AM Forum

Adaptive management in the time of COVID:

How a global pandemic can inspire management of the Delta for a resilient future

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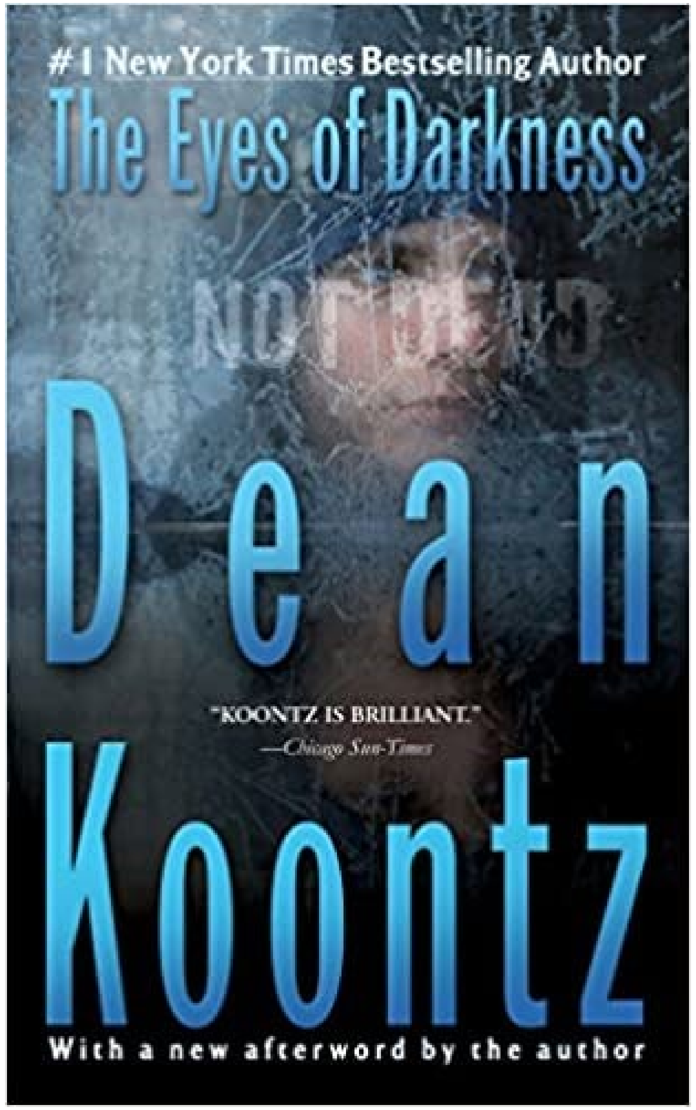
Delta Science Program

DELTA STEWARDSHIP COUNCIL

The future is here.



Lesson 1:

- Masking
- Guidance on outdoor activity
- Guidance on handling surfaces
- Social distancing
- Domestic and international travel
- School policies

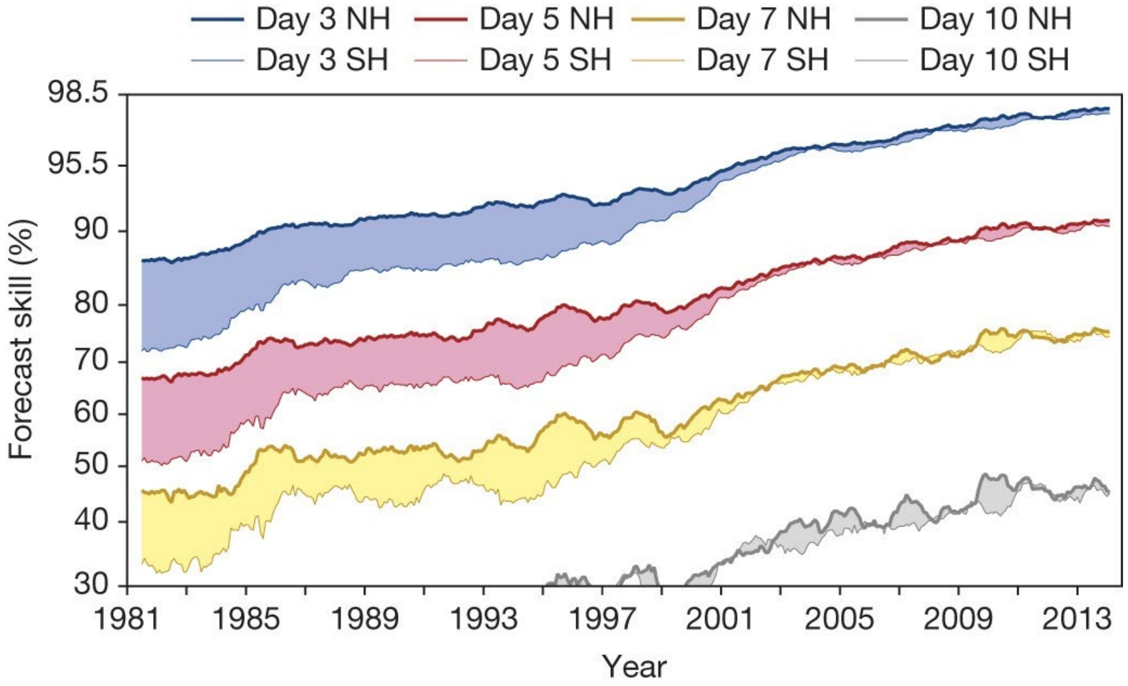
ADAPTIVE MANAGEMENT

- Methods of vaccine distribution
- Testing availability
- Contact tracing
- Herd immunity vs. transmission prevention

JUST DO IT.

"Just do"ing weather forecasting produced rapid improvement in accuracy and data availability

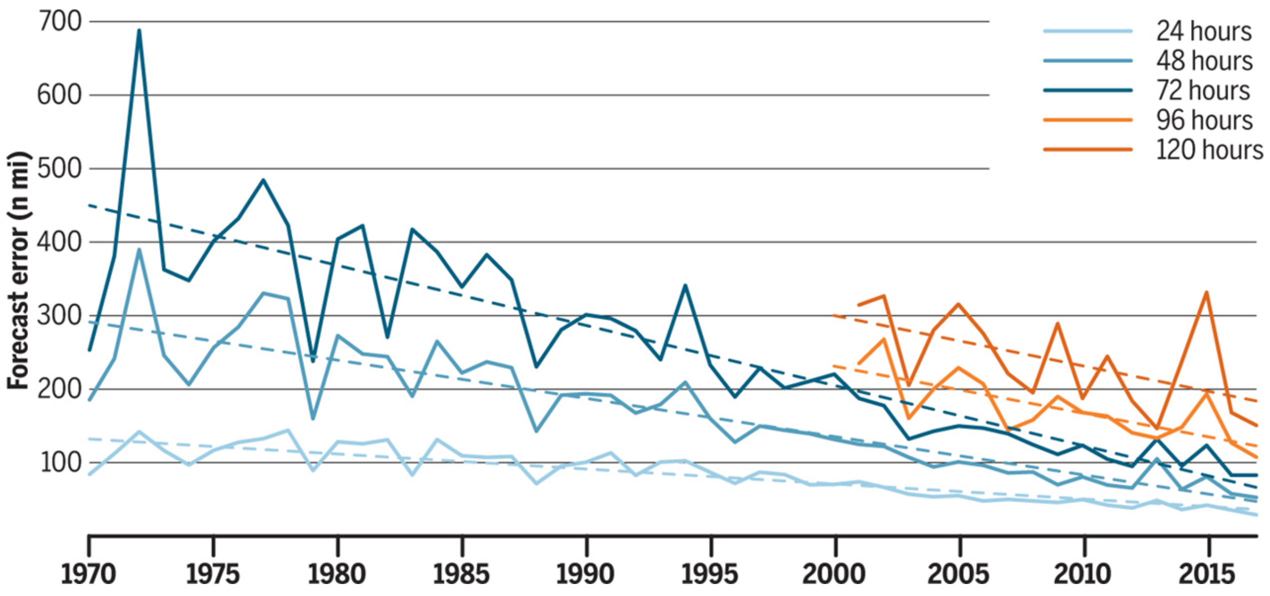
Skill for 3-, 5-, 7-, and 10-day forecasts for northern and southern hemispheres (NH and SH)



