FWG Involvement in Phase 7 Watershed Model Development

Forestry Workgroup

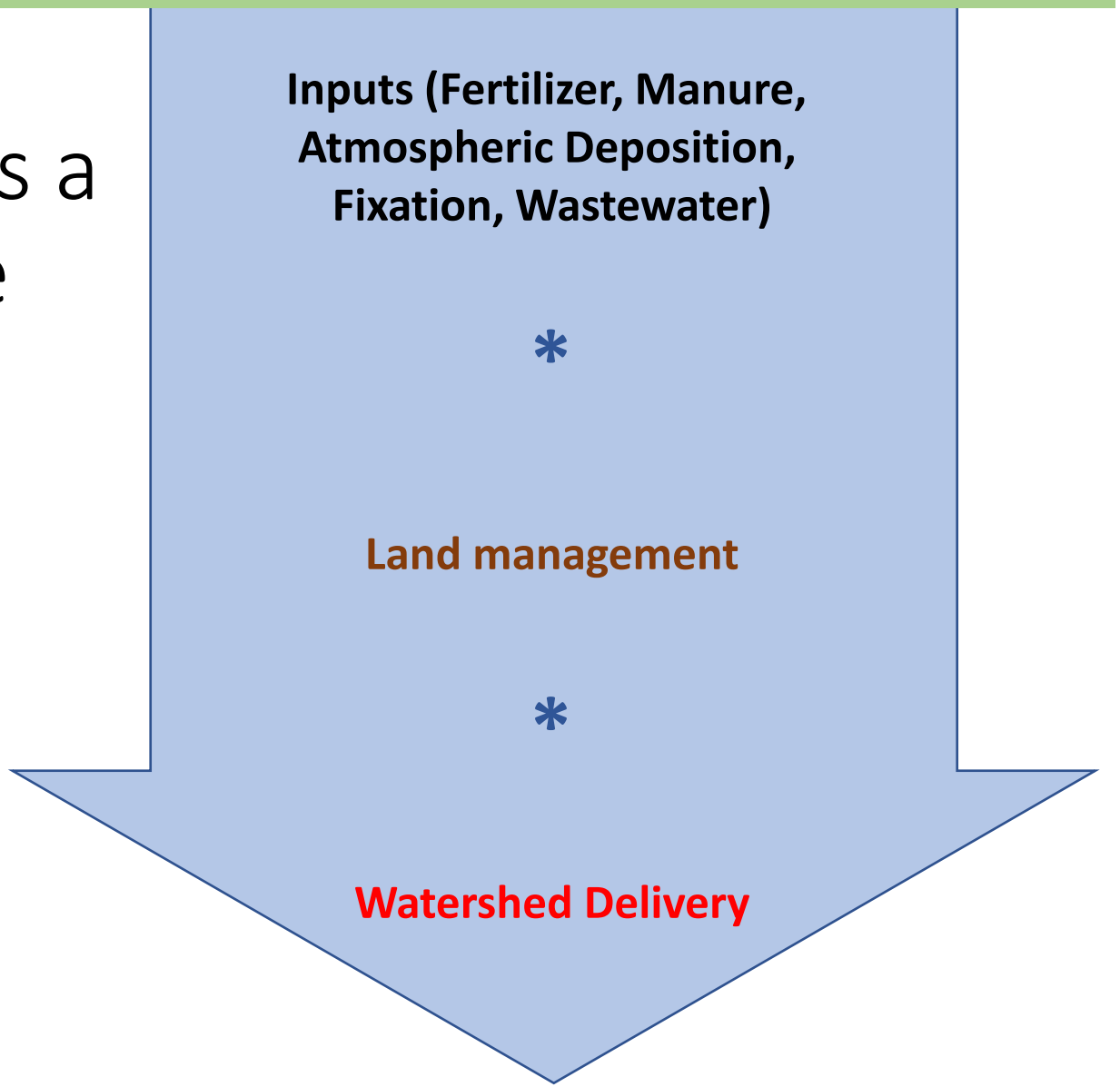
4/2/2024

Outline

- Background on Watershed Model
- Bay TMDL Summary
- Data ideals for management models
  - Consistency > Accuracy
  - Weather independent values > Actual values
- Forestry Workgroup involvement and decisions.

CAST Structure

CAST is a simple model



Load by land-river segment and land use

CAST is a simple model

CAST Structure

Inputs (Fertilizer, Manure, Atmospheric Deposition, Fixation, Wastewater)

*

Land management

*

Watershed Delivery

Load by land-river segment and land use

CAST Structure

Average Load

+

△ Inputs * Sensitivity

*

BMPs

*

Acres

*

Land to Water

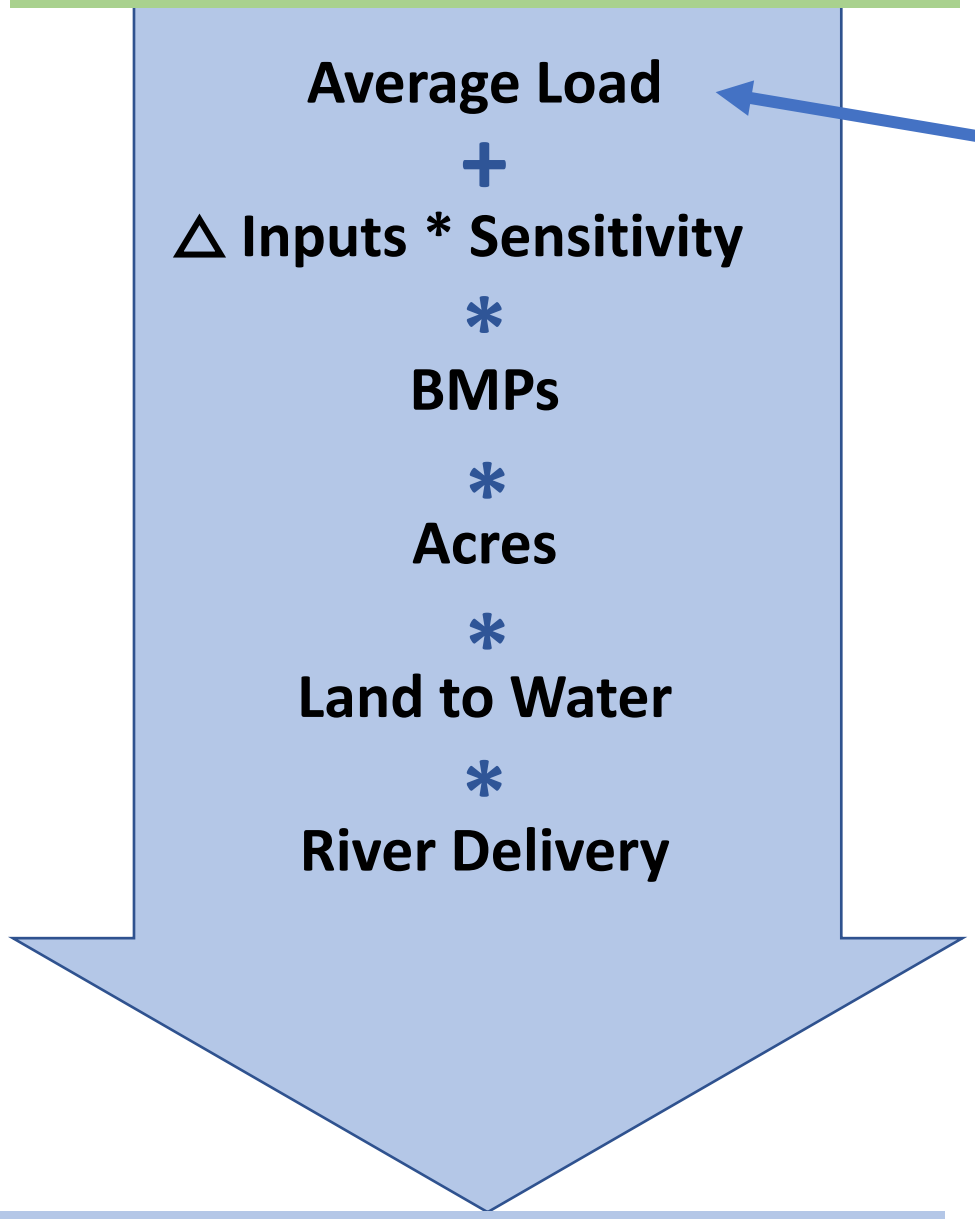
*

River Delivery

Load by land-river segment and land use

CAST Structure

Illustrative example



Average nitrogen load to stream for Forest watershed wide is 1.68 pounds per acre per year

Load by land-river segment and land use

CAST Structure

Illustrative example

Average Load

+

△ Inputs * Sensitivity

*****

BMPs

*****

Acres

*****

Land to Water

*****

River Delivery

Load by land-river segment and land use

Your area receives 6.5 lbs of atmospheric deposition while the watershed wide average is 10.

