



# 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**

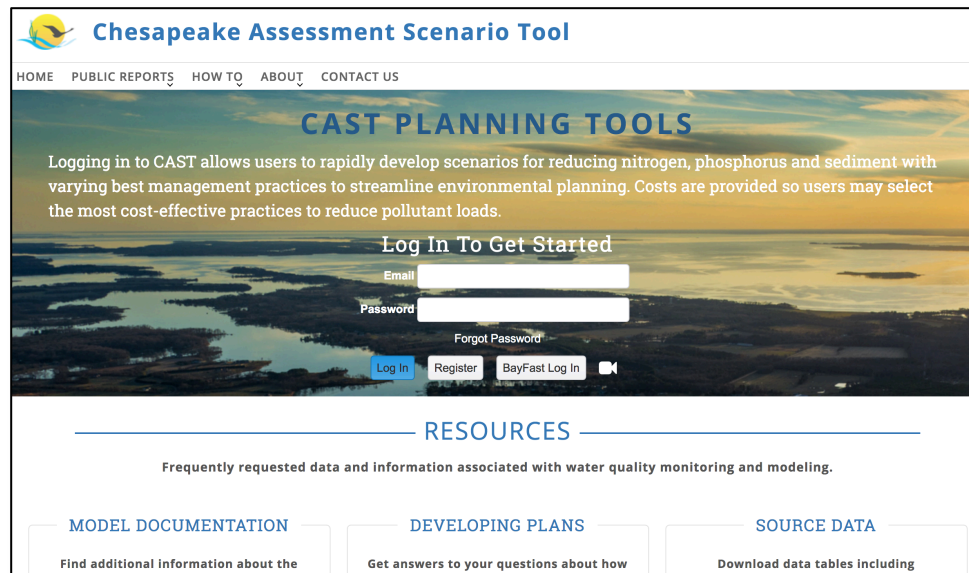
# Chesapeake Assessment Scenario Tool (CAST)

## 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**



The screenshot shows the homepage of the Chesapeake Assessment Scenario Tool (CAST). At the top, there is a navigation bar with links: HOME, PUBLIC REPORTS, HOW TO, ABOUT, and CONTACT US. Below this is a large banner image of a coastal landscape with water and trees. Overlaid on the banner is the text "CAST PLANNING TOOLS" and a description: "Logging in to CAST allows users to rapidly develop scenarios for reducing nitrogen, phosphorus and sediment with varying best management practices to streamline environmental planning. Costs are provided so users may select the most cost-effective practices to reduce pollutant loads." Below the description is a "Log In To Get Started" section with input fields for "Email" and "Password", a "Forgot Password" link, and buttons for "Log In", "Register", and "BayFast Log In". At the bottom, there is a "RESOURCES" section with the text "Frequently requested data and information associated with water quality monitoring and modeling." and three columns: "MODEL DOCUMENTATION" (Find additional information about the), "DEVELOPING PLANS" (Get answers to your questions about how), and "SOURCE DATA" (Download data tables including).

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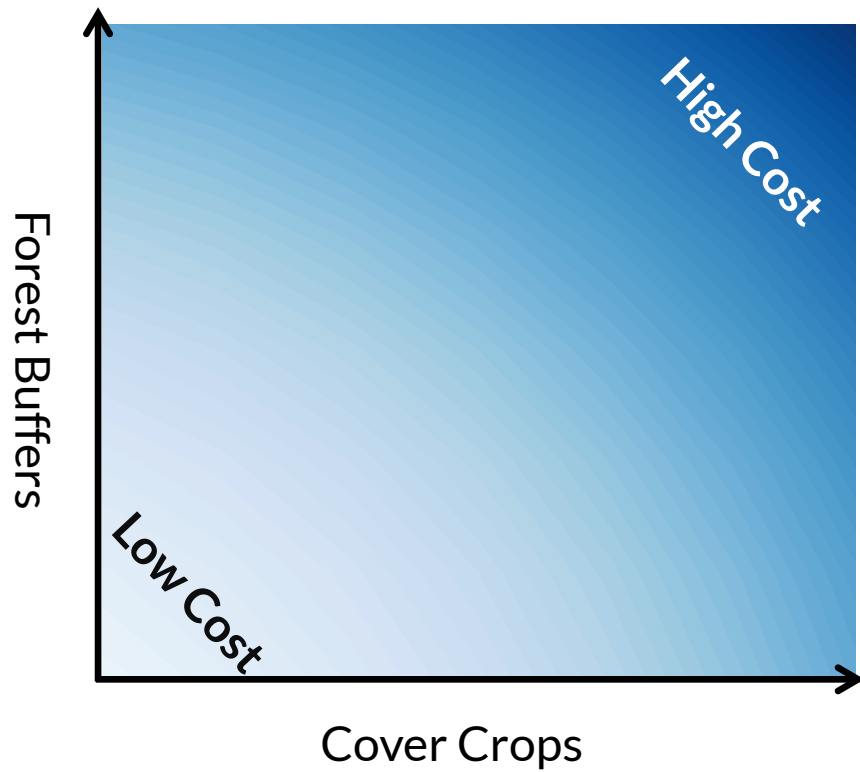
Load Sources  
Cost profiles

