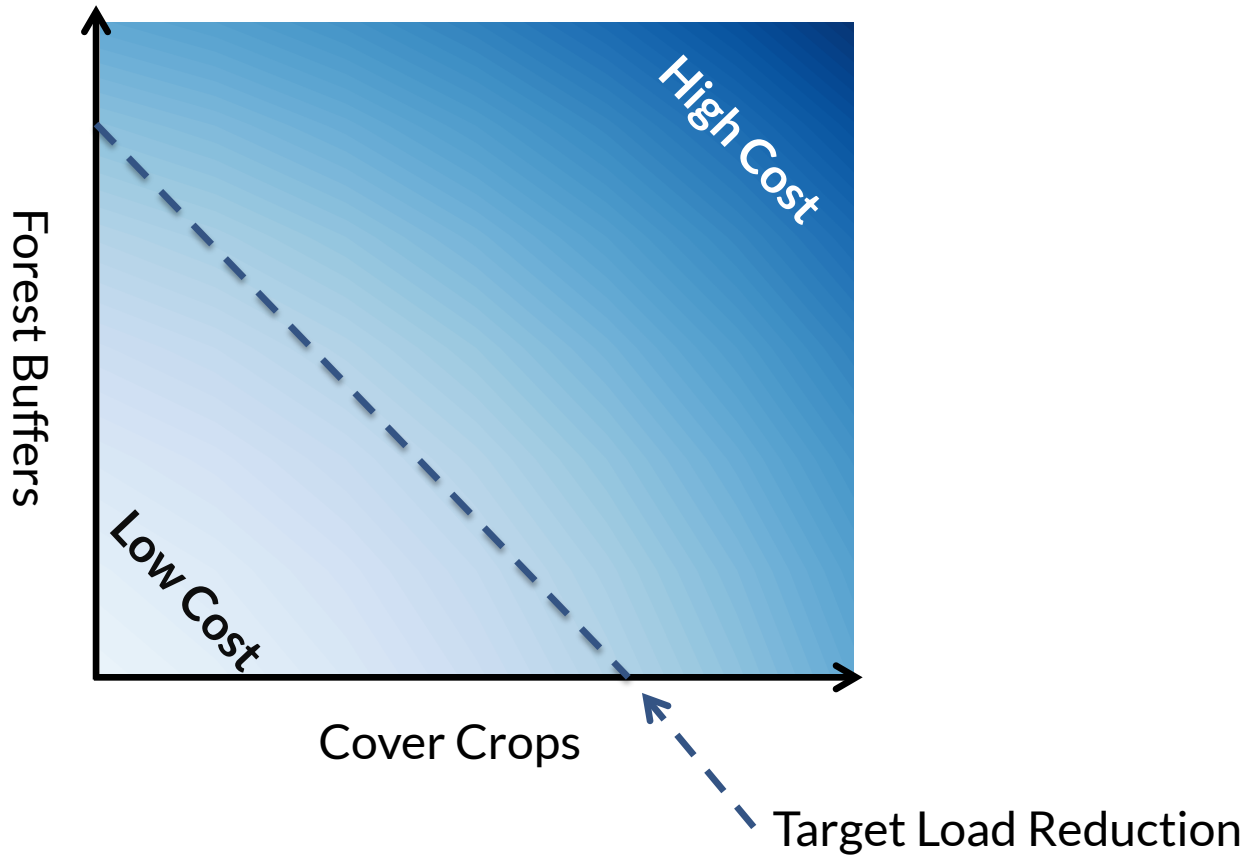
CAST provides:

- **Estimates of nitrogen, phosphorus, and sediment load reductions** (e.g. by sector, load source, delivery edge)
- **The cost of the scenario.**