Each additional pound of atmospheric deposition results in 0.023 lbs of runoff

1.68 + (6.5-10) * 0.023 = 1.6 lbs/acre

CAST Structure

Illustrative example

Average Load

+

△ Inputs * Sensitivity

*****

BMPs

*****

Acres

*****

Land to Water

*****

River Delivery

Load by land-river segment and land use

BMPs are applied which give, in aggregate, a 25% reduction

1.6 * (1-25%) = 1.2 lbs/acre

This is just for illustration – there are no BMPs for true forest in P6

CAST Structure

Illustrative example

Average Load

+

△ Inputs * Sensitivity

*****

BMPs

*****

Acres

*****

Land to Water

*****

River Delivery

There are 100 acres of True Forest in this segment

1.2 lbs/acre * 100 acres = 120 lbs

Load by land-river segment and land use

CAST Structure

Illustrative example

Average Load

+

△ Inputs * Sensitivity

*****

BMPs

*****

Acres

*****

Land to Water

*****

River Delivery

The land here is 50% leaker than average due to high groundwater recharge in the piedmont carbonate

The river system reduces loads by 50% by passing through a reservoir

120 lbs * 1.5 * (1-.50) = 90 lbs
Delivered to the Bay from this land use and segment

Load by land-river segment and land use

Three linked models

Phase 7 CAST Structure

Average Load
+
Δ Inputs * Sensitivity
*
BMPs
*
Acres
*
Land to Water
*
River Delivery

Load by land-river segment and land use

Inform

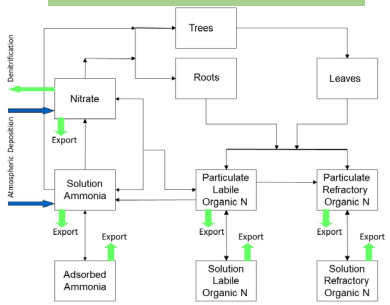
Constrain

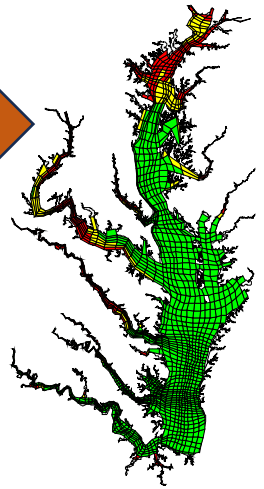
CalCAST

Average Load
+
Δ Inputs * Sensitivity
*
BMPs
*
Acres
*
Land to Water
*
River Delivery

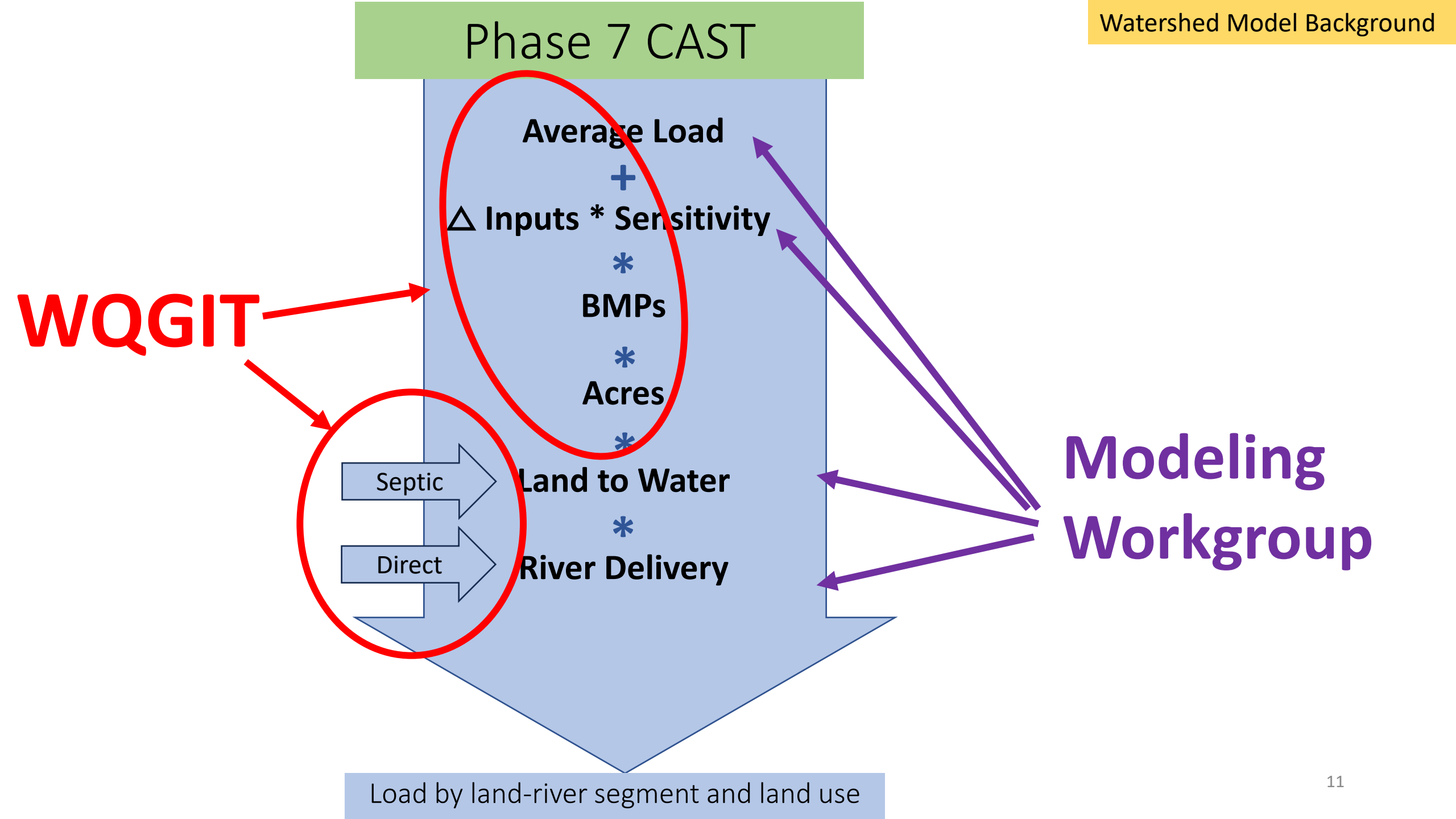
Load by land-river segment and land use

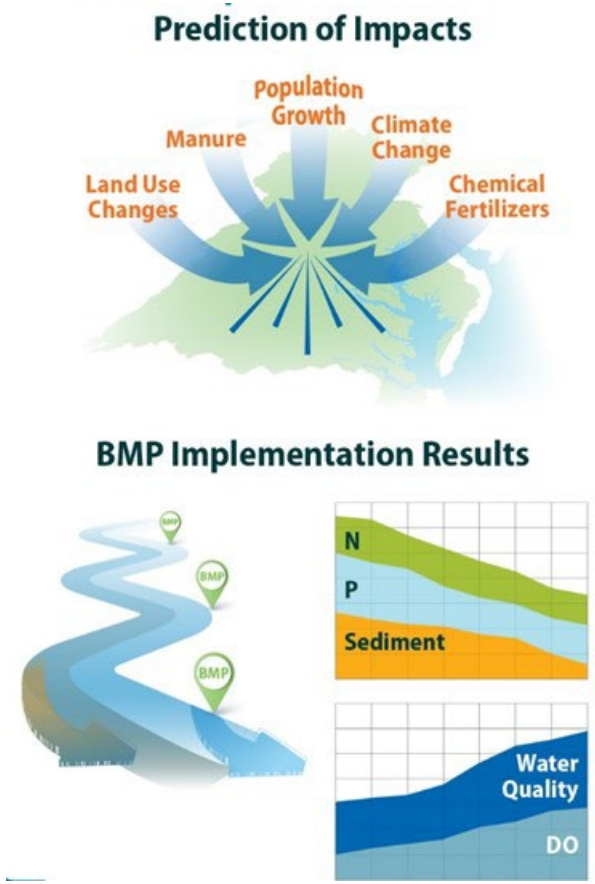
Temporal downscaling model





CAST model documentation; section 1
https://cast.chesapeakebay.net/Documentation/ModelDocumentation


Phase 7 CAST
Average Load
+
Δ Inputs * Sensitivity
*
BMPs
*
Acres
*
Land to Water
*
River Delivery
Septic
Direct
WQGIT
Modeling Workgroup
Load by land-river segment and land use