Bauer et al., *Nature*, 2015

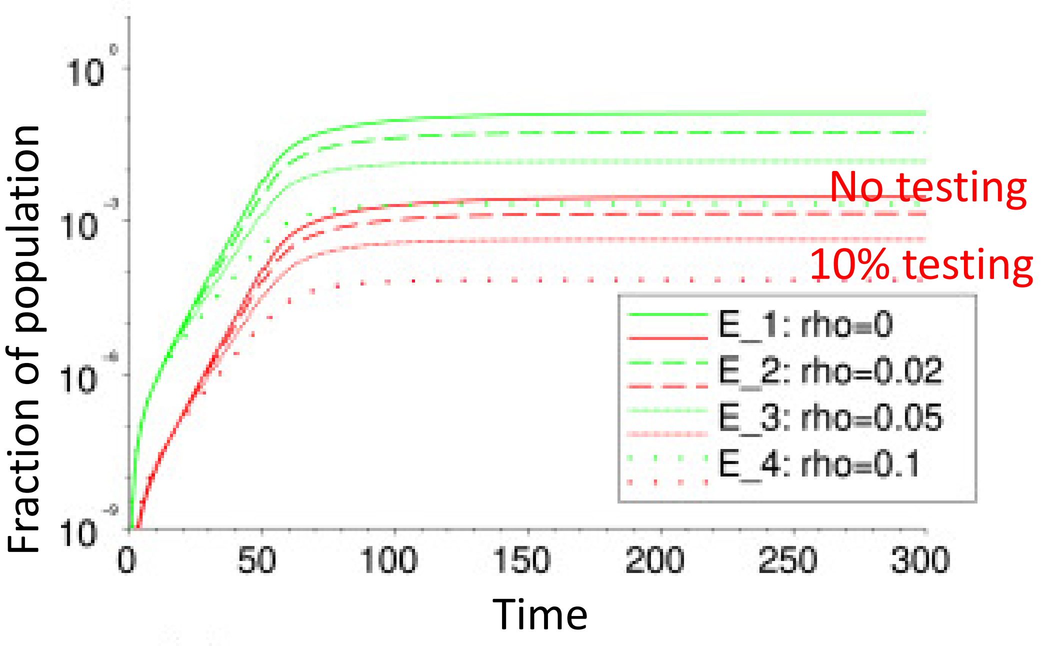
Advances in hurricane prediction

Data from the NOAA National Hurricane Center (NHC) (*13*) show that forecast errors for tropical storms and hurricanes in the Atlantic basin have fallen rapidly in recent decades. The graph shows the forecast error in nautical miles (1 n mi = 1.852 km) for a range of time intervals.