BMP effects on  
• loads • other BMPs

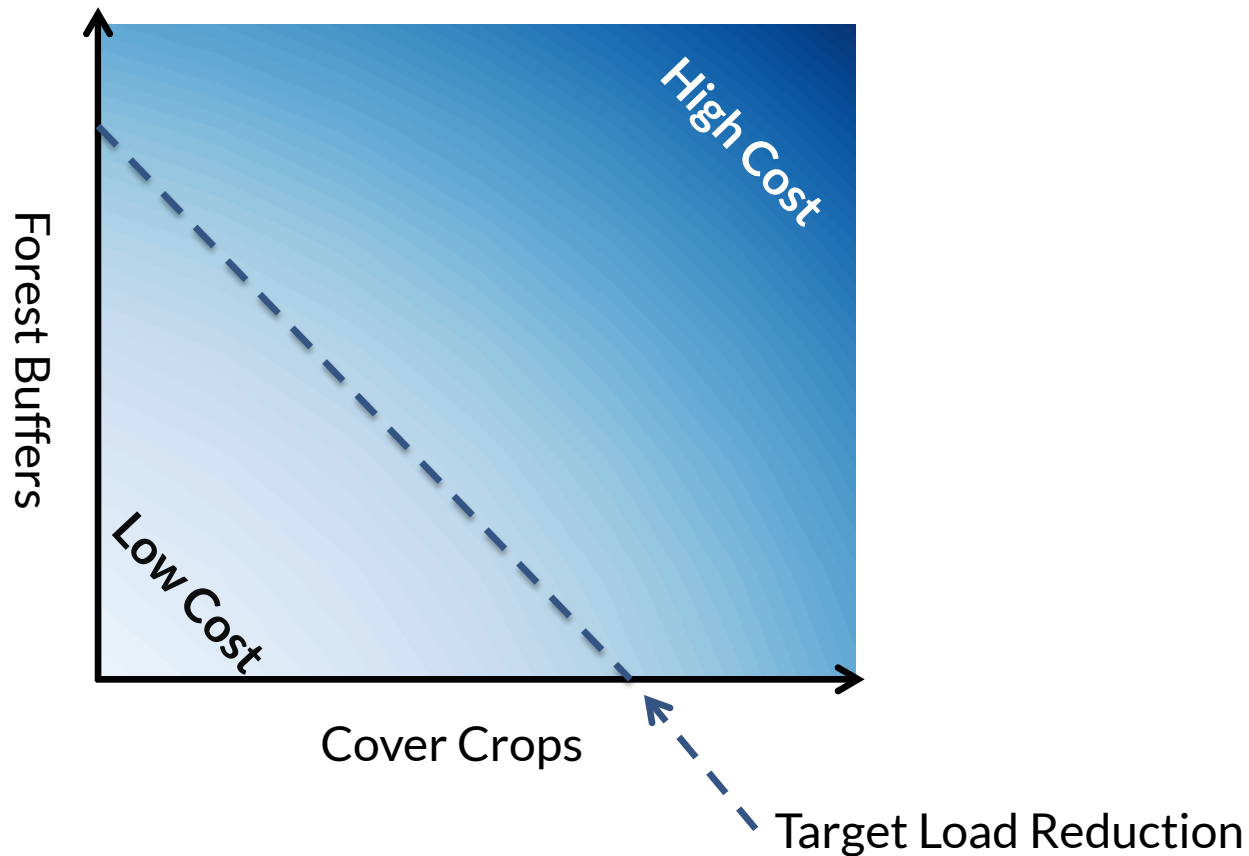
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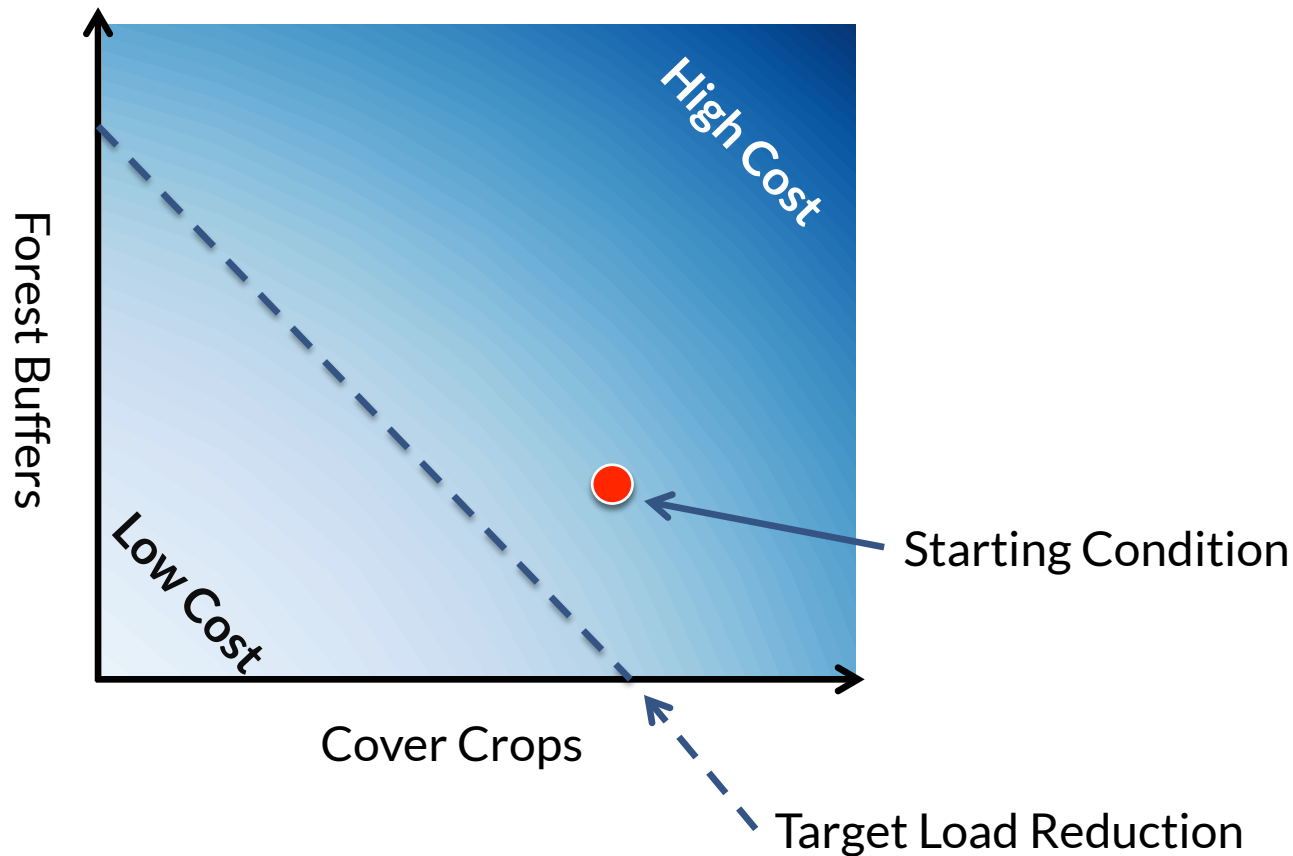