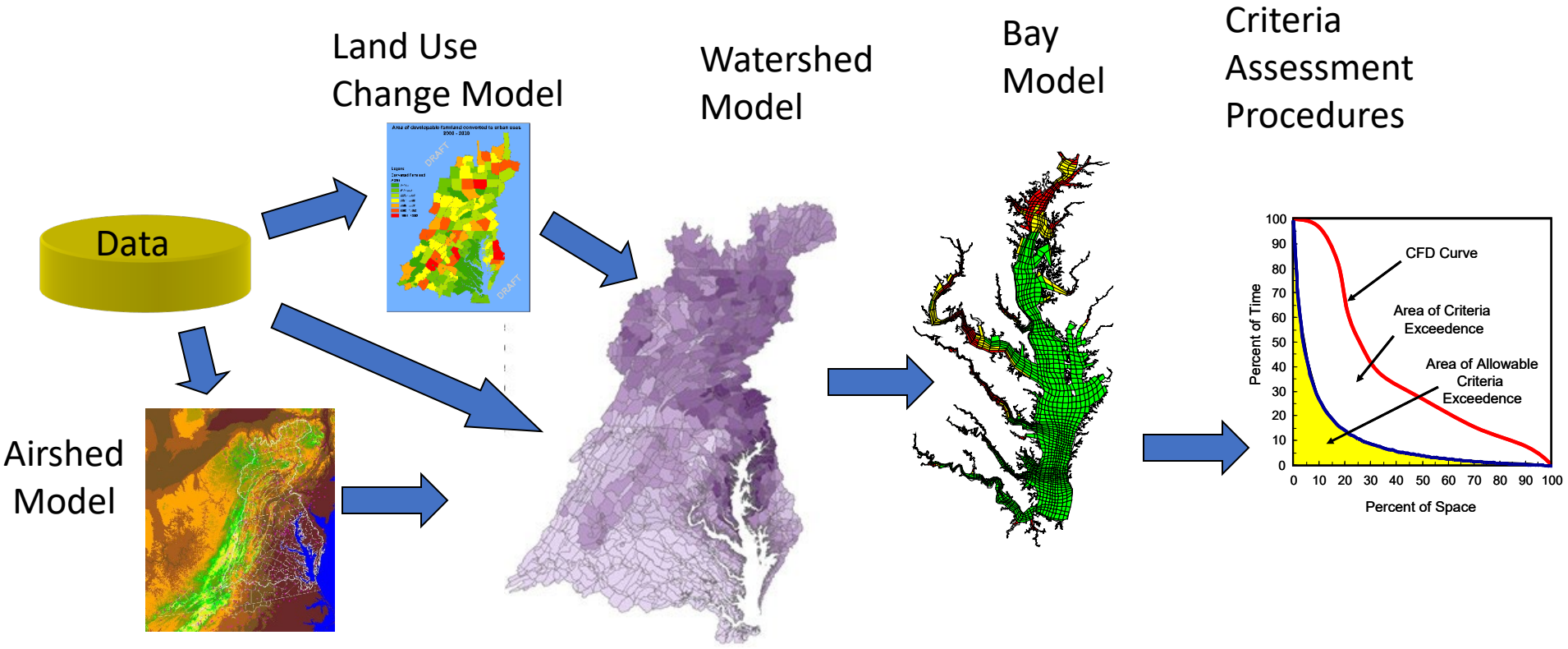
TMDL summary

What management practices…

…. will reduce nitrogen and phosphorus to levels …

…. that will achieve appropriate dissolved oxygen, clarity, and chlorophyll in the Bay?

CBP Decision Support System



What management practices…

…. will reduce nitrogen and phosphorus to levels …

…. that will achieve appropriate dissolved oxygen, clarity, and chlorophyll in the Bay?

Guidelines for WIP Planning Targets

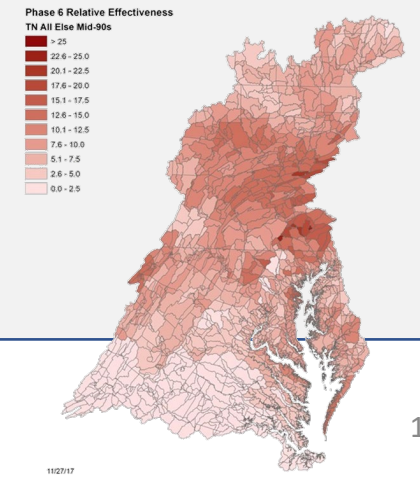
Everything
Everywhere
Everyone

Effort

No BMPs

Effectiveness

Increasing relationship between
Relative Effectiveness and Effort



Nutrient Targets

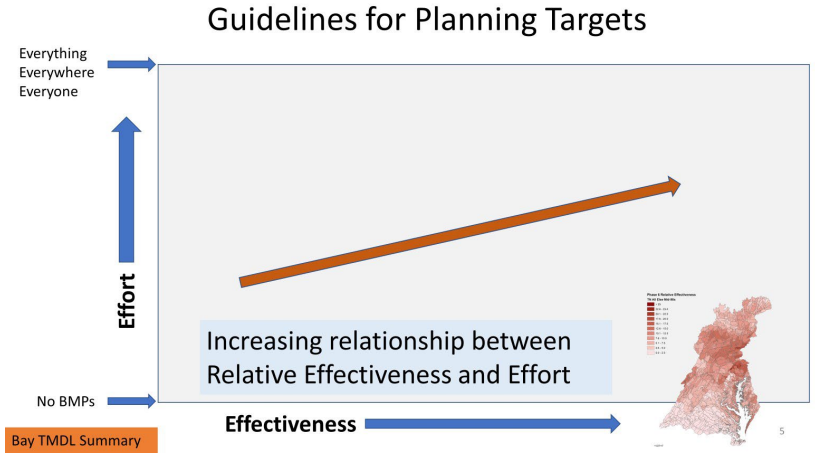
Major	State		2018 Planning Targets approved by PSC	
Major	State	StateBasin	Nitrogen	Phosphorus
Potomac	DC	DC Potomac	2.42	0.130
Eastern Shore	DE	DE Eastern Shore	4.55	0.108
Eastern Shore	MD	MD Eastern Shore	15.21	1.286
Patuxent	MD	MD Patuxent	3.21	0.301
Potomac	MD	MD Potomac	15.30	1.092
Susquehanna	MD	MD Susquehanna	1.18	0.053
Western Shore	MD	MD Western Shore	10.89	0.948
Susquehanna	NY	NY Susquehanna	11.53	0.587
Eastern Shore	PA	PA Eastern Shore	0.45	0.025
Potomac	PA	PA Potomac	6.11	0.357
Susquehanna	PA	PA Susquehanna	66.59	2.661
Western Shore	PA	PA Western Shore	0.02	0.001
Eastern Shore	VA	VA Eastern Shore	1.43	0.164
James	VA	VA James	25.92	2.731
Potomac	VA	VA Potomac	16.00	1.892
Rappahannock	VA	VA Rappahannock	6.85	0.849
York	VA	VA York	5.52	0.556
James	WV	WV James	0.04	0.005
Potomac	WV	WV Potomac	8.18	0.427

- Nutrient loads in million lbs/year
- Long-term hydrology
  - When the targets are reached, these are the annual average loads
- Will be reevaluated with new models and climate change through 2035 in 2027/2028

Primary use of the CBP Watershed Model

- Represent anthropogenic changes in load
- Set and track reduction goals

- Ideally:
  - Include all load sources
  - Treat all jurisdictions equally
  - Track actions that change loads
  - Factor out the temporal variability of weather



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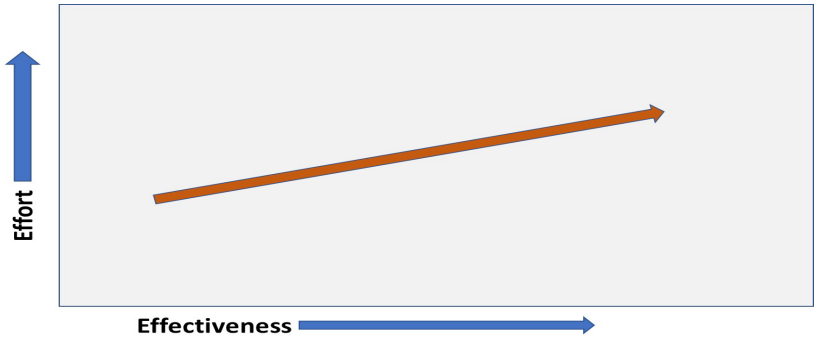
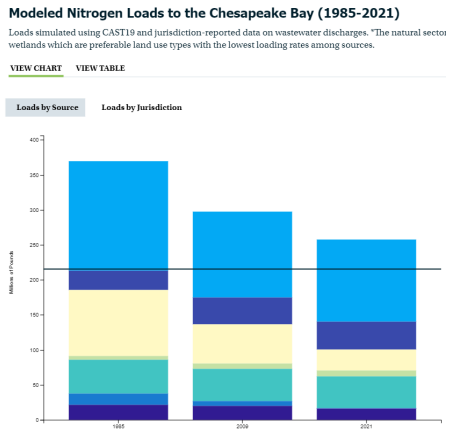
Data Ideals