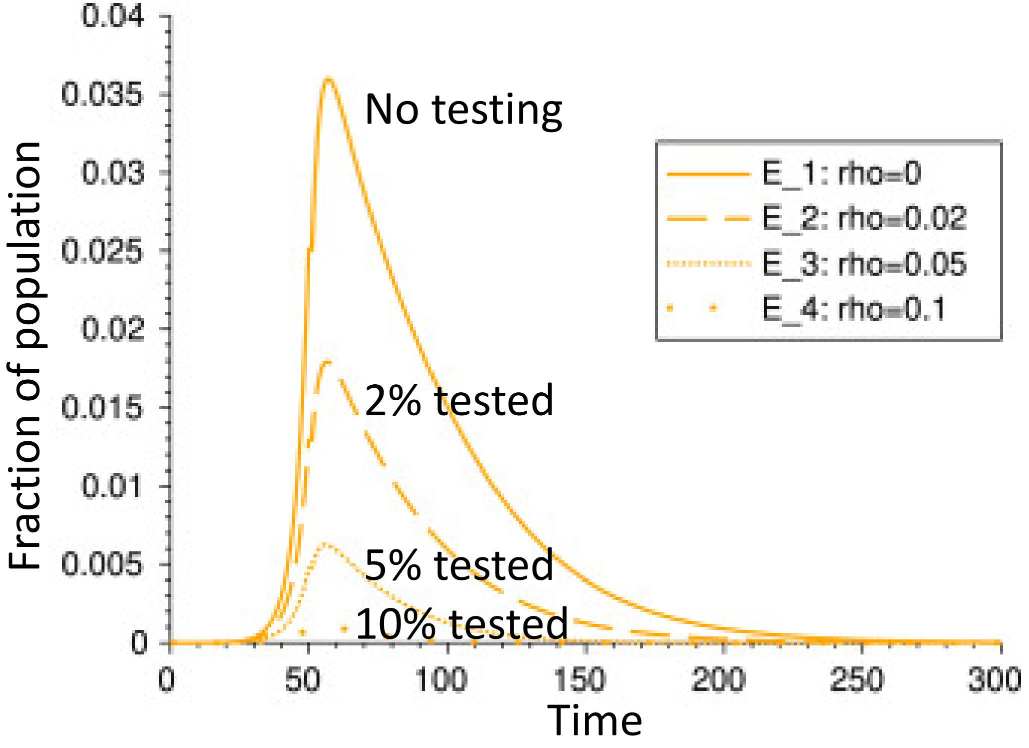


Alley et al., *Science*, 2019

Lesson 2: Monitoring leads to better outcomes



(a) Recovered in green, dead in red

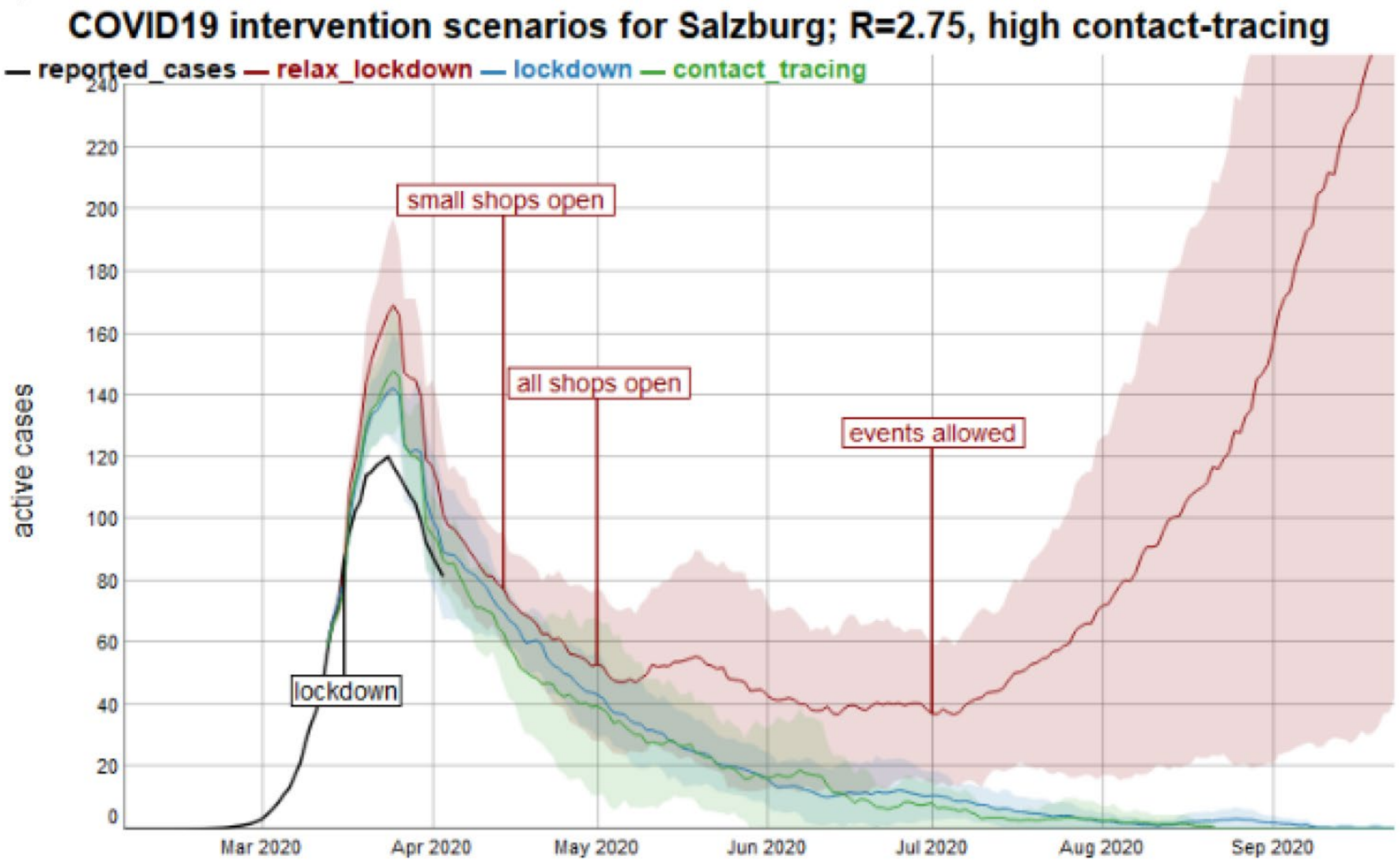


(b) Infected

Modeled COVID outcomes as a function of testing rate

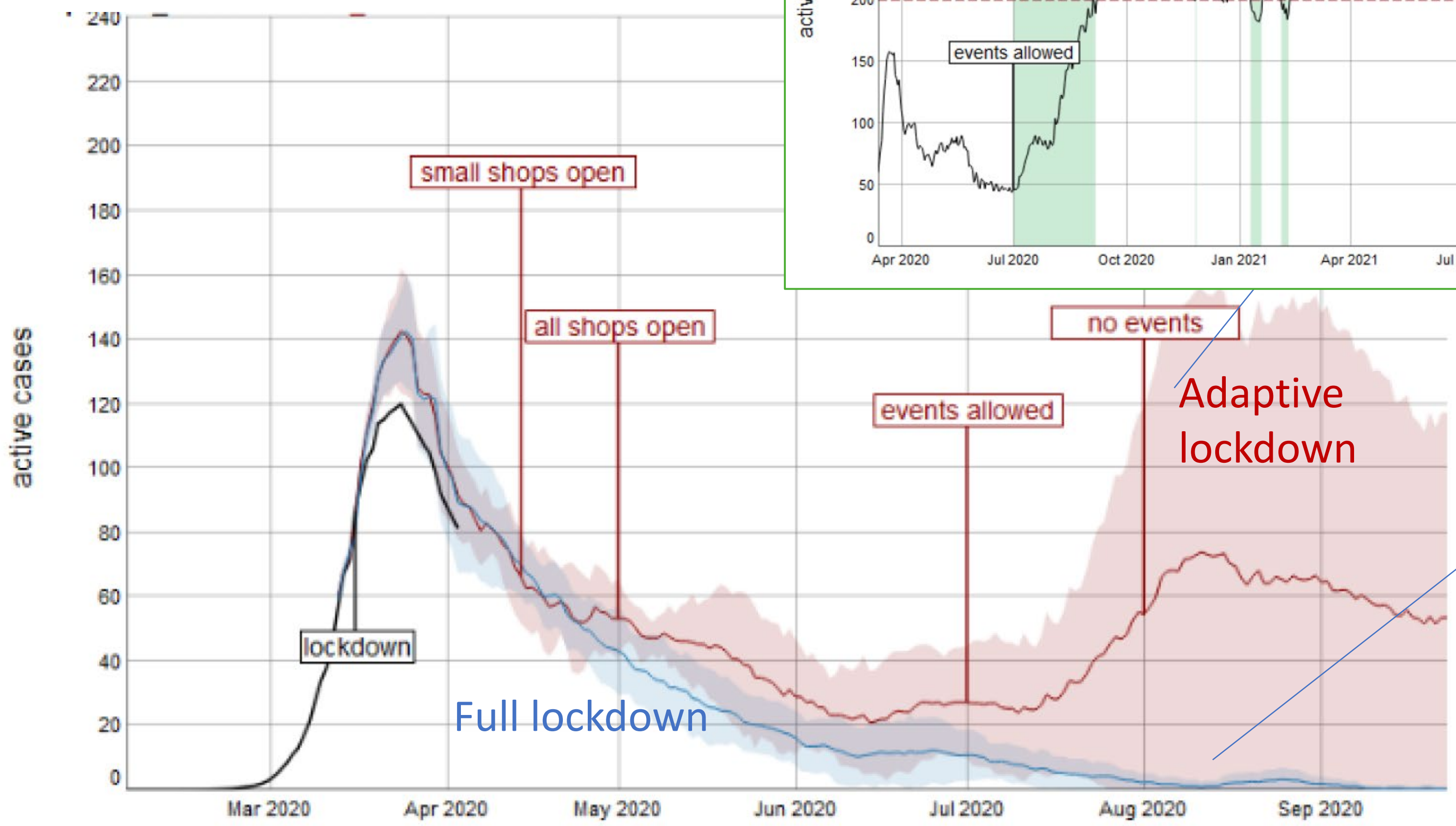
Aronna et al., *Epidemics*, 2021

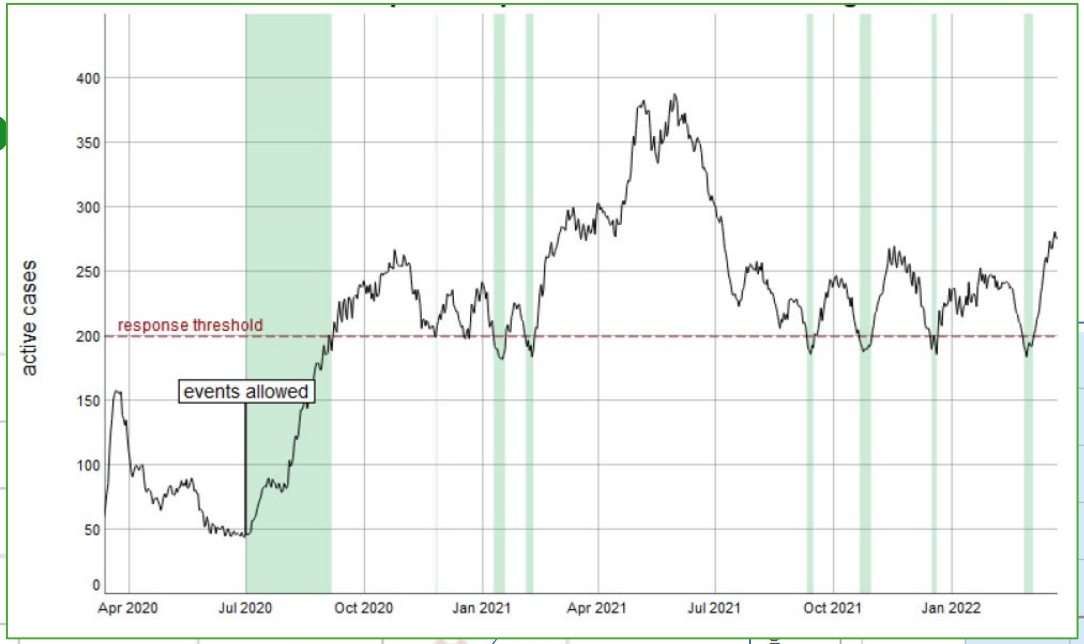
Lesson 2: Monitoring leads to better outcomes



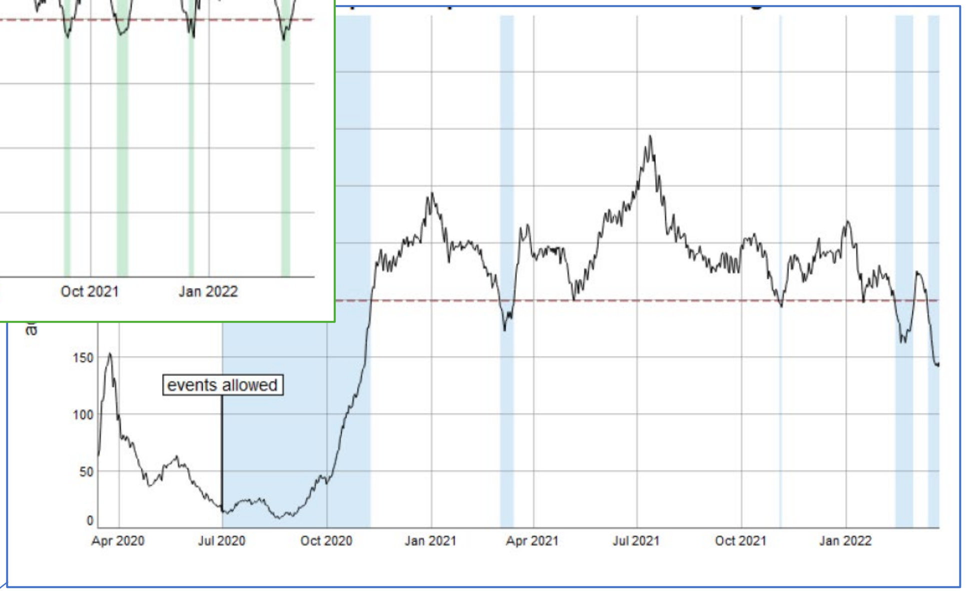
Wallentin et al., *Int. J. Health Policy Manag.*, 2020