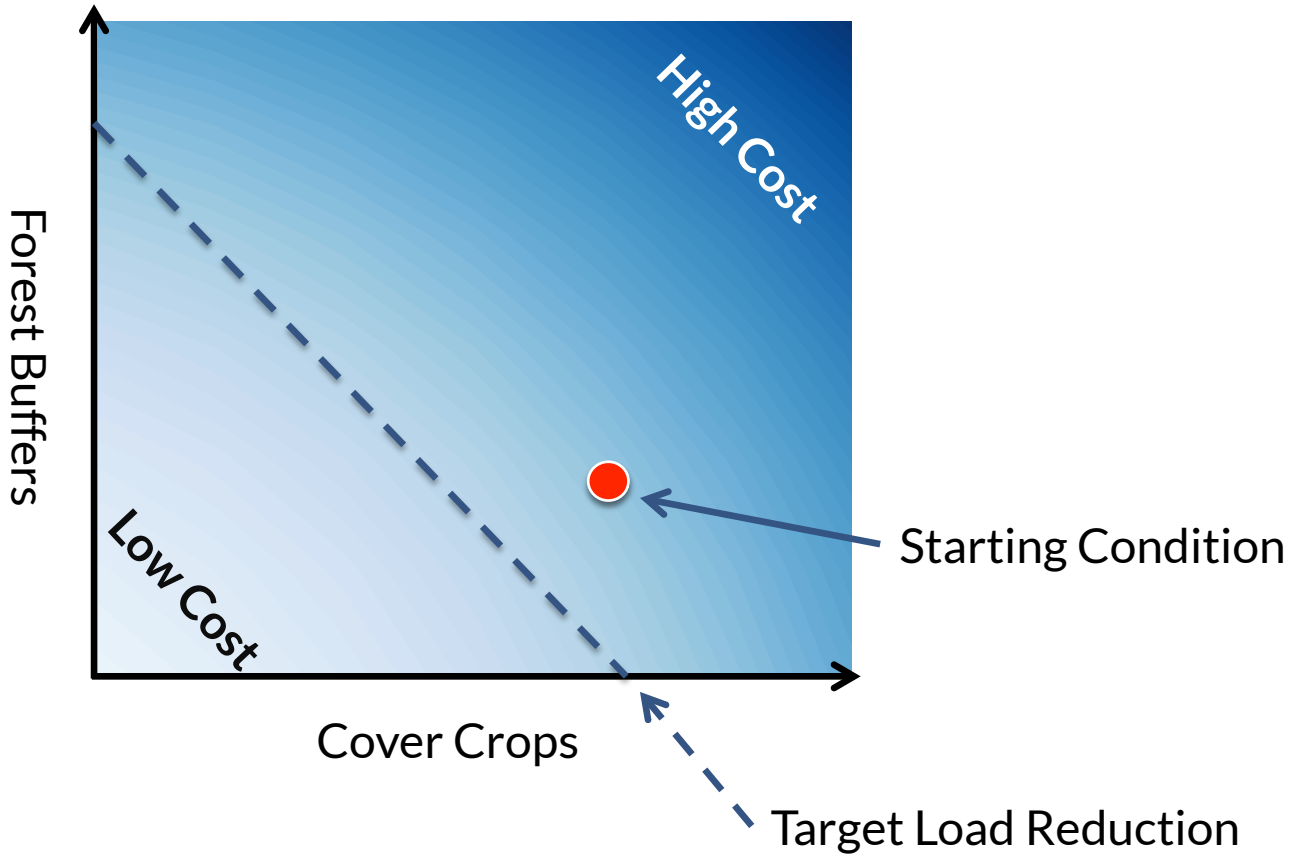
What is meant by optimization?