Consistency > Accuracy

Spatial and temporal trends are more important that the absolute value



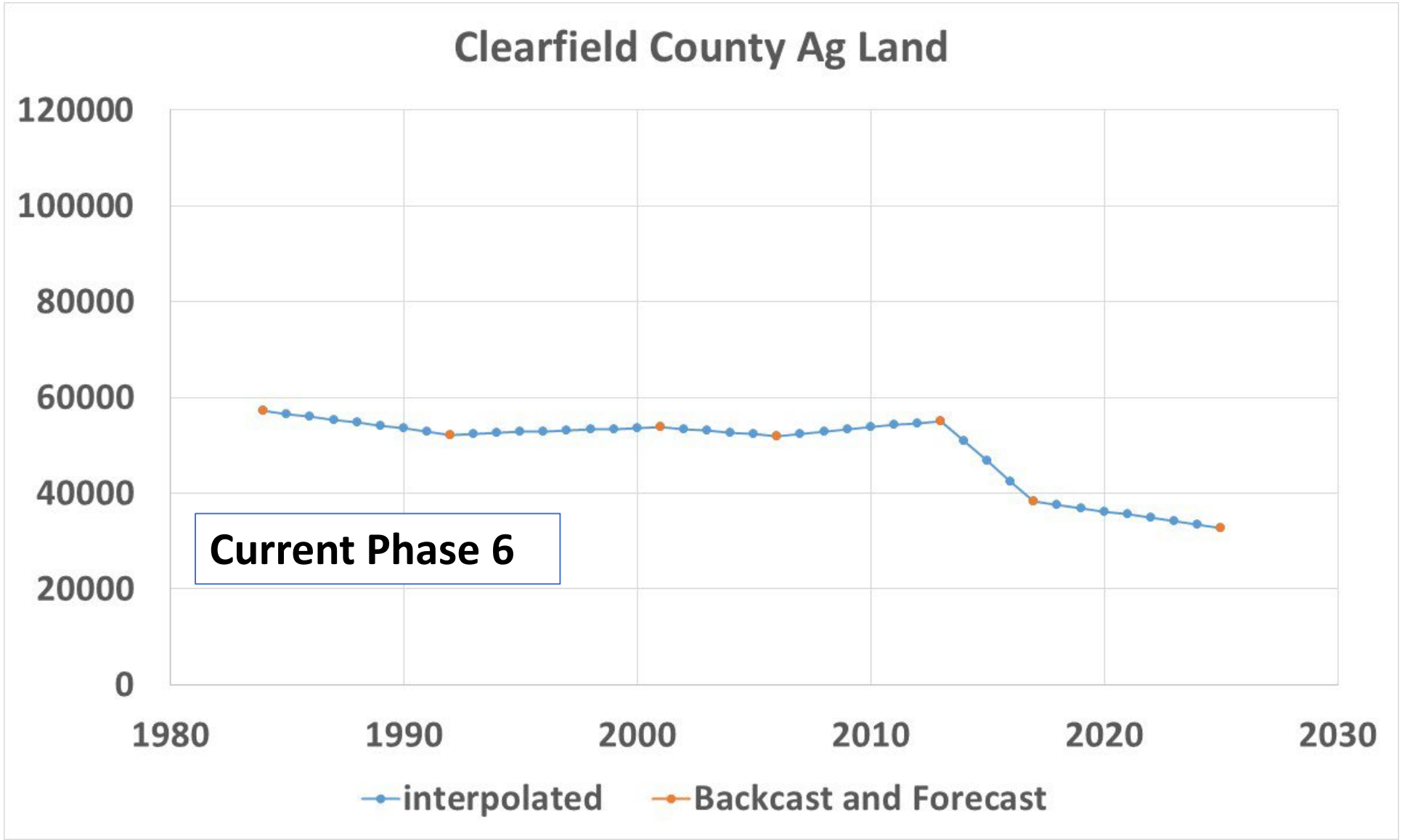
Spatial - Model used to allocate responsibility between jurisdictions