Monitoring suppo… decision making





Alternate realization



Lockdown triggered by 200 active cases

Wallentin et al., *Int. J. Health Policy Manag.*, 2020

Two types of uncertainty

- Uncertainty due to **incomplete knowledge**
  - Incomplete understanding of the processes that drive system behavior
  - Effects of different hypotheses can be compared, but full range of outcomes impossible to estimate
- Uncertainty due to **randomness**
  - Includes effects of heterogeneity among populations, temporal variability of system drivers (e.g., weather), and spatial variability of the environment
  - Effects can be estimated by sampling probabilistically from distributions of behavior or parameters

Adaptive management is *science-informed*, not *science-based*

- This is because of considerable "knowledge uncertainty".
- Recognizing this may lessen stigma of making "wrong" decisions.
- The onus is on scientists to effectively communicate *risk*.
  - Accounts for probabilities of certain outcomes and knowledge that goes into estimating probabilities.
  - Example (Aven and Bouder, 2020): "The result of the risk assessment is that the number of deaths is unlikely (less than 5%) to exceed x in the coming month, given the implementation of policy y. This assessment is based on current knowledge on the topic using the best models and data available. There are, however, considerable uncertainties about the underlying phenomena and how the epidemic will develop—many of the assumptions of the models used are subject to large uncertainties. Overall, the knowledge supporting the risk assessment is considered rather weak."

- Further reading: Aven and Bouder (2020) The COVID-19 pandemic: How can risk science help? *J. Risk Res.*

More lessons learned from heterogeneous management of the coronavirus pandemic

From Forman et al., 2020. "12 lessons learned from the management of the coronavirus pandemic." *Health Policy* 124(6): 577-580.

- Transparency is vital
- Successful responses hinge on decisive leadership
- We need unified responses to pandemics rather than diverse disconnected strategies
- Effective communication must occur at the highest political levels
- Global solidarity is the only way to win the war against COVID-19
- We need to test the responsiveness and resilience of health systems and make changes and improvements based on the results
- Accountability is critical for building trust and for sound, inclusive decision making
- There are opportunities to introduce novel approaches, such as using robots and artificial intelligence in this—and in future—pandemic response

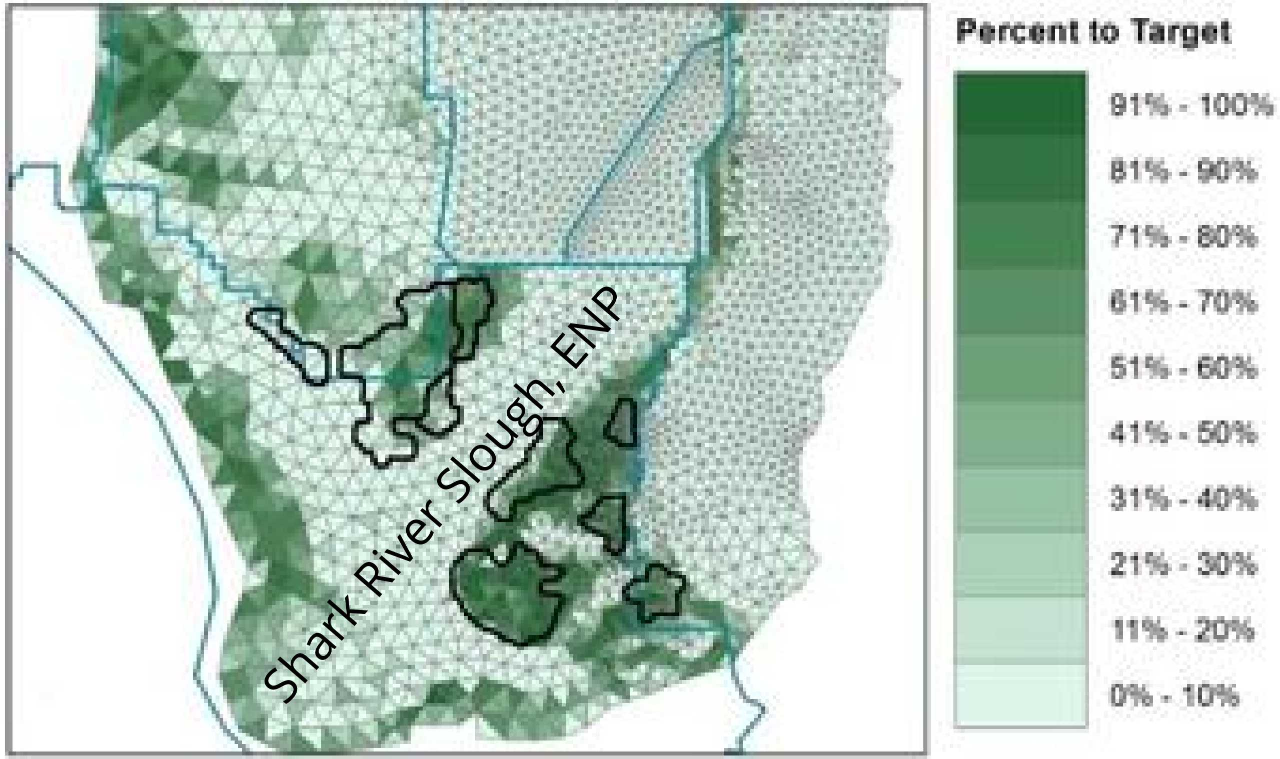
*How to achieve **system-scale adaptive management** in integrated socio-ecological systems?*

Case study: Adaptive Management of the Everglades

Recommended reading: Sklar, 2019, in *The Coastal Everglades: The Dynamics of Social-Ecological Transformation in the South Florida Landscape*

Image from USACE Fact Sheet, 2019

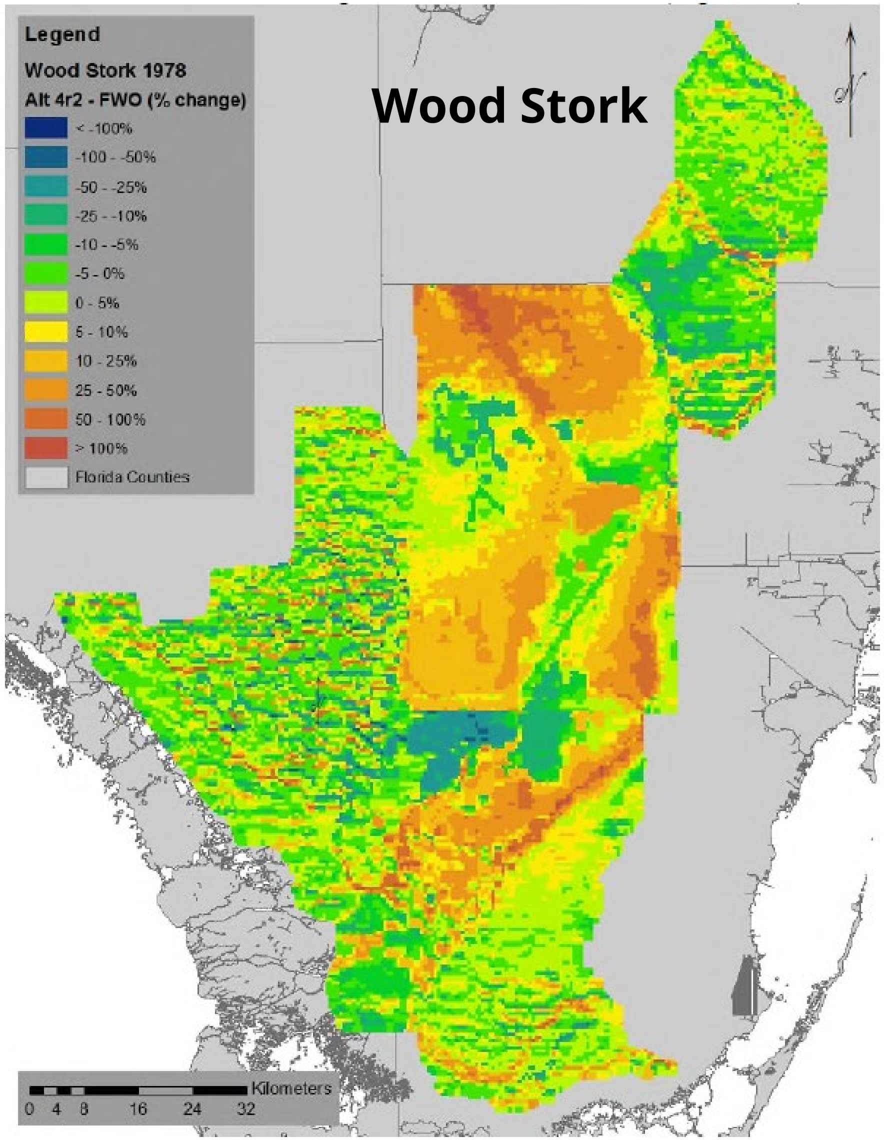
Participatory modeling produced interagency convergence in case of federally endangered Cape Sable Seaside Sparrow