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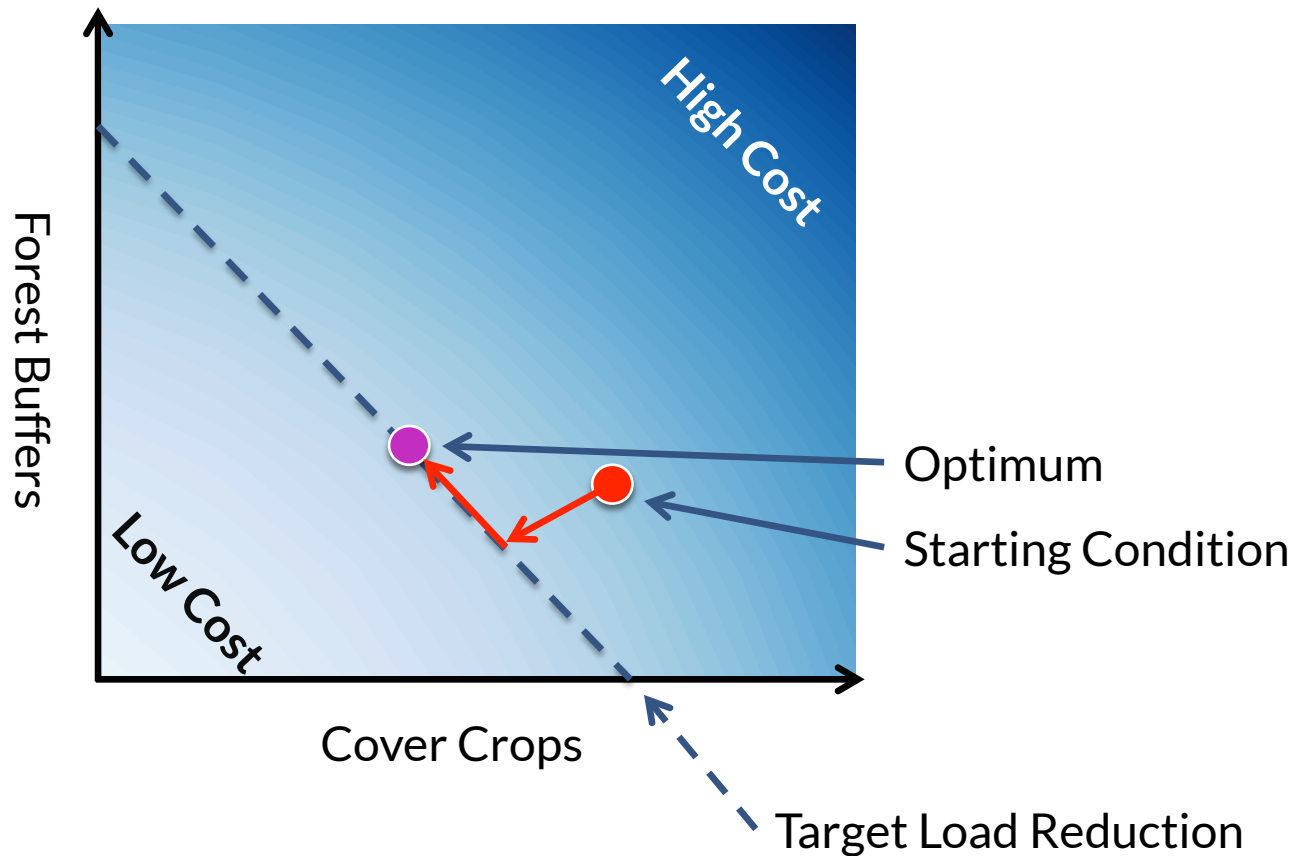