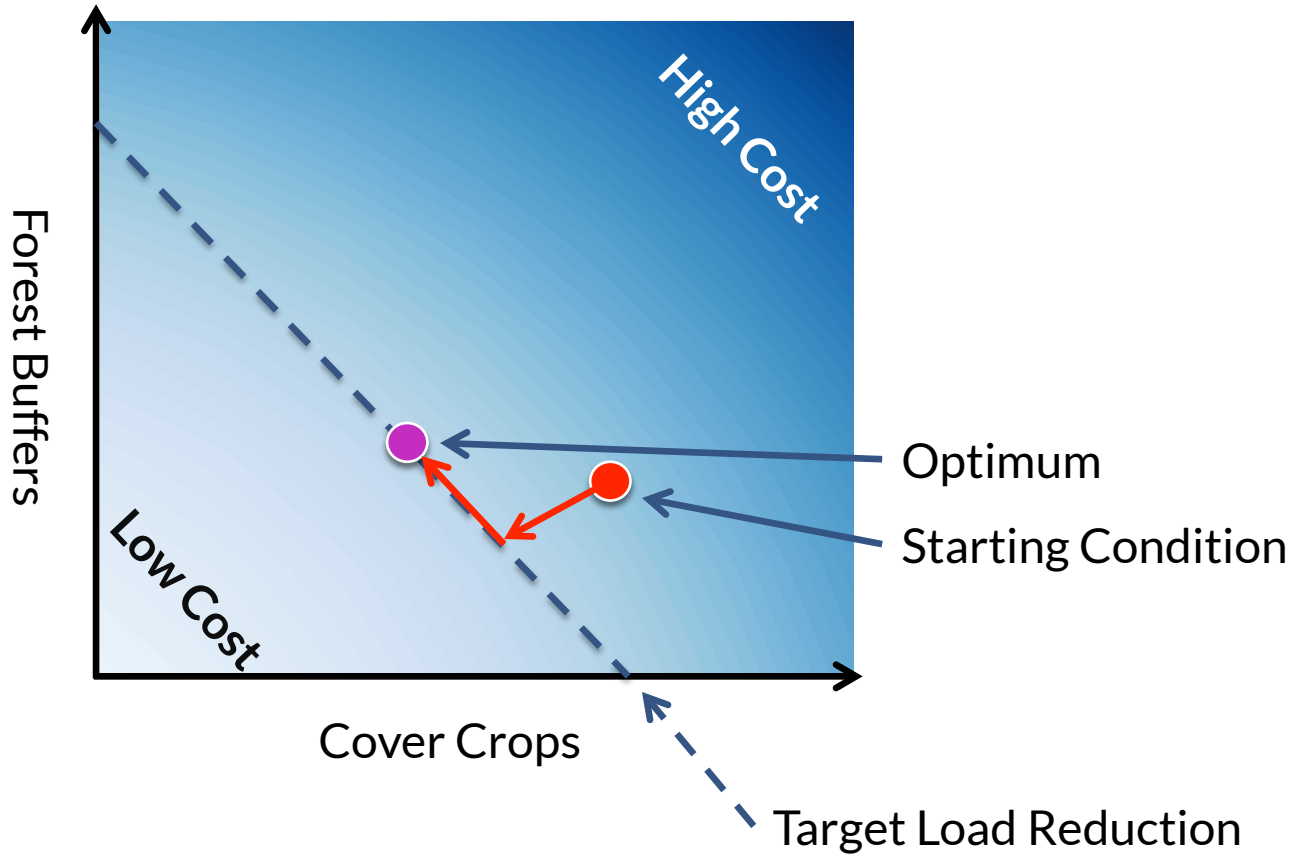
What is meant by optimization?