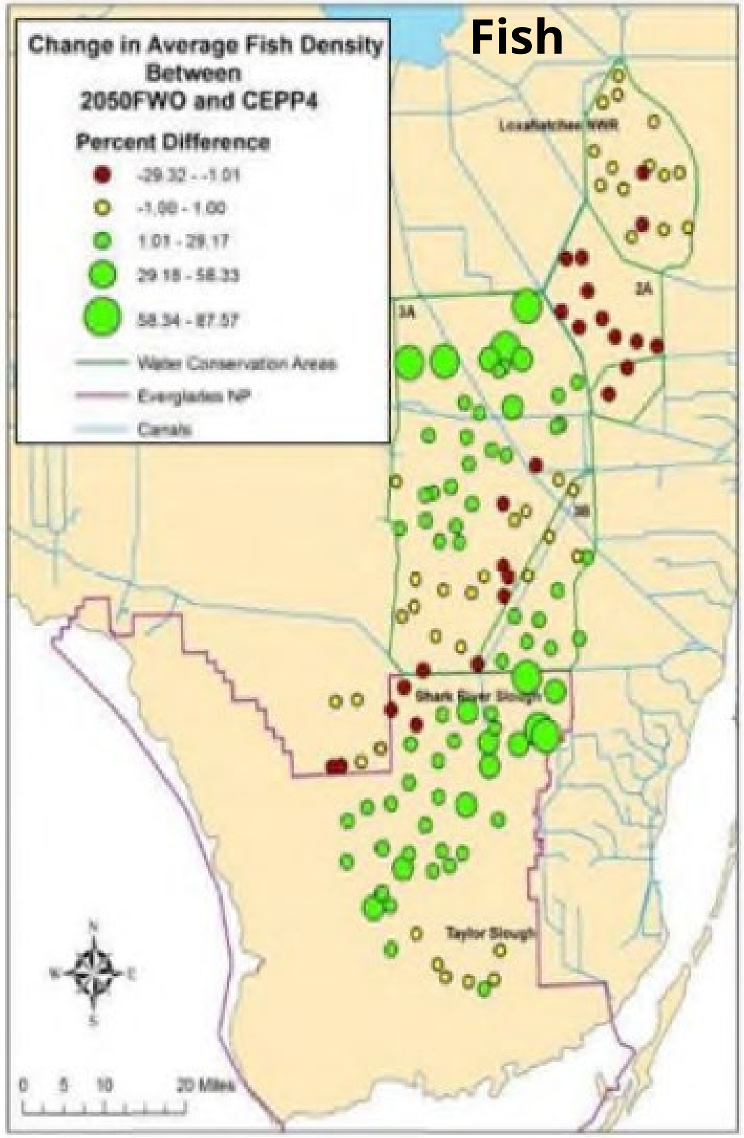


Marl Prairie Indicator model output
Image: USGS / Stephanie Romañach

Image: NPS / Lori Oberhofer

Modeling demonstrated clear habitat benefits for CEPP over future without restoration (FWO)





Model outputs from Beerens (2014, left) and Trexler (2010, right), as reproduced in Sklar, 2019

Models demonstrated that full restoration not possible and enabled stakeholders to rapidly converge on revised goals

Table 8-2: Scaled Performance Measure Scores (Zero to 100 Scale) developed by t CERP and Florida Scientific Community from Habitat Suitability Indices for the Future WithOut (FWO) restoration and the restoration design that eventually became know as CEPP and here referred to as Alternative 4 (Alt4)..

Metric #	Performance Measure Metric	FWO	ALT4
1.1	Inundation Duration in the Ridge and Slough Landscape	68	97
2.1	Sheetflow in the Ridge and Slough Landscape -- Timing	21	32
2.2	Sheetflow in the Ridge and Slough Landscape -- Continuity	35	27
2.3	Sheetflow in the Ridge and Slough Landscape -- Distribution	46	49
3.1	Hydrologic Surrogate for Soil Oxidation -- Drought Intensity Index	50	95
4.1	Number and Duration of Dry Events -- Number	60	95
4.2	Number and Duration of Dry Events -- Duration	26	100
4.3	Number and Duration of Dry Events -- PPOR	2	100
5.1	Slough Vegetation Suitability -- Hydroperiod	53	92
5.2	Slough Vegetation Suitability -- Dry down	69	100
5.3	Slough Vegetation Suitability -- Dry Season Depth	23	65
5.4	Slough Vegetation Suitability -- Wet Season Depth	12	74
	Percentage of Target HU (HSI x 100)	**44**	**82**

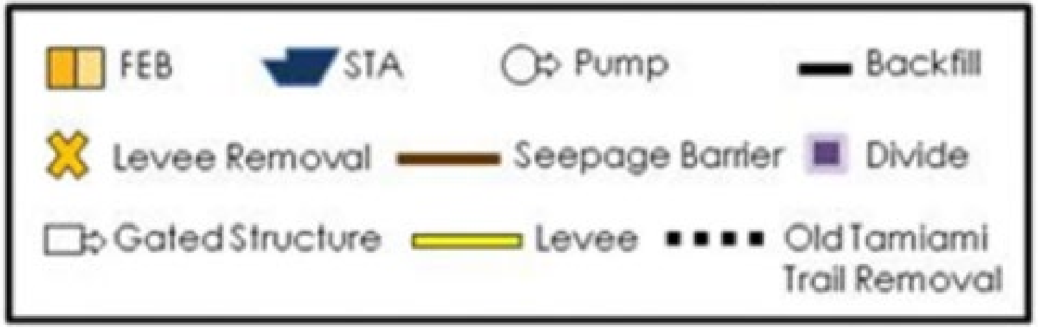
Sklar, 2019

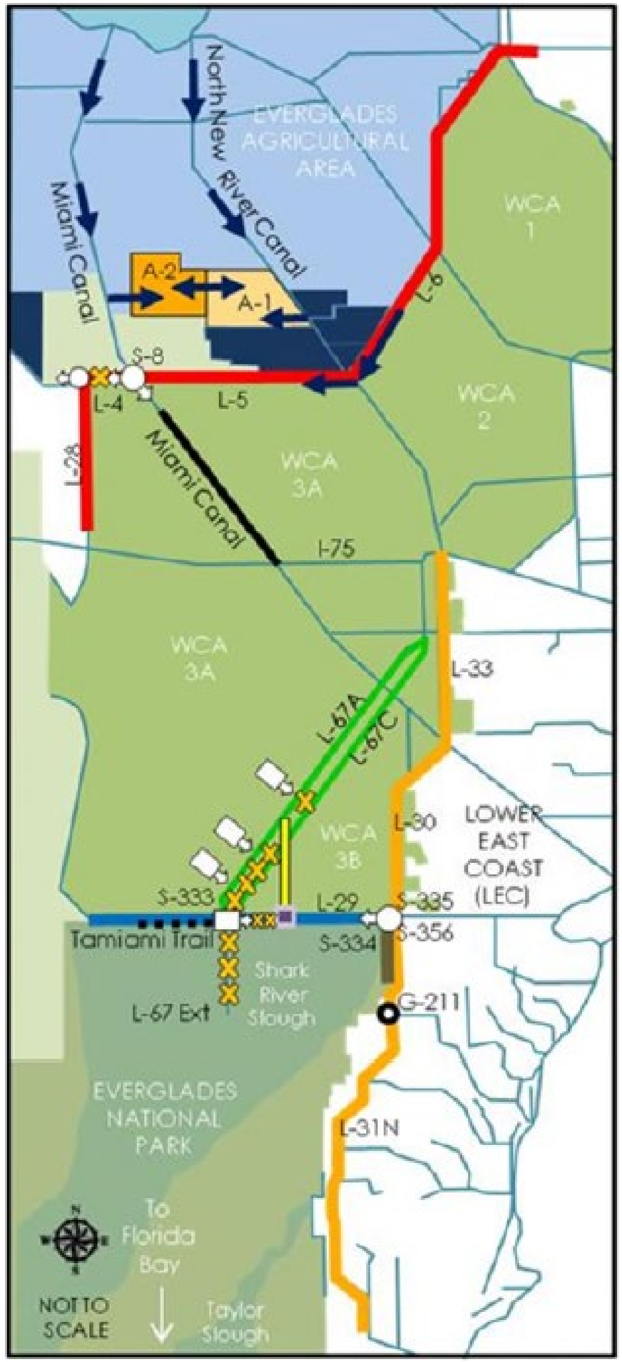
Modeling + relaxation of some habitat restoration targets brought deer hunters to agreement