Temporal - Model used to track TMDL, based on changes since 1995

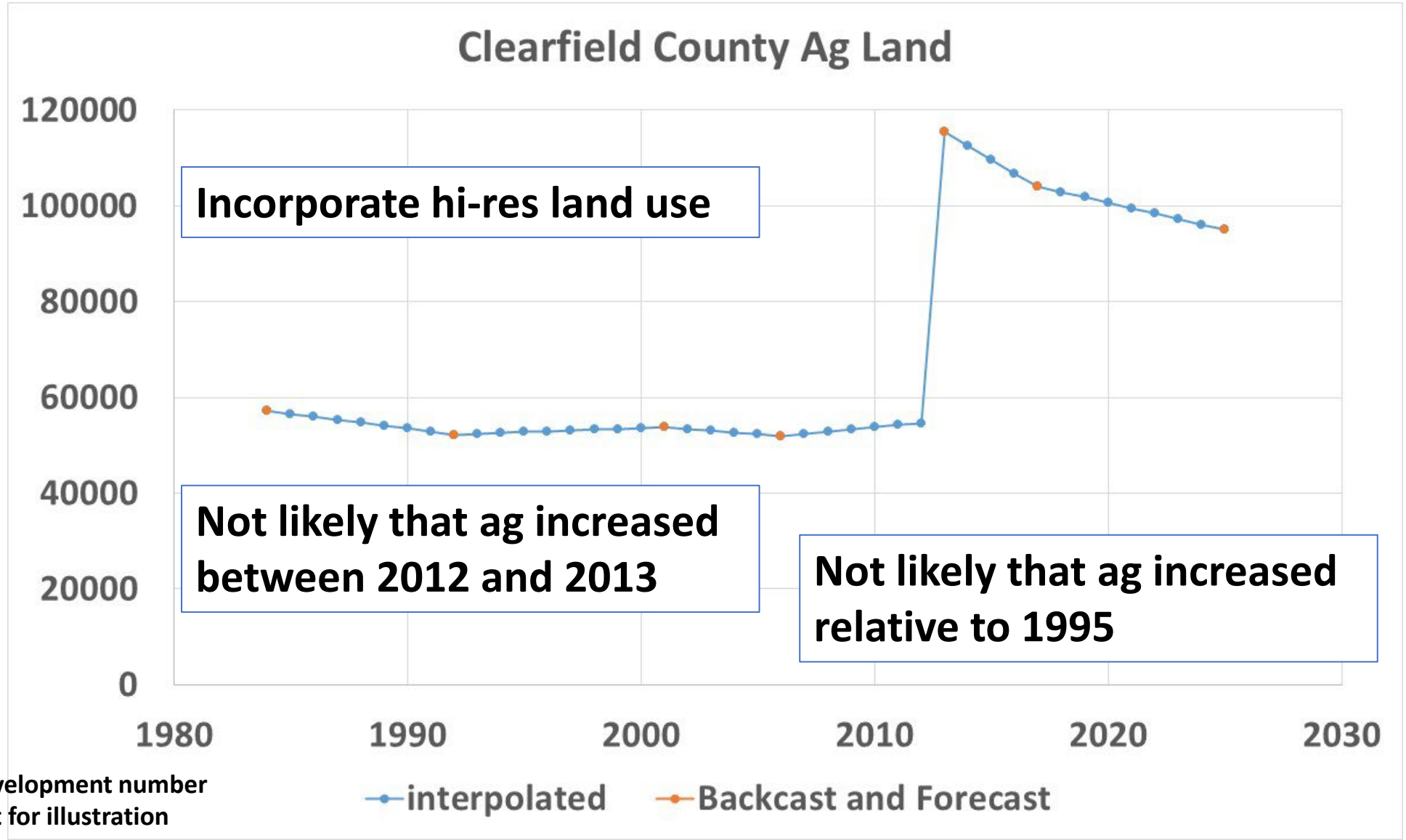
Data Ideals

Consistency example



Data Ideals

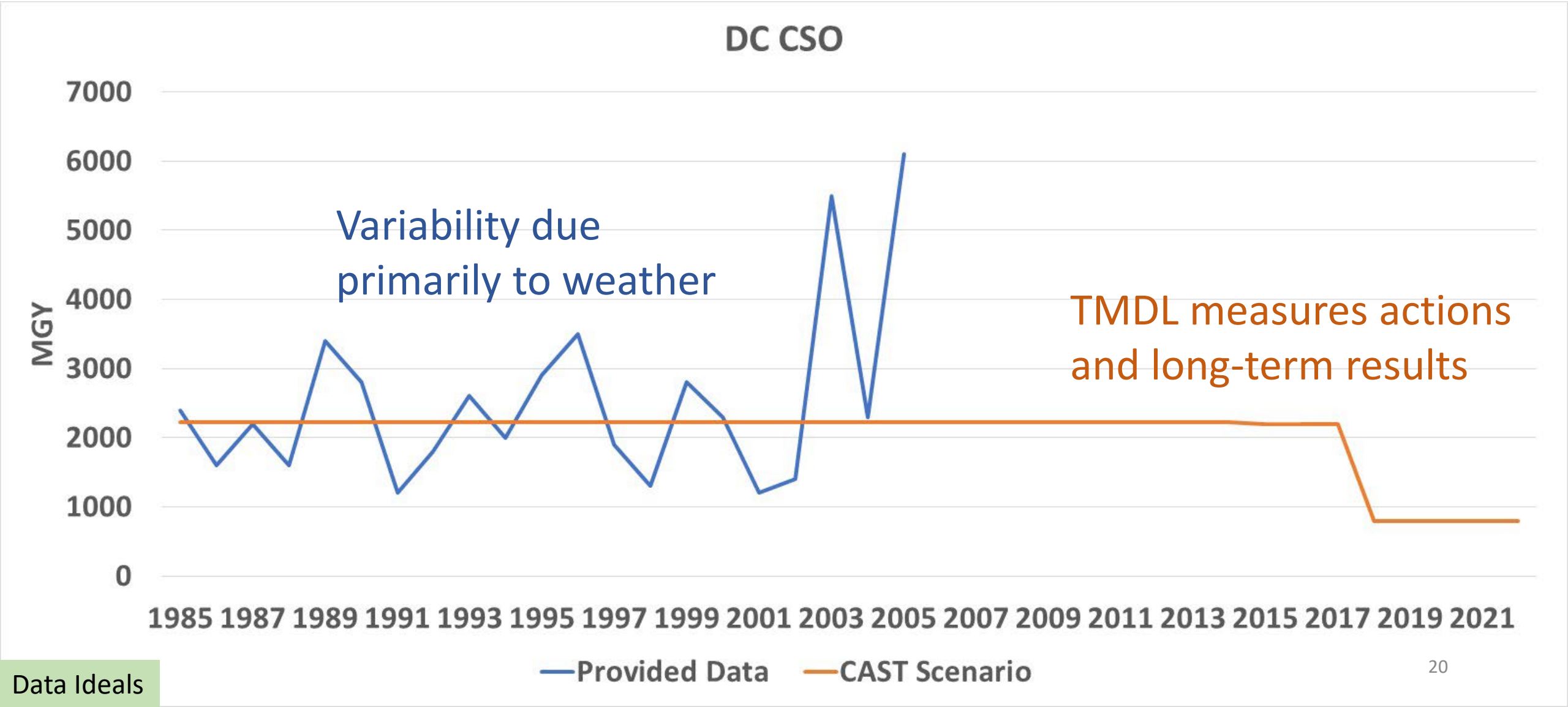
Consistency example



2013 is current development number
ust for illustration

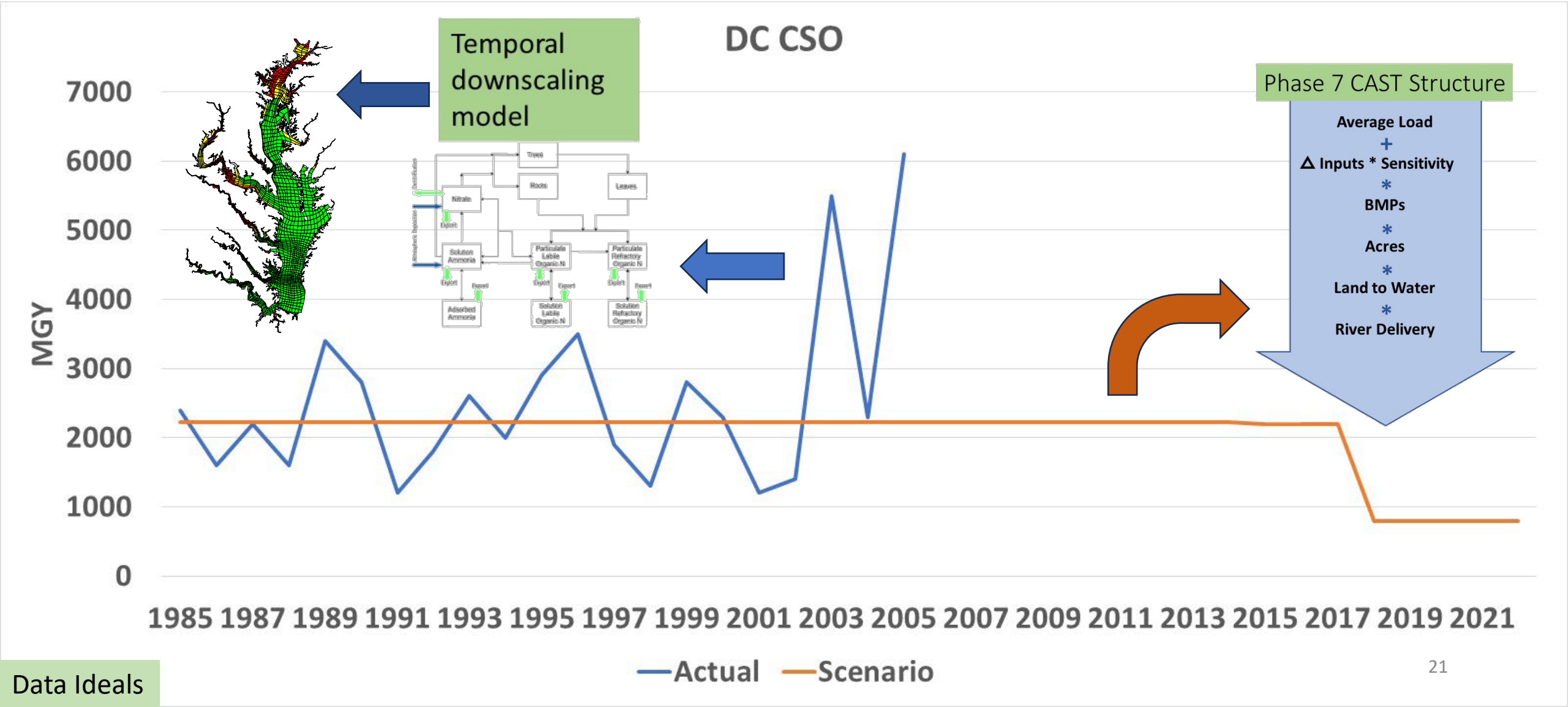
Data Ideals

Weather independence > Actual Values



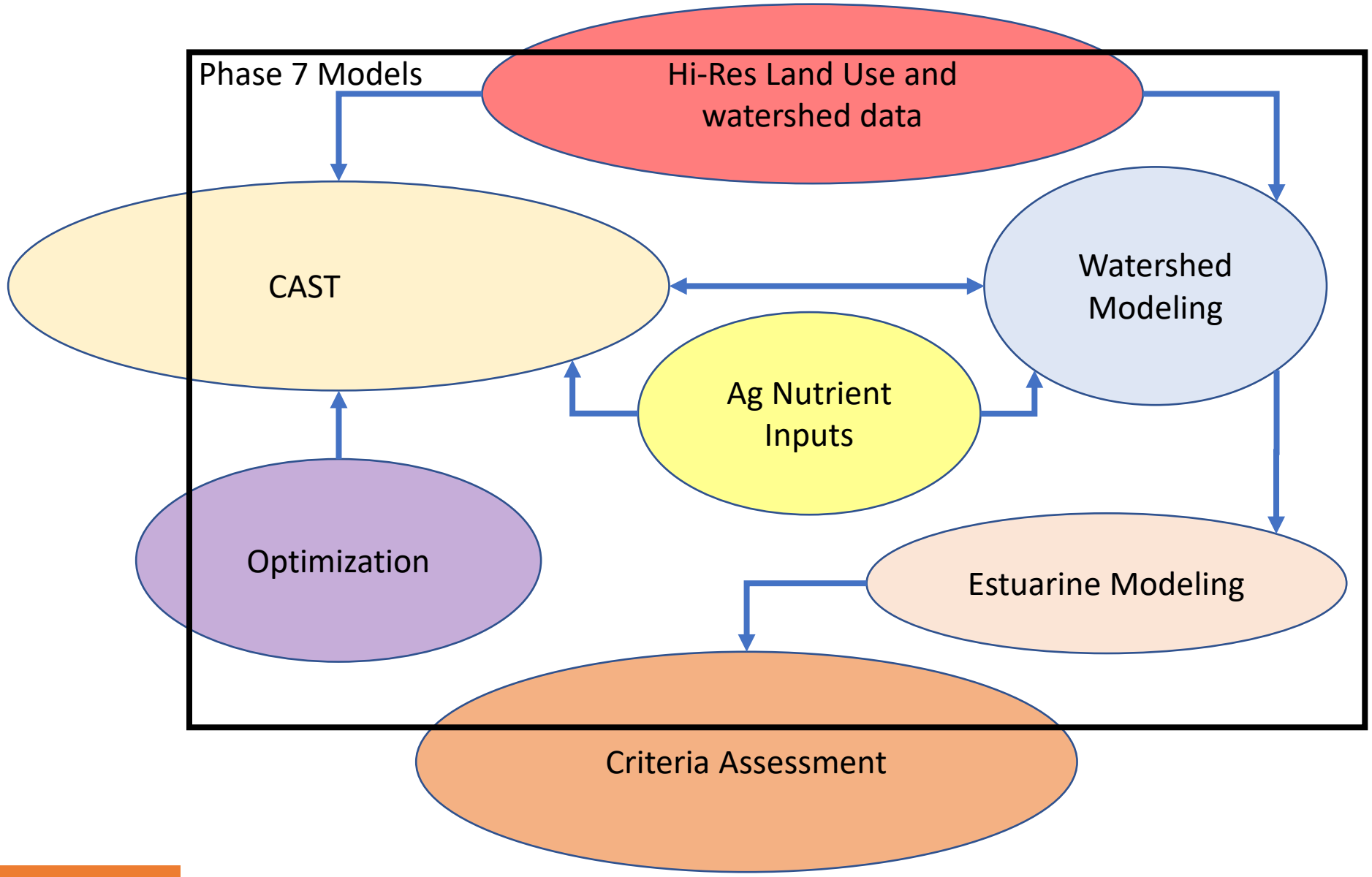
Data Ideals

Weather independence + Actual Values



Data Ideals

Phase 7 Development Tracks



Web page

- Overview
- Seven Projects
  - Descriptions
  - Documents
- Linked from
  - Modeling Workgroup
  - WQGIT
  - Many WQGIT WGs