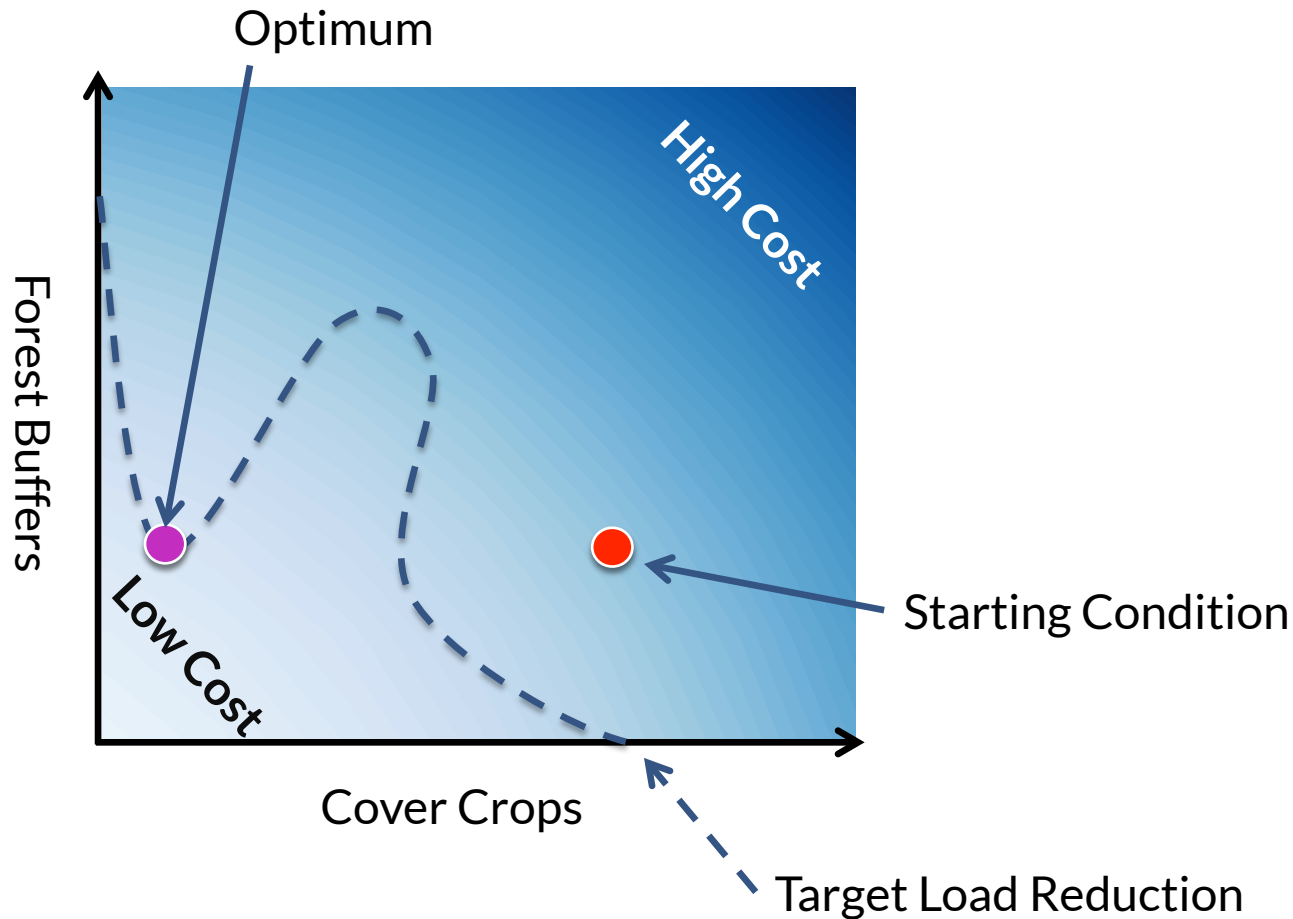
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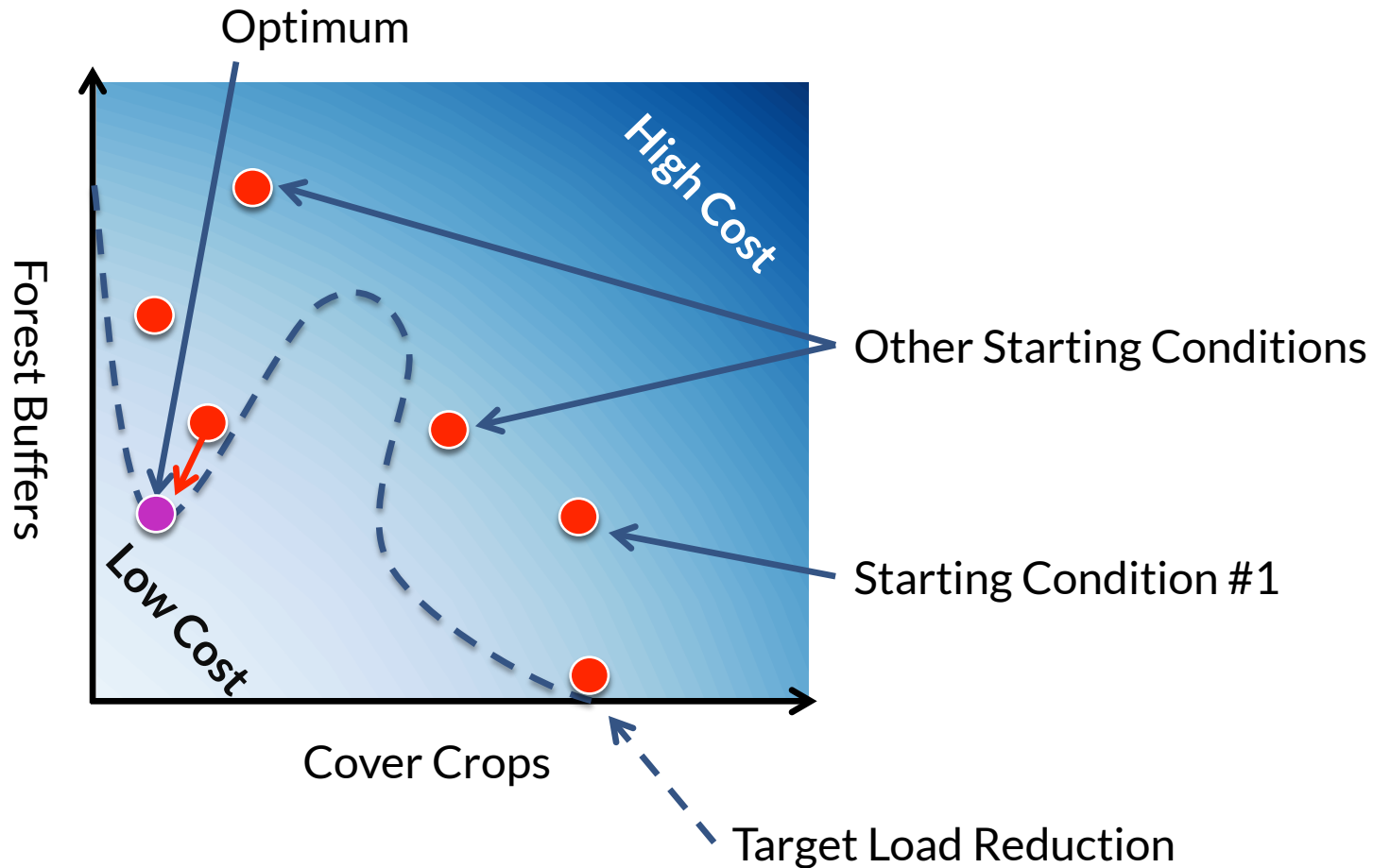
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- Number of acres (or other unit) of each BMP in each land-use category and land river segment (continuous)
- Treatment technology upgrades at each significant point source facility (discrete)