Image: evergladeshuntinglodge.com

Participatory modeling produced convergence to incremental adaptive management plan comprising 4 components

- The Redline: Increased water storage and delivery of clean water across Everglades Agricultural Area boundary into the Water Conservation Areas (WCAs)
- The Greenline: More natural conveyance and distribution of water through WCA-3A and WCA-3B
- The Blueline: Improved delivery of water to Everglades National Park
- The Yellowline: Management of seepage across the eastern boundary of Everglades National Park





Sklar, 2019

What integrated, collaborative modeling looks like in the Everglades

jem.gov

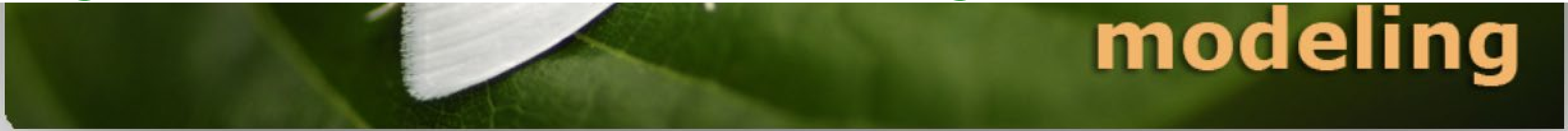
JEM joint ecosystem modeling

A collaborative approach to modeling and standards

home modeling standards data partners contact

Ecological models are needed to facilitate evaluation and assessment of alternative approaches to restore Greater Everglades ecosystems. However, the provision of useful and accessible models is a challenge because there is often a disconnect between model developers and model users. Joint Ecosystem Modeling (JEM) was established to meet this challenge, with the goal of getting ecological models into the hands of users. JEM is a partnership among federal and state agencies, universities and other organizations which is currently funded by the USGS Priority Ecosystem Science program, the Everglades National Park, and the Peninsular Florida Landscape Conservation Cooperative.

What integrated, collaborative modeling looks like in the Everglades



Tools

- **EverVIEW Data Viewer**
- EverVIEW Extensions
- Slice and Dice
- Data Converter
- NetCDF Grid Converter
- NetCDF to CSV Converter
- Surface Generator
- CSSS Sparrow Helper

Models

- Alligator
- Amphibian
- Crayfish
- CSSS Marl Prairie
- ELM
- ELVeS
- EverKite
- EverSnail
- Prey Fish Biomass
- Small Fish Density
- Slough Vegetation
- Roseate Spoonbill
- WADEM
- Wood Stork

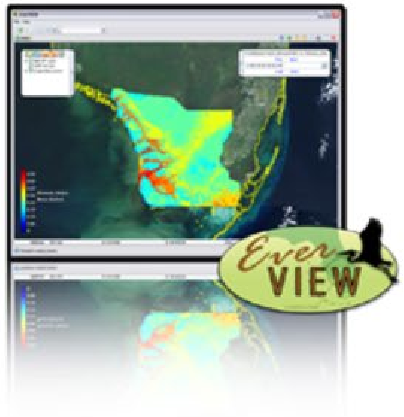
EverVIEW Data Viewer

As EverVIEW matures, it will offer the end user a desktop environment where models can be parameterized and run, with their output immediately displayed geographically. Through a series of toolboxes, users will have access to data manipulation, modeling, and visualization tools.

Download

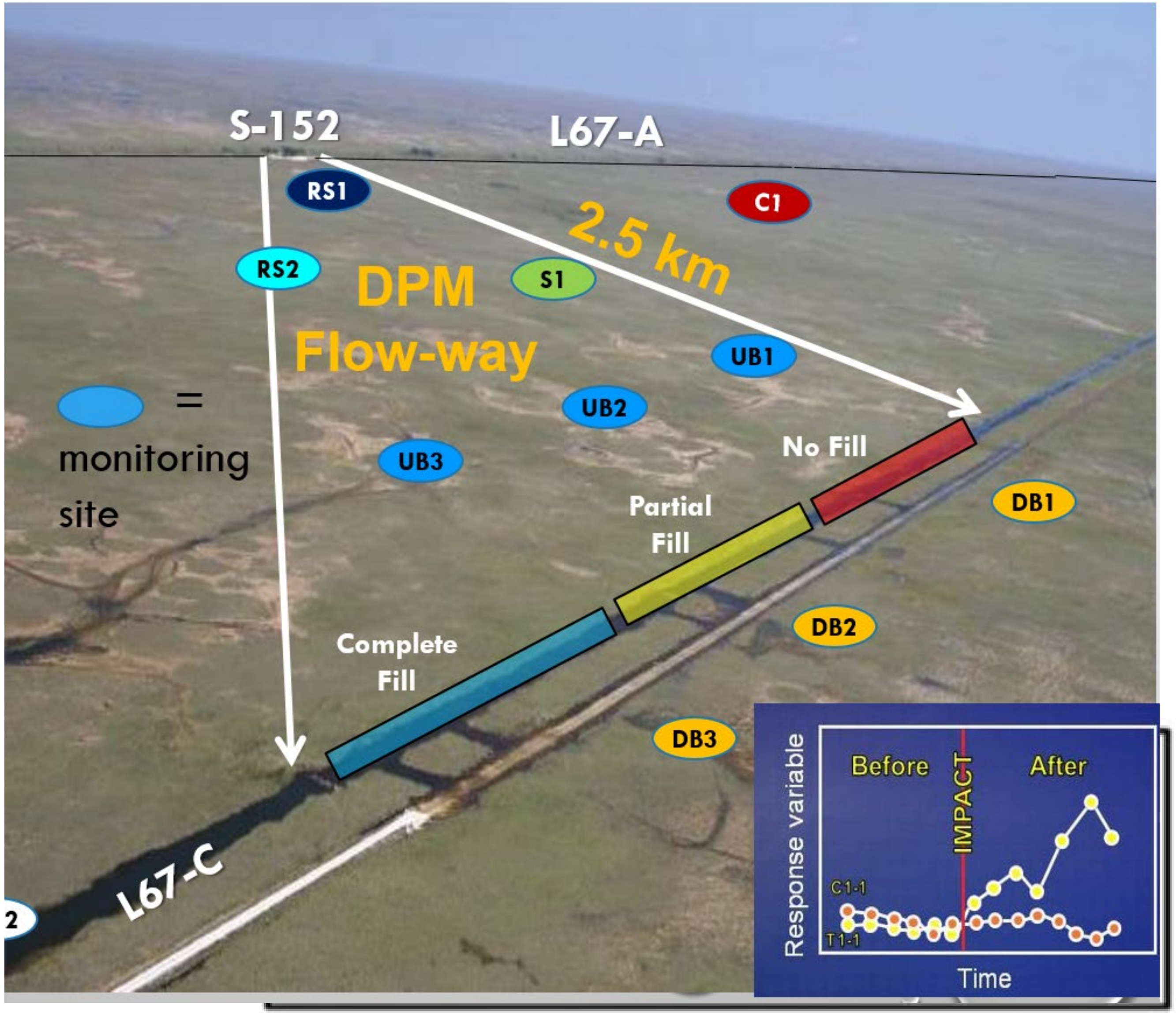
- Windows Version 2.9.0 (64-bit)
- Mac OS X Version 2.9.0 (64-bit)
- Linux Version 2.9.0 (64-bit)