Phase 7 Model Development | Ch

chesapeakebay.net/what/programs/modeling/phase_7_model_development

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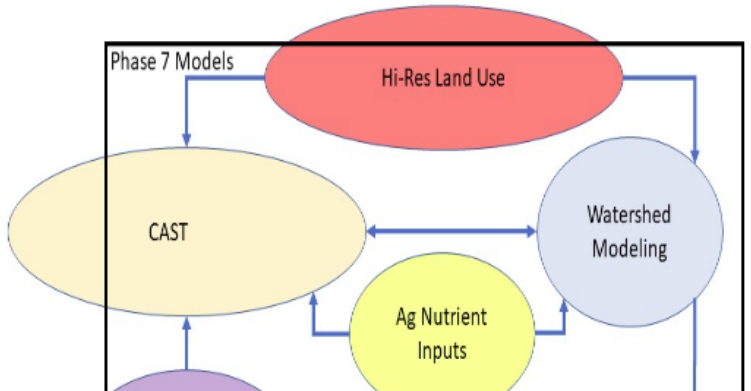
WHAT WE DO > PROGRAMS & PROJECTS > PHASE 7 MODEL DEVELOPMENT

Phase 7 Model Development

The Chesapeake Bay Program is updating its modeling and analysis tools used in the Chesapeake Bay TMDL.

Currently in development, the Phase 7 Modeling Tools will be used by the partnership to inform decisions related to nutrient and sediment reduction goals outlined in the Chesapeake Bay Watershed Agreement. Integral to this updated suite of tools is the ability to project climate change effect through 2035. The model, which will be ready for use by 2027, consists of six interrelated projects:

1. High Resolution Land Use
2. Chesapeake Assessment Scenario Tool (CAST)
3. Optimization
4. Agricultural Inputs
5. Watershed Modeling
6. Estuarine Modeling
7. Criteria Assessment



Modeling

Phase 7 Model Development

Programs & Projects

Modeling
Monitoring
Quality Assurance
Resource Lands Assessment
Chesapeake Bay TMDL
Watershed Implementation Plans
BMP Verification

Bay TMDL Summary

Watershed Model Plan – Big Picture

2022	2022	2022	2022	2023	2023	2023	2023	2024	2024	2024	2024	2025	2025	2025	2025	2026	2026	2026	2026
1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Work plan			Build	Work plan	Build Models			Work plan	Build Models			Work plan	Build Models			Review Models			
Build Model Structure				Improve Models												Review Models			

FWG can re-examine

- Land use types
- Relative Loading Rates
- Sensitivities – types and numbers – advise MWG
- Inputs
- BMPs

P7 Mapped land uses

Forest and Wetlands

- 40 Forest
- 41 Tree Canopy, Other
- 53 Riverine Wetlands Tree Canopy
- 54 Riverine Wetlands Forest
- 63 Terrene Wetlands Tree Canopy
- 64 Terrene Wetlands Forest
- 50 Riverine Wetlands Barren
- 51 Riverine Wetlands Herbaceous
- 52 Riverine Wetlands Shrubland
- 55 Riverine Wetlands Harvested Forest
- 60 Terrene Wetlands Barren
- 61 Terrene Wetlands Herbaceous
- 62 Terrene Wetlands Shrubland
- 65 Terrene Wetlands Harvested Forest

Harvested / Succession

- 42 Natural Succession Barren
- 43 Natural Succession Herbaceous
- 44 Natural Succession Shrubland
- 45 Harvested Forest Barren
- 46 Harvested Forest Herbaceous

Phase 6 Land Uses
True Forest
Headwater or Isolated Wetland
Non-tidal Floodplain Wetland
Harvested Forest
Mixed Open

Phase 7 CAST

Average Load

Δ Inputs * Sensitivity

*

BMPs

*

Acres

*

Land to Water

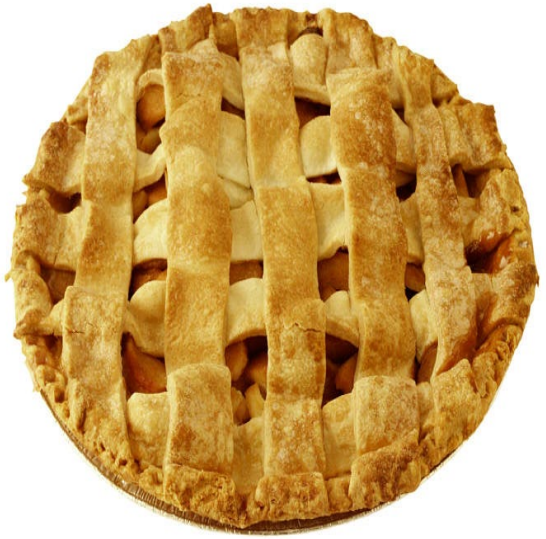
*

River Delivery

Phase 6 method

Average Loads – Average edge-of-small-stream loading rate for a given land use for the entire CB watershed

Average Loads



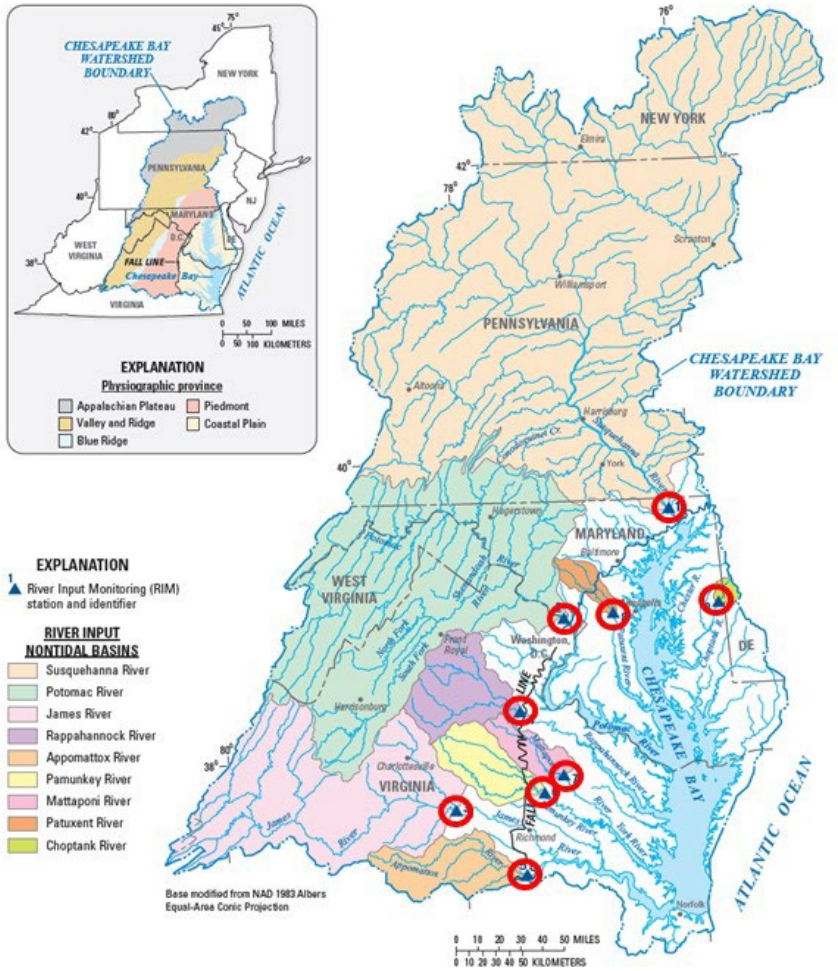
Estimate Total Non-point Source

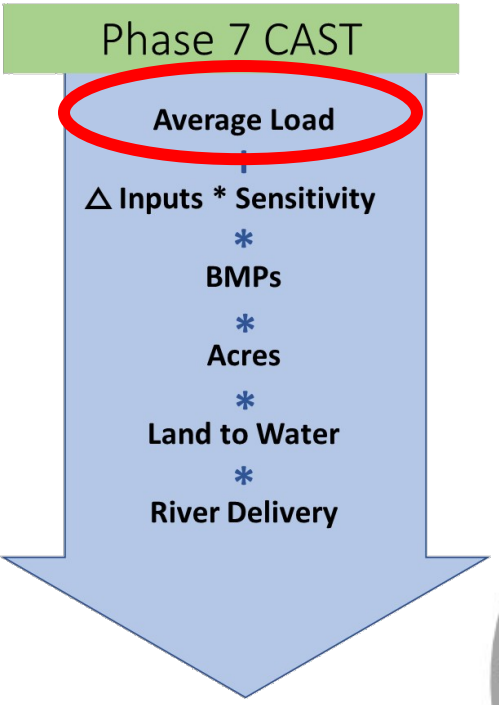
Modeling Workgroup

Monitoring Data

subtract point source

divide by transport

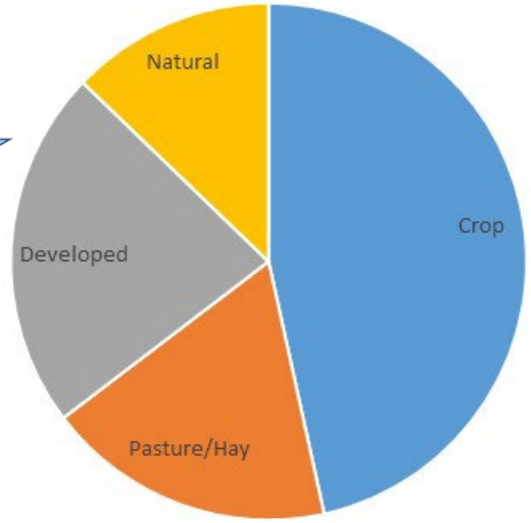




Phase 6 method

Average Loads

Average Loads – Average edge-of-small-stream loading rate for a given land use for the entire CB watershed