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(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  $\geq$  load targets
- BMP'd acres  $\leq$  available acres (by segment and land-use)
  - BMP'd roads  $\leq$  available miles
  - BMP'd shorelines  $\leq$  available miles
  - BMP'd animals  $\leq$  available animal counts

## Other Constraints:

- BMP constraints, for example:
  - agricultural land retirement  $\leq$  X acres
  - cover crop oats  $\geq$  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:**

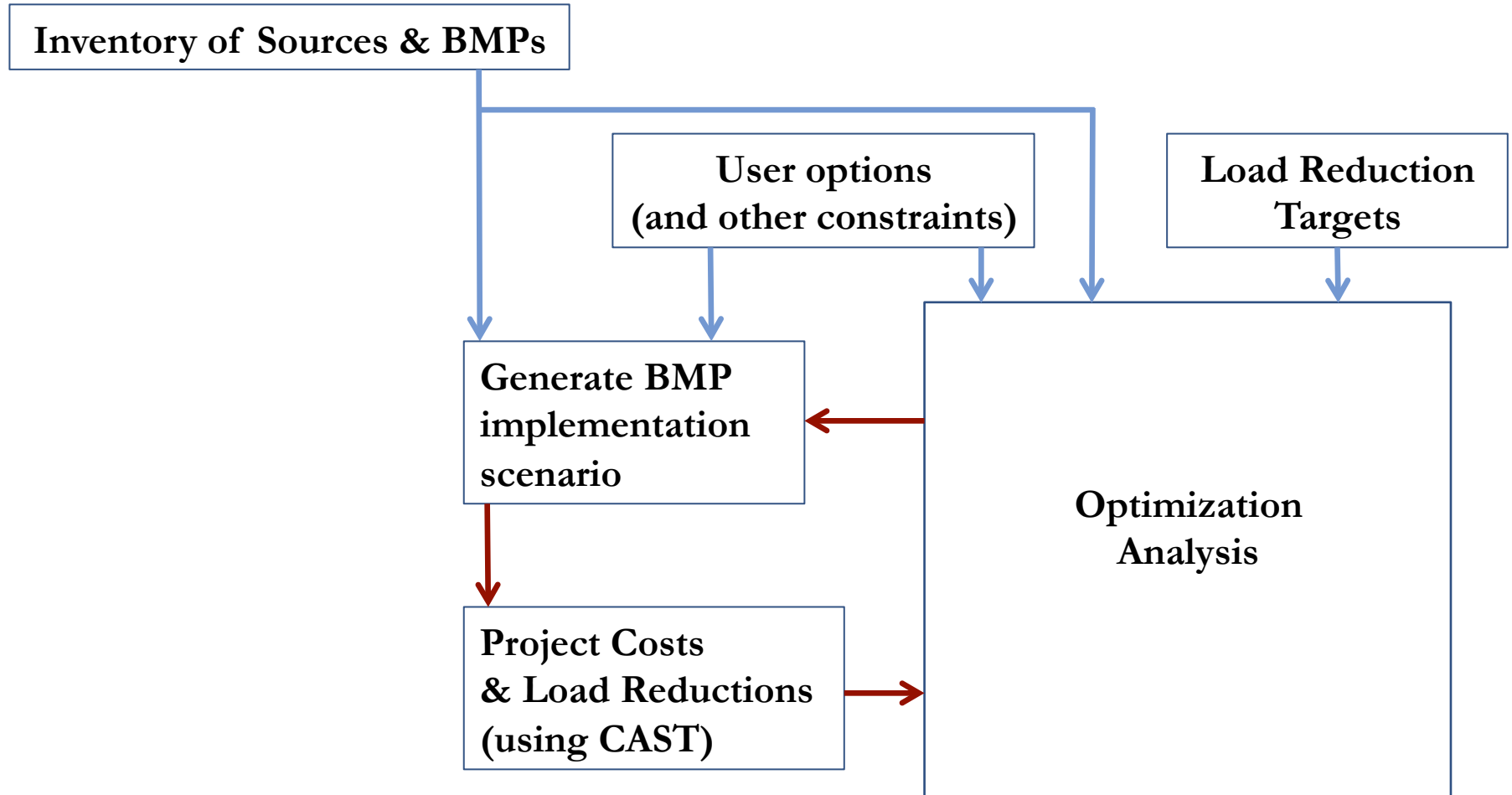
- objectives and designs for a Phase 2 prototype
- suitable algorithms (or combinations)