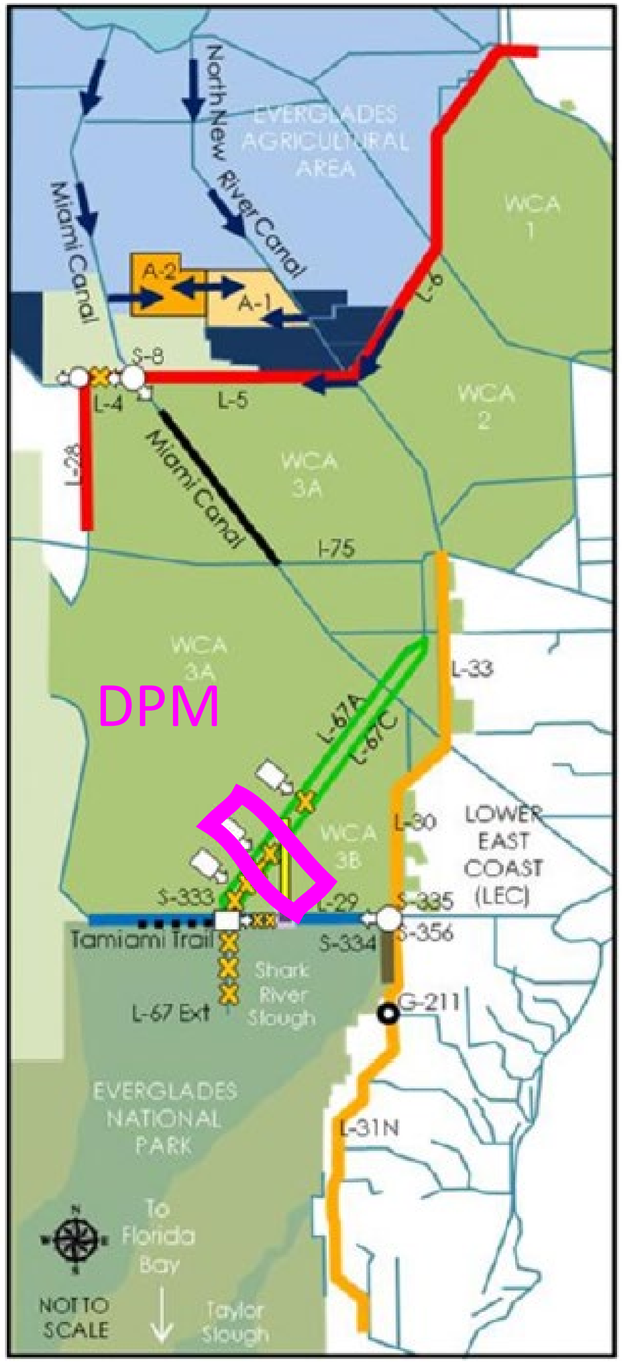
Software requirements
Update process walk-through
Release notes
Read more here...



Subscribe to the JEM EverVIEW Email List

Everglades Decompartmentalization Physical Model (DPM) as adaptive management test of levee removal

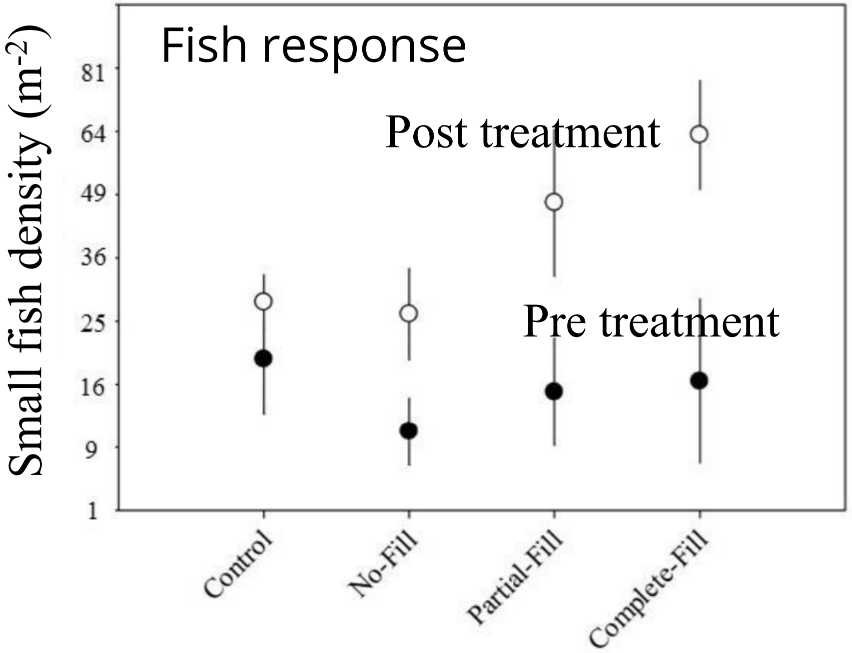




Images: Colin Saunders, SFWMD (left); Sklar, 2019 (right)

Flow pulses cleared choked sloughs and created conditions favorable to sediment redistribution and habitat

(Credit: C. Saunders, SFWMD)



(Bush, 2017)

- Some tradeoff with phosphorus transport into marsh (Larsen et al., *WRR*, 2017)
- Sediment redistribution became easier to achieve than anticipated because of clearing of floating periphyton/vegetation mats
- Canal backfill treatments resulted in greatest increase in fish and greatest degree of hydrologic connectivity (Bush, PhD thesis, FIU, 2017; Larsen et al., 2017)

Another surprise: Executing short-term plan led to long-term operations, additional experiments, and scaling up

2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021

Modeling, planning

Pre-treatment monitoring

Post-treatment monitoring

Original design time frame

Extended operations

Uncertainties tested

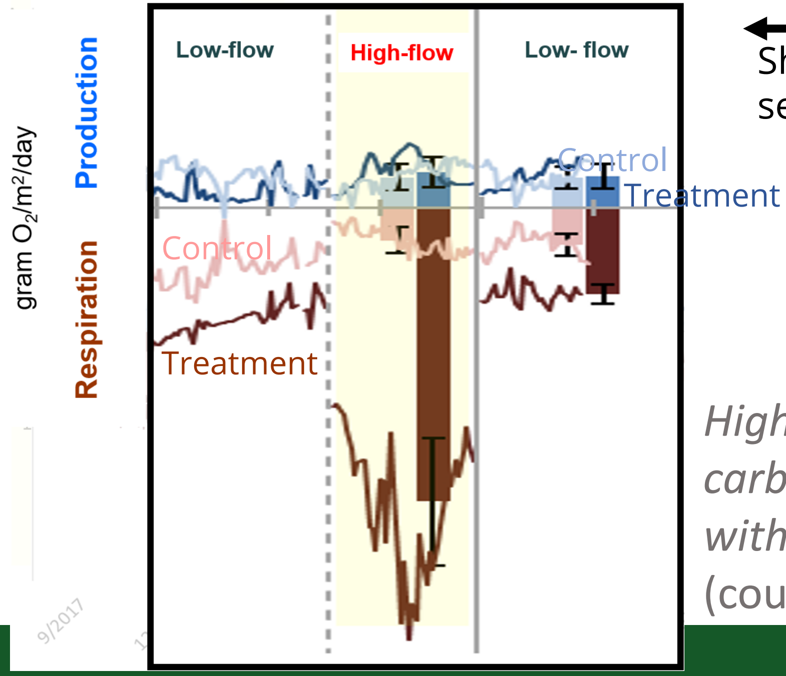
Sheetflow and canal fill treatment impacts on sediment, water quality, and fish

Active management strategies for achieving sheetflow at landscape scale

Constructed fixes (e.g., spreader swales) to reduce canal sediment influx to wetlands and fixes (e.g., plugs, fill) to reduce preferential flow in canals

Effects of flow on particulate nutrient mobilization within and downstream of canals