Divide into Broad Classes

Modeling Workgroup

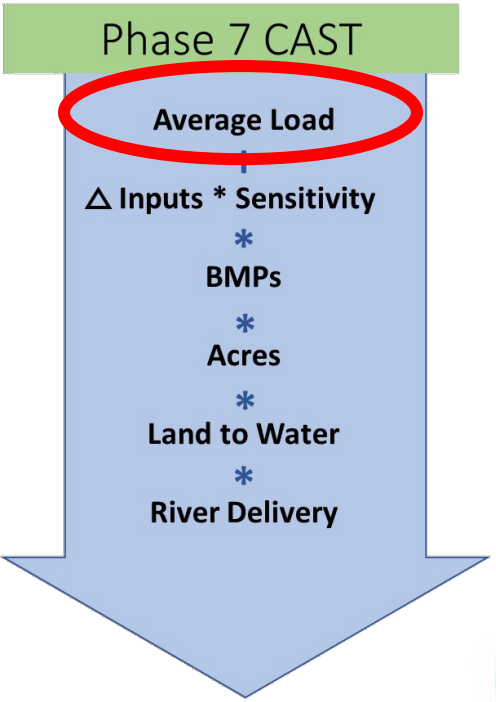
P5: Multiple models

Phase 5.3.2

Sparrow

CEAP

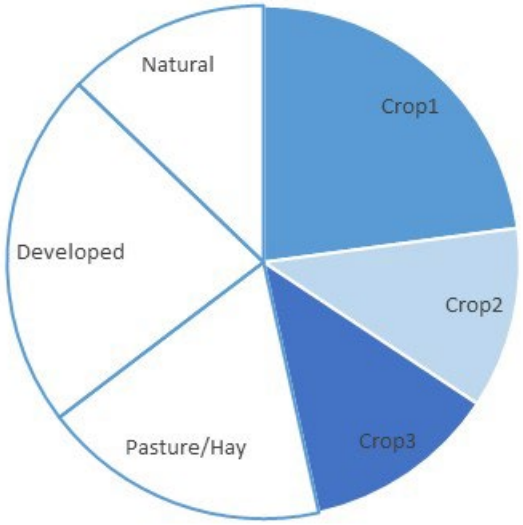
P6: Multiple Models and CalCAST



Phase 6 method

Average Loads

Average Loads – Average edge-of-small-stream loading rate for a given land use for the entire CB watershed



Split Classes into individual land uses

MWG and WQGIT Workgroups

Multiple lines of evidence to develop ratios

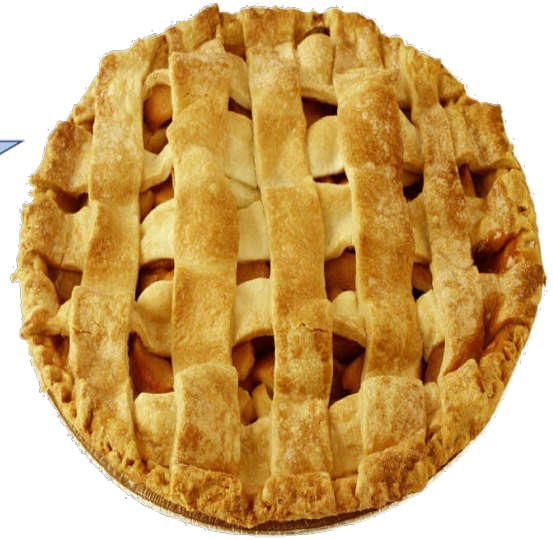
- for example silage is 16% higher than grain

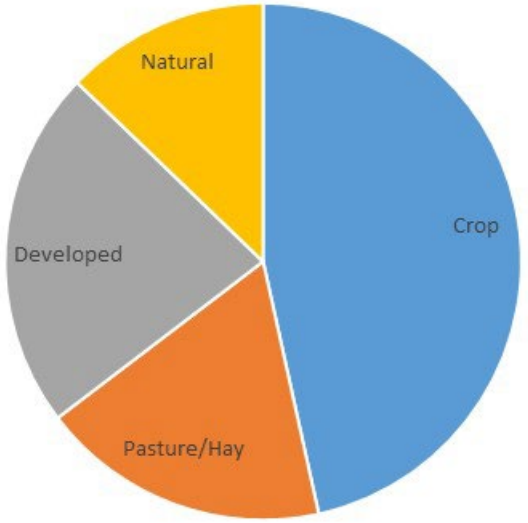
Phase 7 CAST

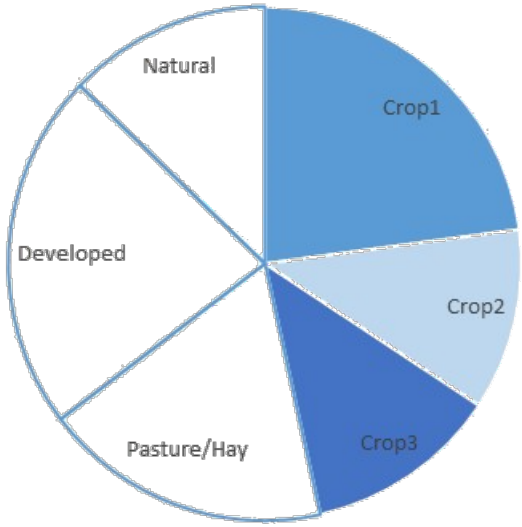
Average Load
+
Δ Inputs * Sensitivity
*
BMPs
*
Acres
*
Land to Water
*
River Delivery

Phase 7 method

Simultaneous Estimation with CalCAST







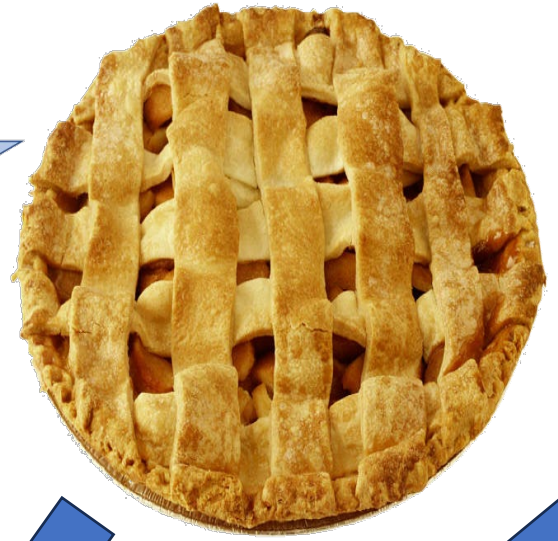
$$\mathrm{NPS}_{l,c,t} = \left(\mathrm{CLR} \times \mathrm{RC}_{cl_l} \times \mathrm{RL}_l + \sum_i \left(\left(\mathrm{Input}_{i,l,c,t} - \widehat{\mathrm{Input}}_{i,l} \right) \times \mathrm{Sens}_{i,cl_l} \times \mathrm{RL}_l \right) \right) \times \mathrm{Acres}_{l,c,t} \times BMP_{i,c,t}$$