**Identify** model simplifications (reduced parameter sets)

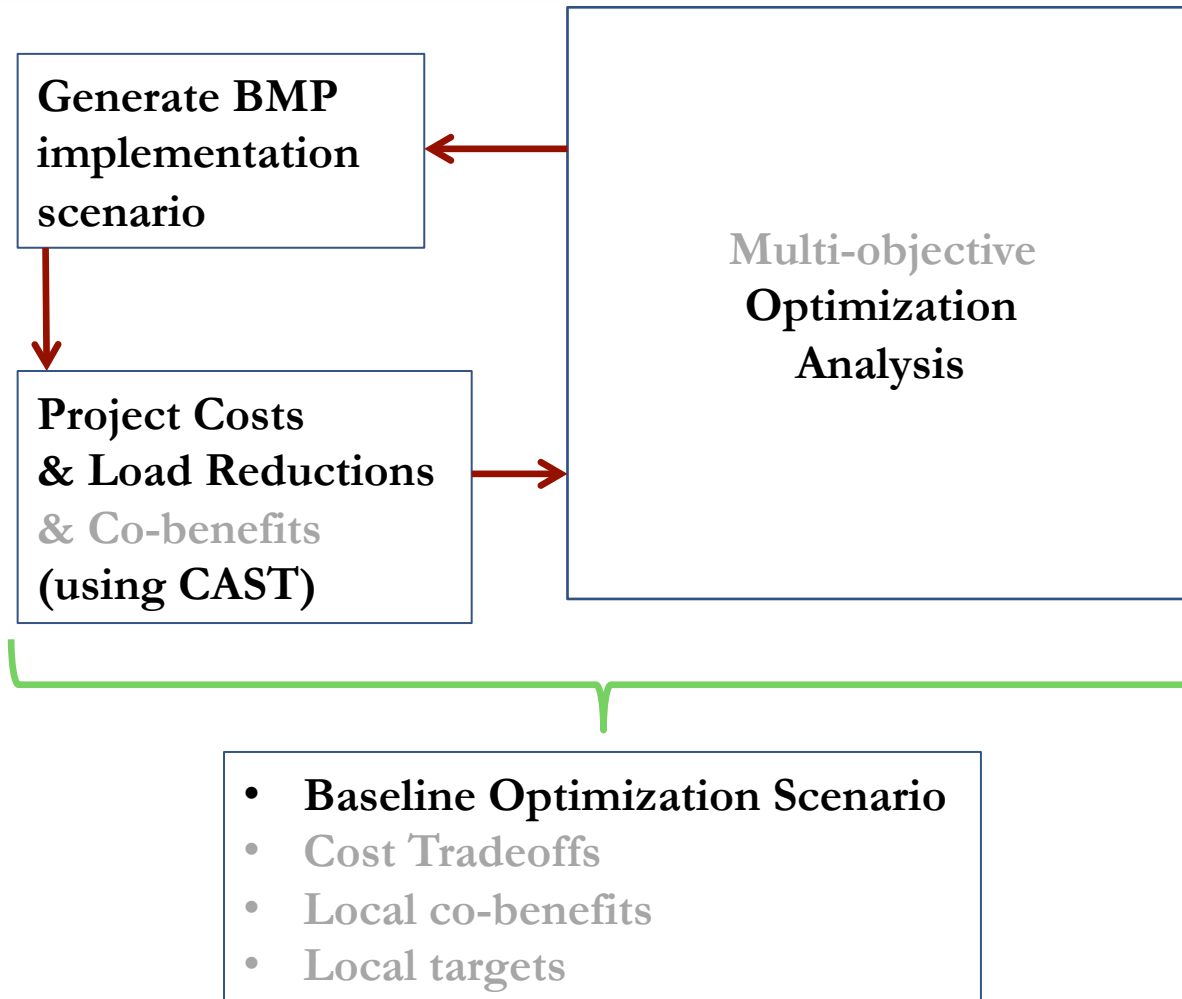
**Design** an efficient interface between CAST and the proposed optimization software