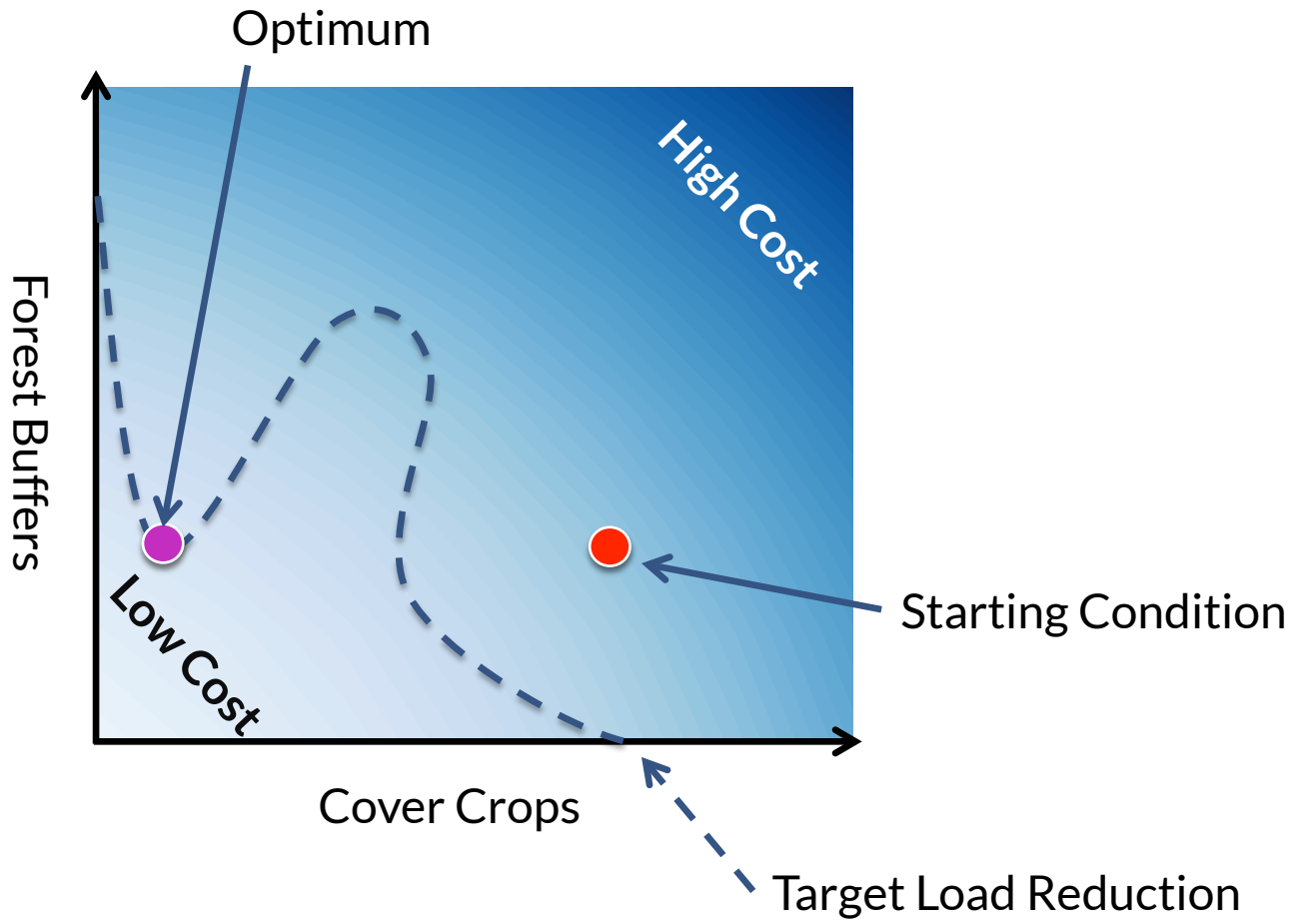
What is meant by optimization?