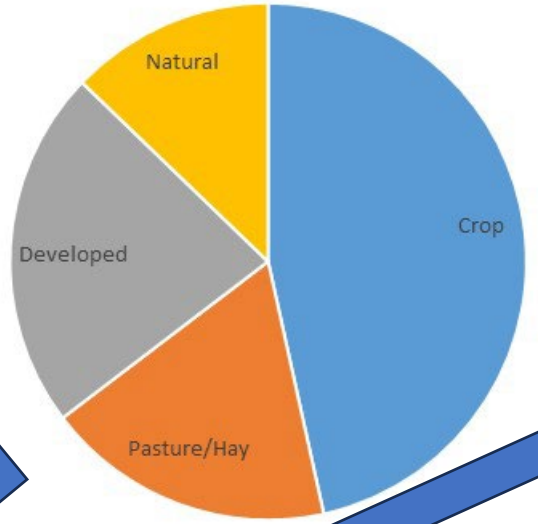
Phase 7 CAST

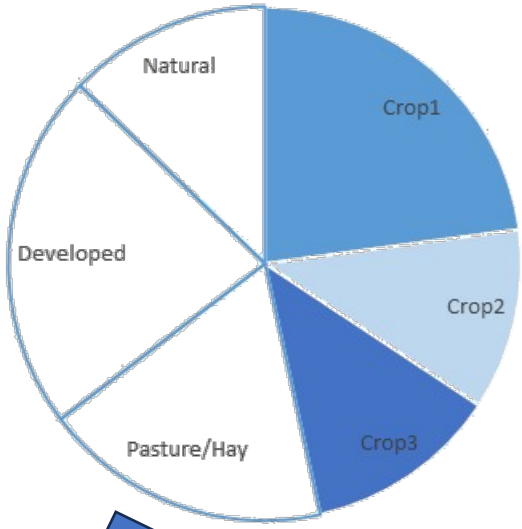
Average Load
+
Δ Inputs * Sensitivity
*
BMPs
*
Acres
*
Land to Water
*
River Delivery

Phase 7 method

Simultaneous Estimation with CalCAST







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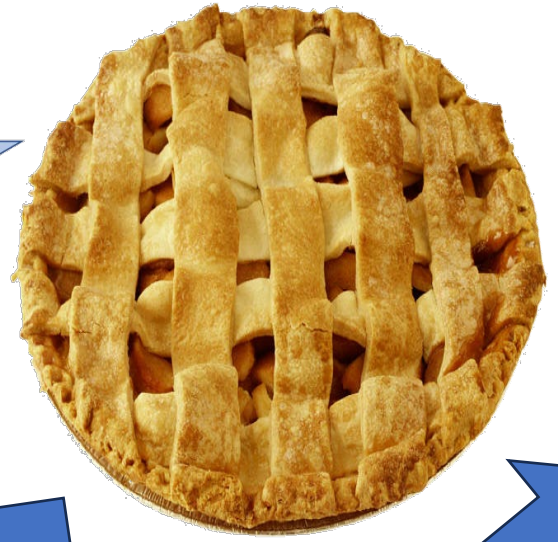
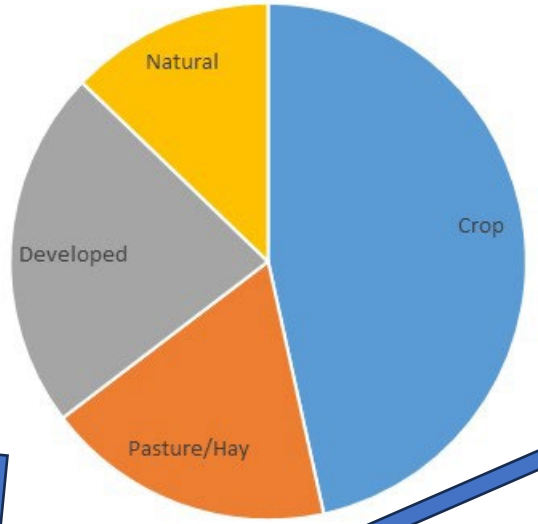
Phase 7 CAST

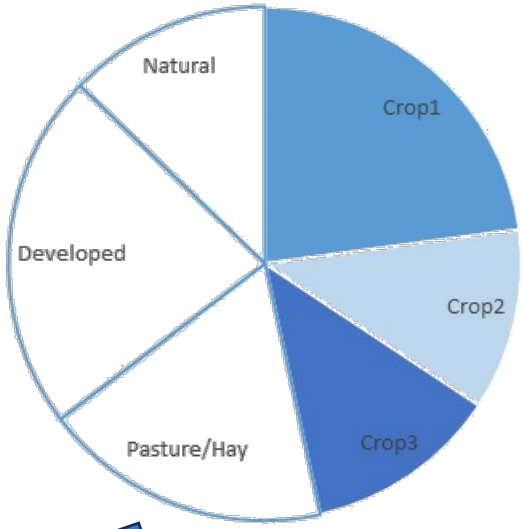
Average Load
+
Δ Inputs * Sensitivity
*
BMPs
*
Acres
*
Land to Water
*
River Delivery

Phase 7 method

CalCAST can help identify parameters







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Loading Ratios

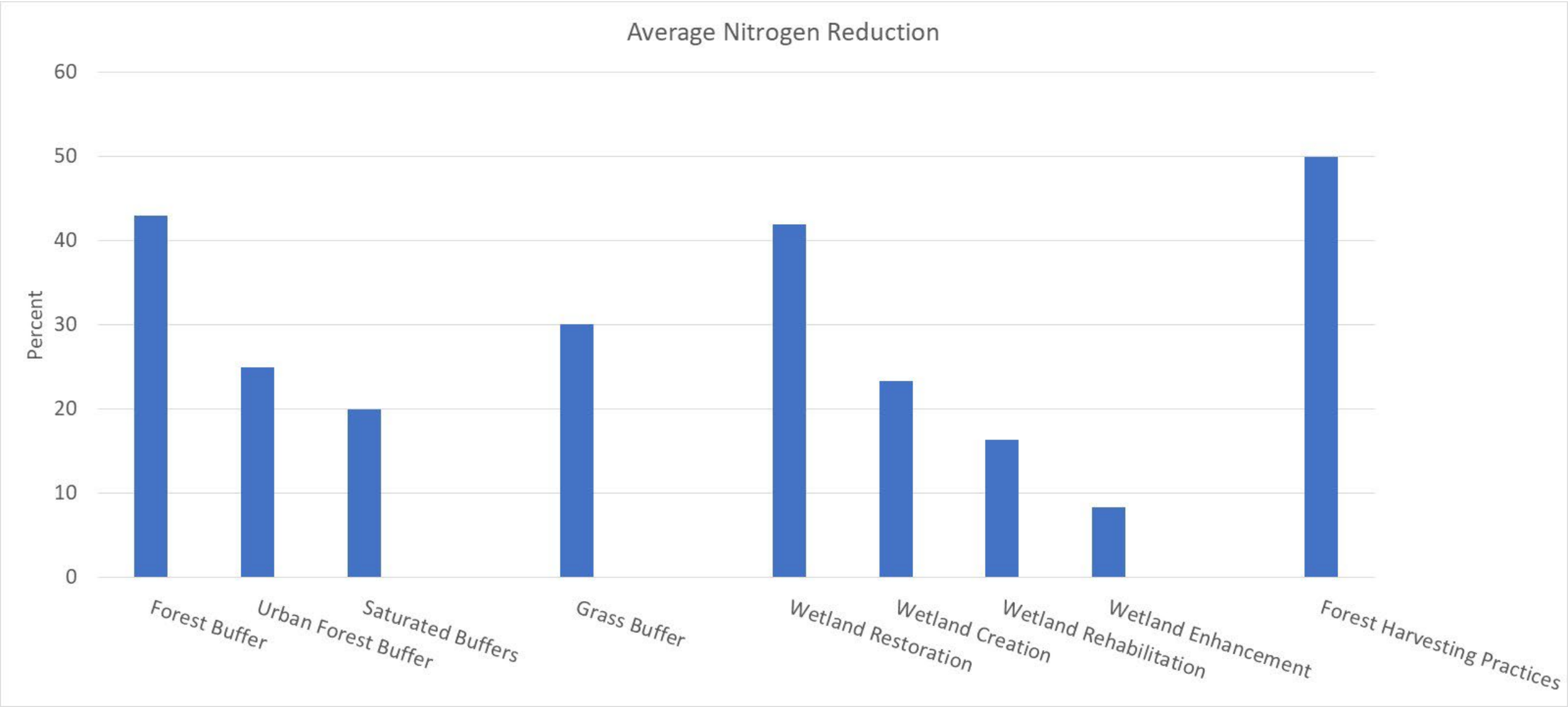
		Nitrogen		Phosphorus	
Land Use	Acres	Loading Rate Ratio	Loading Rate (pounds per acre per year)	Loading Rate Ratio	Loading Rate (pounds per acre per year)
True Forest: Reference Land Use	19,575,737	1	1.68	1	0.08
Headwater or Isolated Wetland	350,820	1	1.68	1	0.08
Non-tidal Floodplain Wetland	397,778	1	1.68	1	0.08
Harvested Forest	264,474	7.07	11.88	3.12	0.24
Mixed Open	906,433	1.46	2.45	5.69	0.43

Sensitivities and inputs – P6

Major Nutrient	Input Type	Forest/Wetland	Harvested Forest	Unit
TN	AtmDep	0.0227	0.1608	lbs/lbs
TP	Stormflow	0.0074	0.023	lbs/inch
TP	Sediment	0.0117	0.0365	lbs/ton

- N sensitivity based on average response of Phase 5 watershed model
- P sensitivity based on pasture sensitivity * load ratios

Natural BMPs



FWG can re-examine

- Land use types
- Relative Loading Rates
- Sensitivities – types and numbers – advise MWG
- Inputs
- BMPs