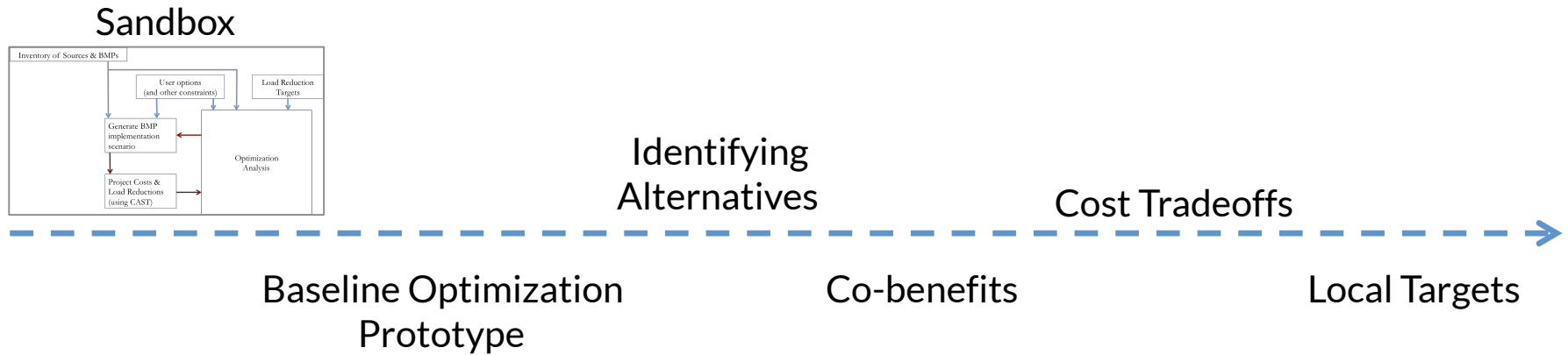
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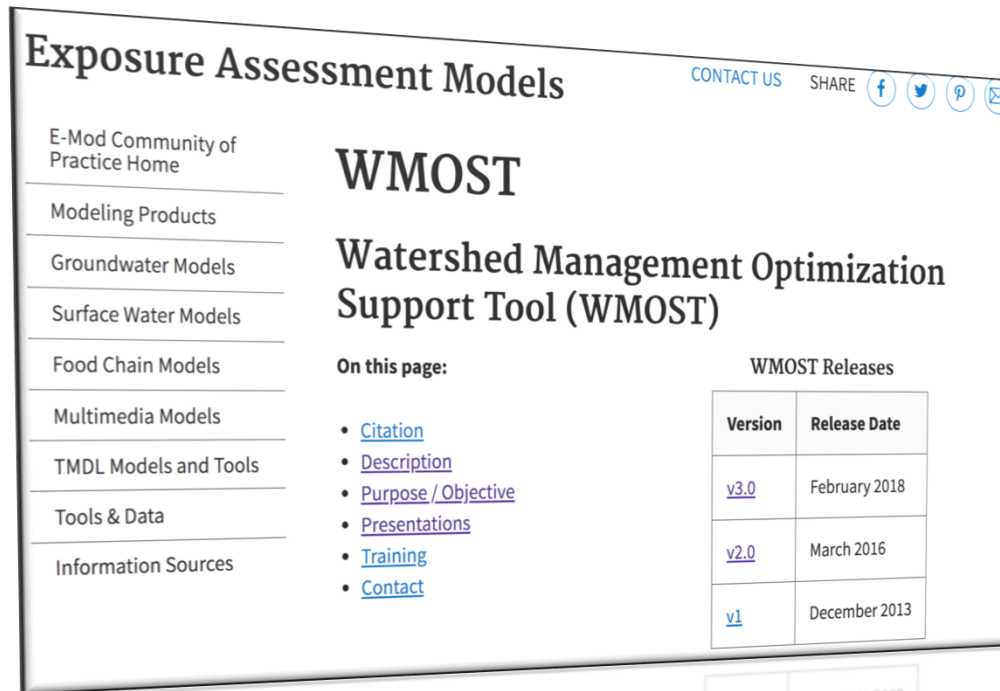


# Looking Forward



# Exploring potential synergies

## Watershed Management Optimization Support Tool (WMOST)



The screenshot shows a web page titled "Exposure Assessment Models" with a navigation menu on the left. The main content area features the title "WMOST" and "Watershed Management Optimization Support Tool (WMOST)". Below this, there is a list of links under "On this page:" and a table of "WMOST Releases".

**Exposure Assessment Models**

E-Mod Community of Practice Home

Modeling Products

Groundwater Models

Surface Water Models

Food Chain Models

Multimedia Models

TMDL Models and Tools

Tools & Data

Information Sources

**WMOST**

**Watershed Management Optimization Support Tool (WMOST)**

On this page:

- [Citation](#)
- [Description](#)
- [Purpose / Objective](#)
- [Presentations](#)
- [Training](#)
- [Contact](#)

WMOST Releases

Version	Release Date
<a href="#">v3.0</a>	February 2018
<a href="#">v2.0</a>	March 2016
<a href="#">v1</a>	December 2013

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

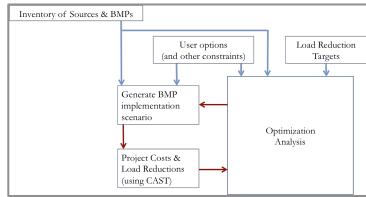
- load reductions
- cost
- co-benefits

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