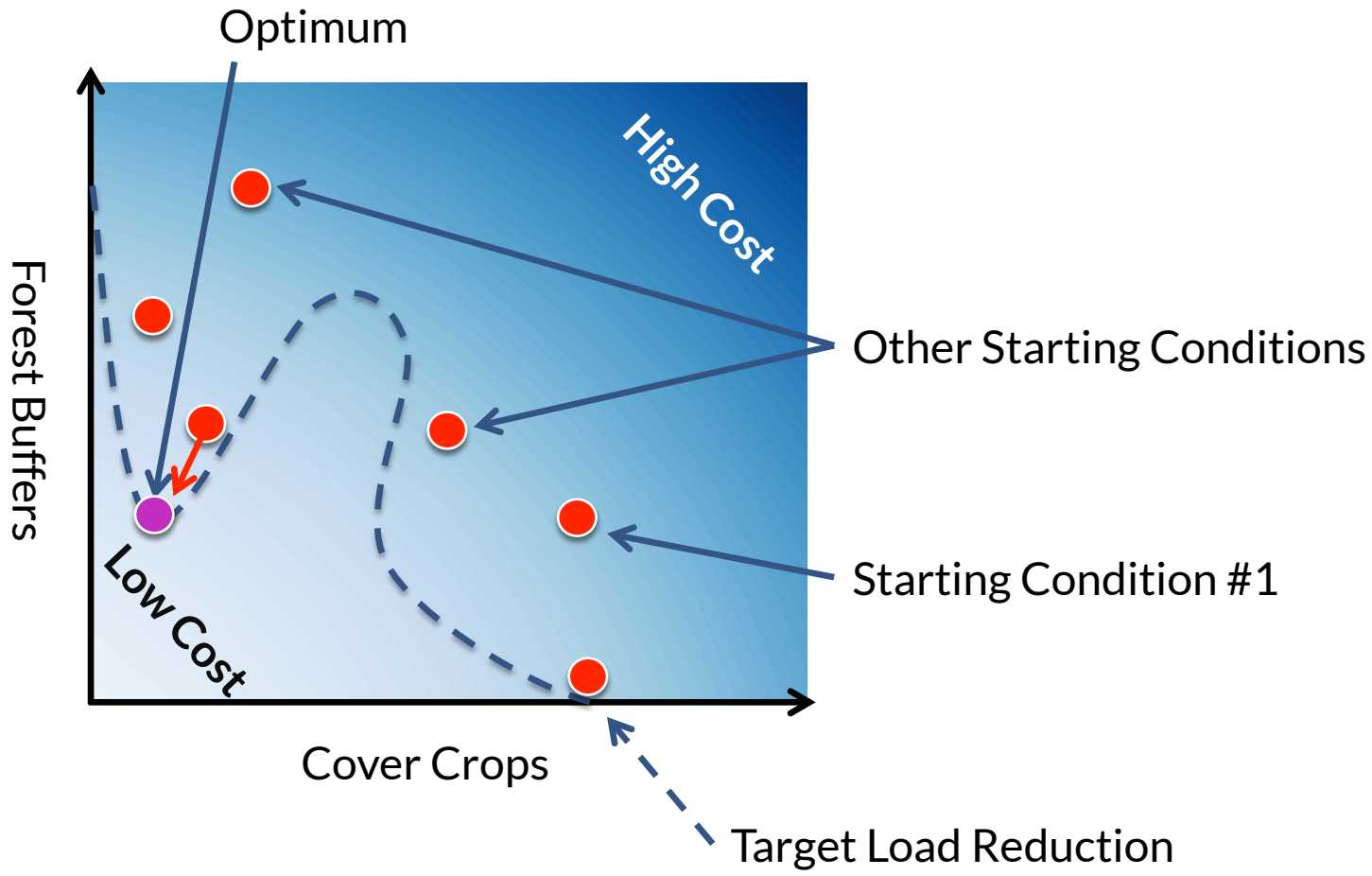
What is meant by optimization?



What is meant by optimization?



What is meant by optimization?



Optimization Description

Objective:

(Primary) Minimize the total annual costs of BMP implementation (includes capital, installation, opportunity, maintenance)

(Secondary) Maximize co-benefits

Optimization Description

Objective:

(Primary) Minimize the total annual costs of BMP implementation (includes capital, installation, opportunity, maintenance)

(Secondary) Maximize co-benefits

Decision Variables:

- Number of acres (or other unit) of each BMP in each land-use category and land river segment (continuous)
- Treatment technology upgrades at each significant point source facility (discrete)

Optimization Description

Objective:

(Primary) Minimize the total annual costs of BMP implementation (includes capital, installation, opportunity, maintenance)

(Secondary) Maximize co-benefits

Decision Variables:

- Number of acres (or other unit) of each BMP in each land-use category and land river segment (continuous)
- Treatment technology upgrades at each significant point source facility (discrete)

Basic Constraints:

- Scale/region of scenario (and/or agencies)
- Nitrogen and Phosphorous delivered load reductions ≥ load targets
- BMP'd acres ≤ available acres (by segment and land-use)
  - BMP'd roads ≤ available miles
  - BMP'd shorelines ≤ available miles
  - BMP'd animals ≤ available animal counts

Other Constraints:

- BMP constraints, for example:
  - agricultural land retirement ≤ *X* acres
  - cover crop oats ≥ *X* % of agricultural acres
- Land use restrictions for certain BMPs
- Capital limitations for certain sectors?

Current Phase

Investigate and Develop an Optimization Plan

Learn about CAST (uses, algorithms, and data/input/output structures)

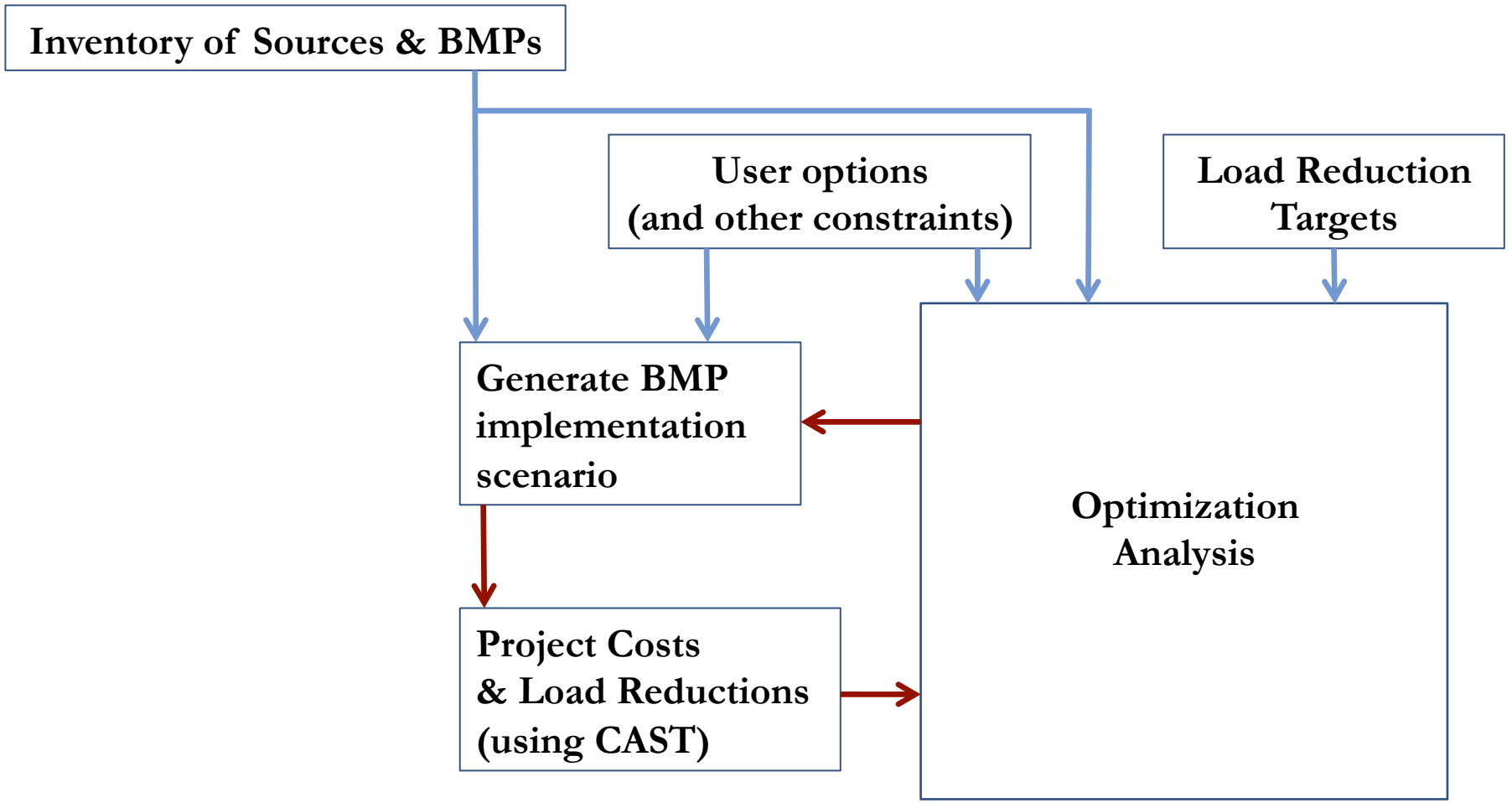
Consider:

- objectives and designs for a Phase 2 prototype
- suitable algorithms (or combinations)

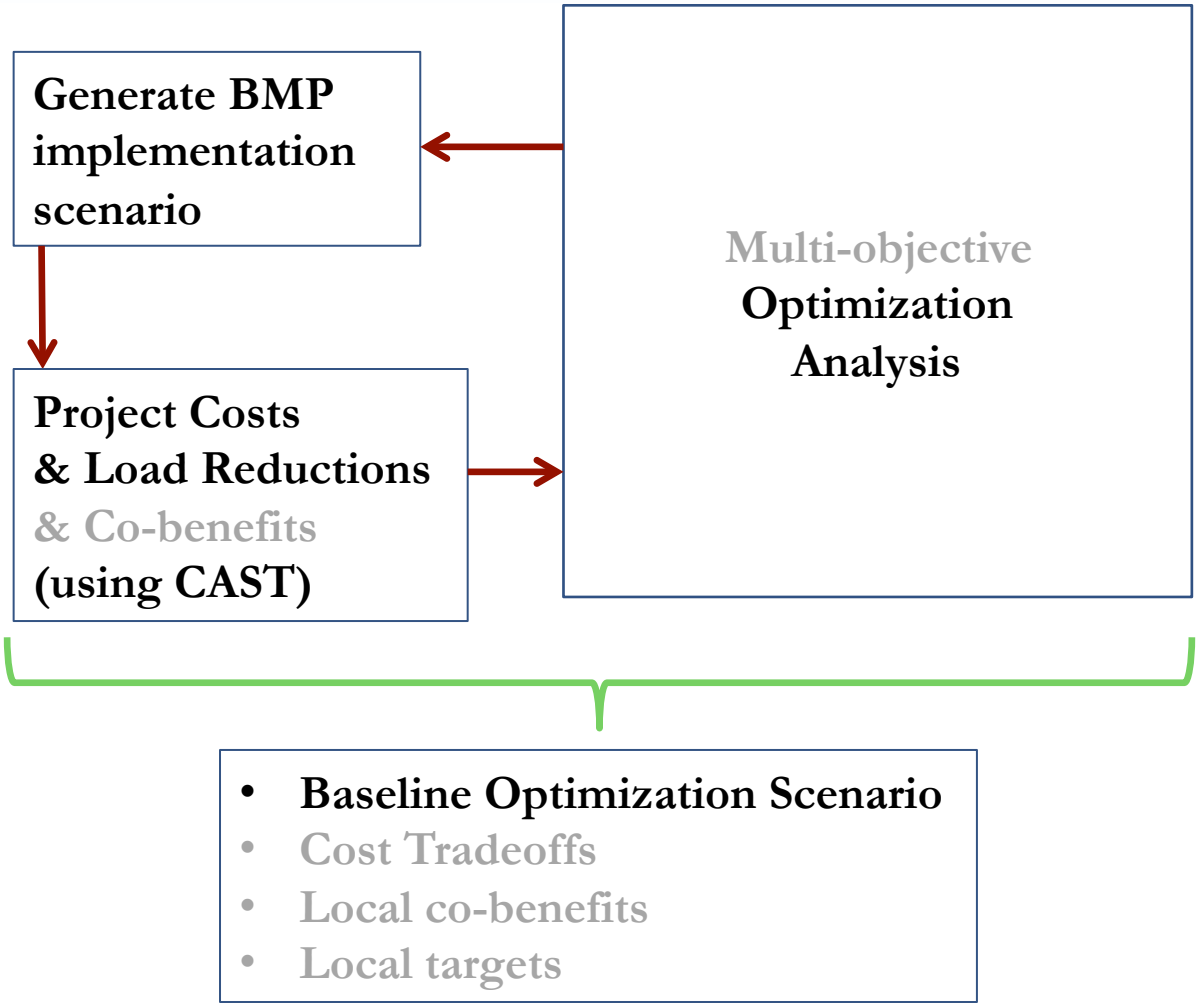
Identify model simplifications (reduced parameter sets)

Design an efficient interface between CAST and the proposed optimization software

Optimization Tool Sandbox

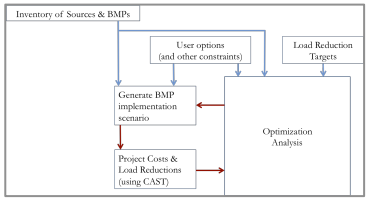


Optimization Tool Sandbox



Looking Forward

Sandbox



Identifying Alternatives

Cost Tradeoffs

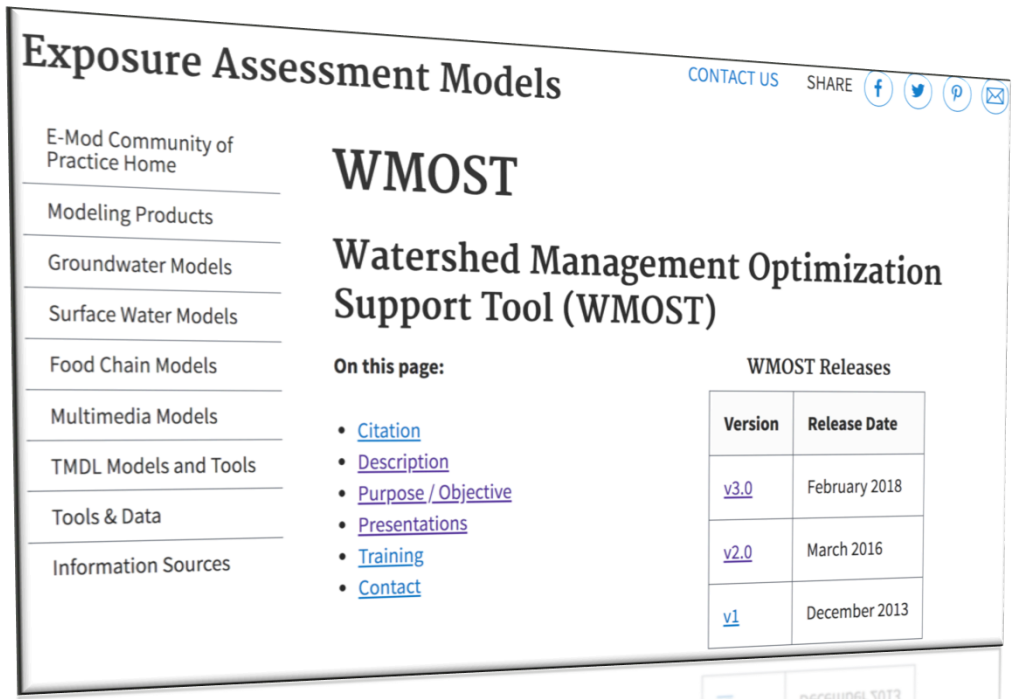
Baseline Optimization Prototype

Co-benefits

Local Targets

Exploring potential synergies

Watershed Management Optimization Support Tool (WMOST)



Developed and maintained by team at the EPA Office of Research and Development

Collaborating with:

- Naomi Detenbeck
- Amy Piscopo

Next Steps

Phase 1: Investigate and Develop an Optimization Plan

Continue developing a prototype in python

Continue learning about CAST (uses, algorithms, and data/input/output structures)

Refine optimization objectives, constraints, user needs

Continue considering suitable algorithms and tool designs for Phase 2 prototype

User Interface

What does a user want to be able to do/see?

Select geographic region of interest and land use types

- Geographic region by State, County, In/Out of CBWS, Land-river segment
- Land Use types by agency, sector, and base conditions

Select BMP constraints

- ideas: exclude certain BMPs, max/min acreage of certain BMPs,

See and compare objective attributes of nondominated solutions

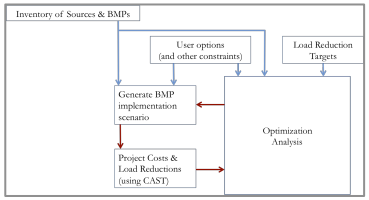
- load reductions
- cost
- co-benefits

See the set of BMP assignments for each solution

- by land use, segment, state, sector
- in categories or individually, and in acreage or percent

Looking Forward

Sandbox



Identifying Alternatives

Cost Tradeoffs

Baseline Optimization Prototype

Co-benefits

Local Targets

What does a user want to be able to do/see…
Select geographic region of interest and land use types
Select BMP constraints
See and compare objective attributes of nondominated solutions
See the set of BMP assignments for each solution

Questions

Other constraints?

Other objectives?

Departures from existing scenarios, with given costs

Computational resources/speed