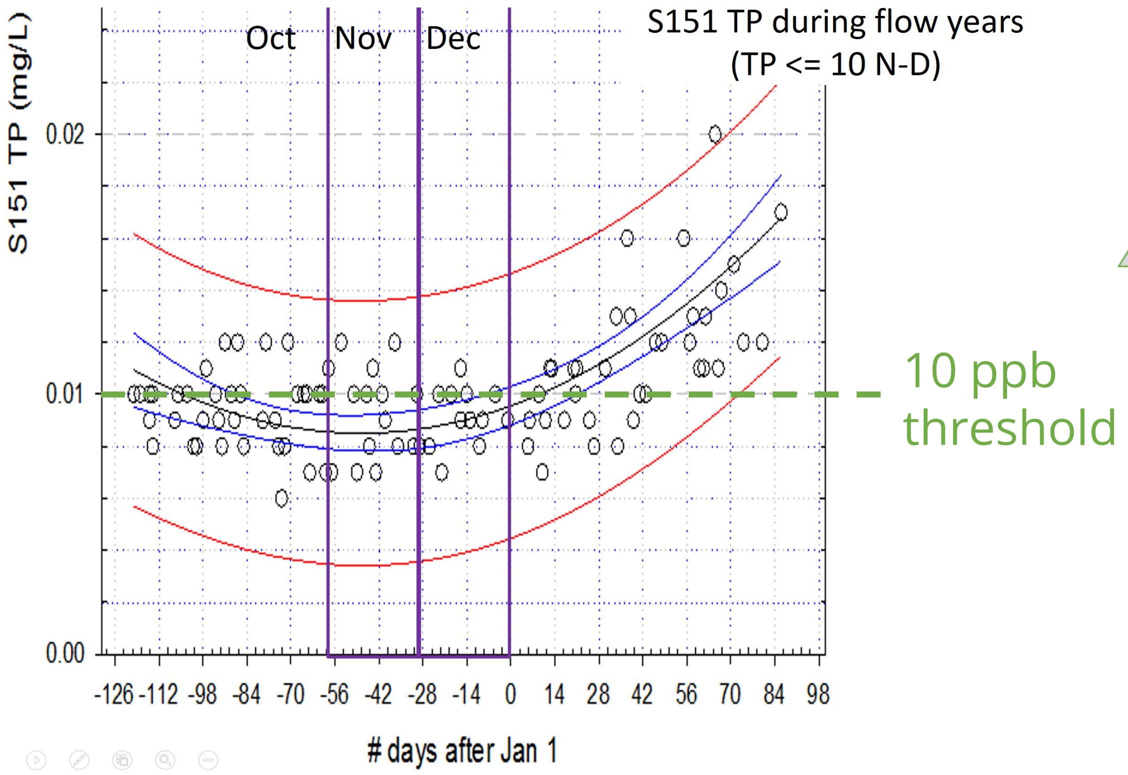
Active measures (herbicides) to extend flow farther; ecological effects of flow (e.g., food web changes, algal composition)



High flow → doubling in carbon respiration in sloughs with no change in productivity

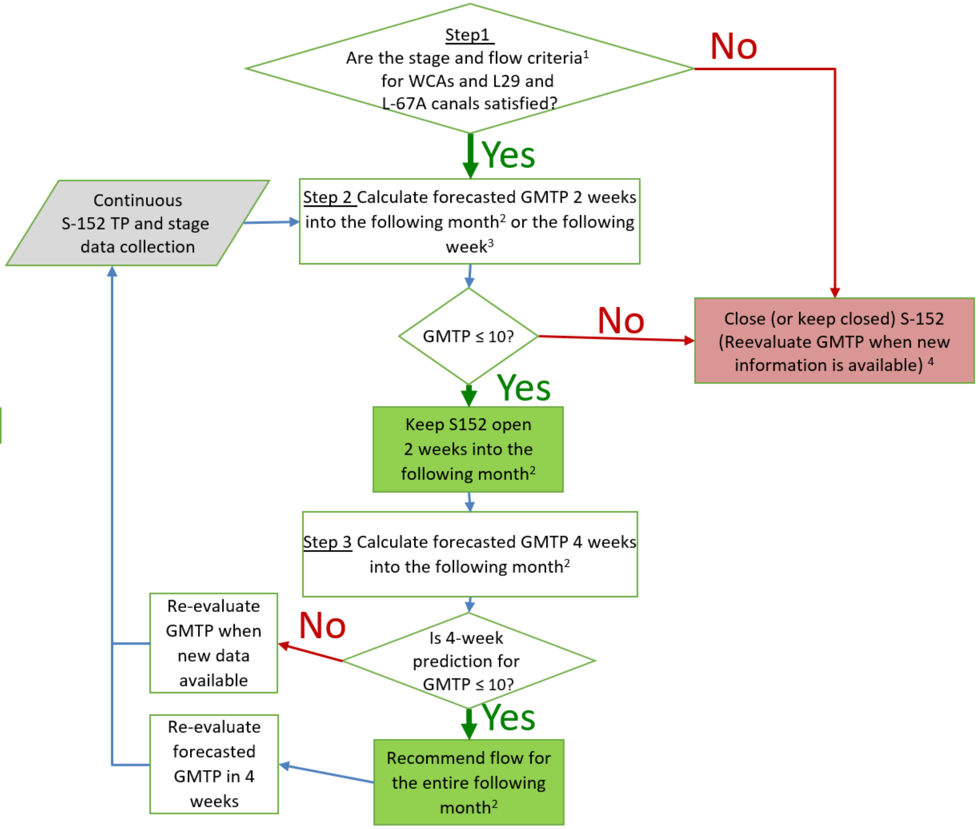
(courtesy J. Harvey, USGS)

How did this happen? Adaptively refined triggers for operation part of solution



Initial operation criteria based on TP monitoring data in canal and simple flow modeling

Decision Tree Using Operation Triggers



Refined criteria based on more sophisticated regression-based forecasting

Images courtesy DPM Science Team

Global pandemic and Everglades experiences add nuance to adaptive management cycle

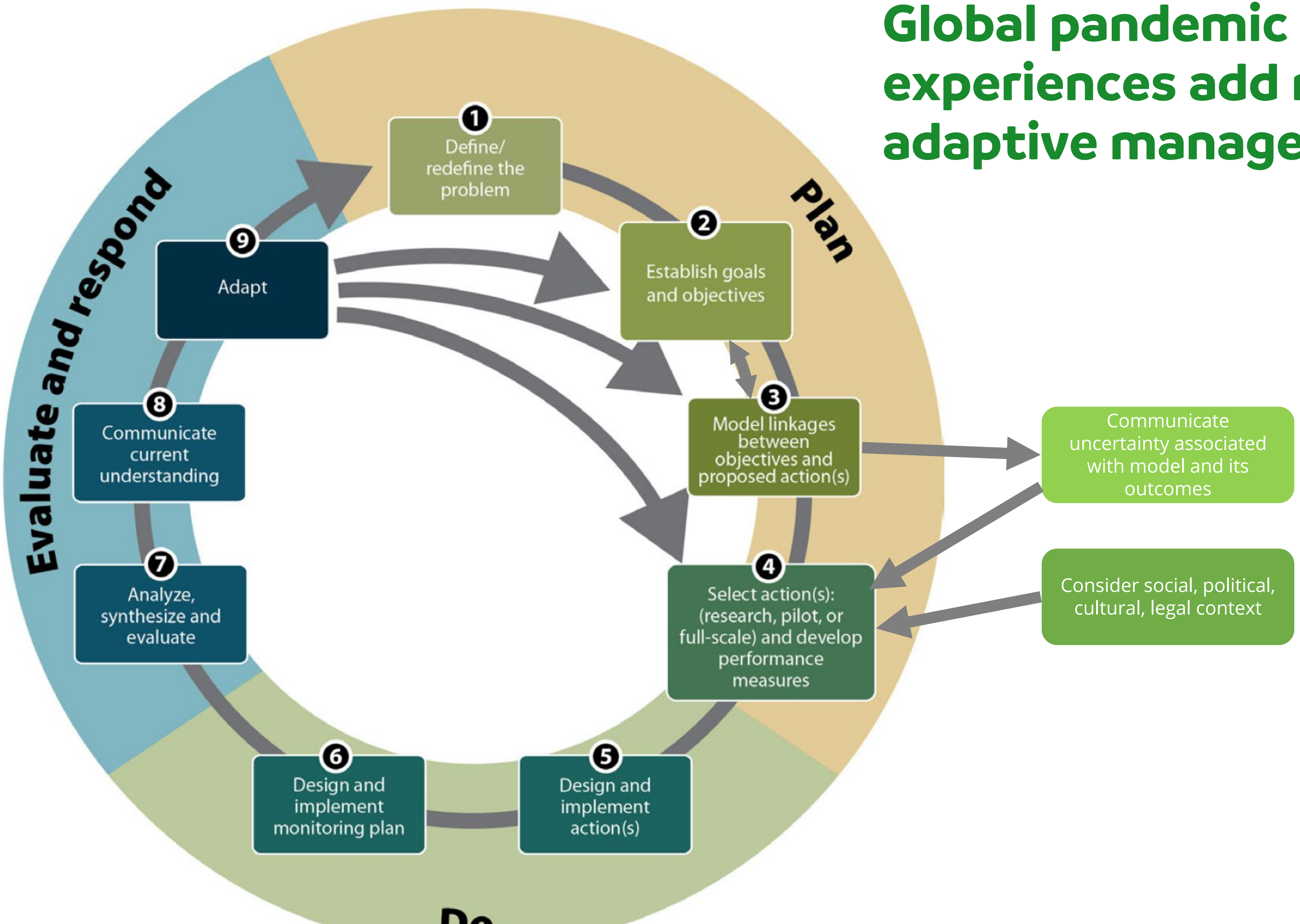
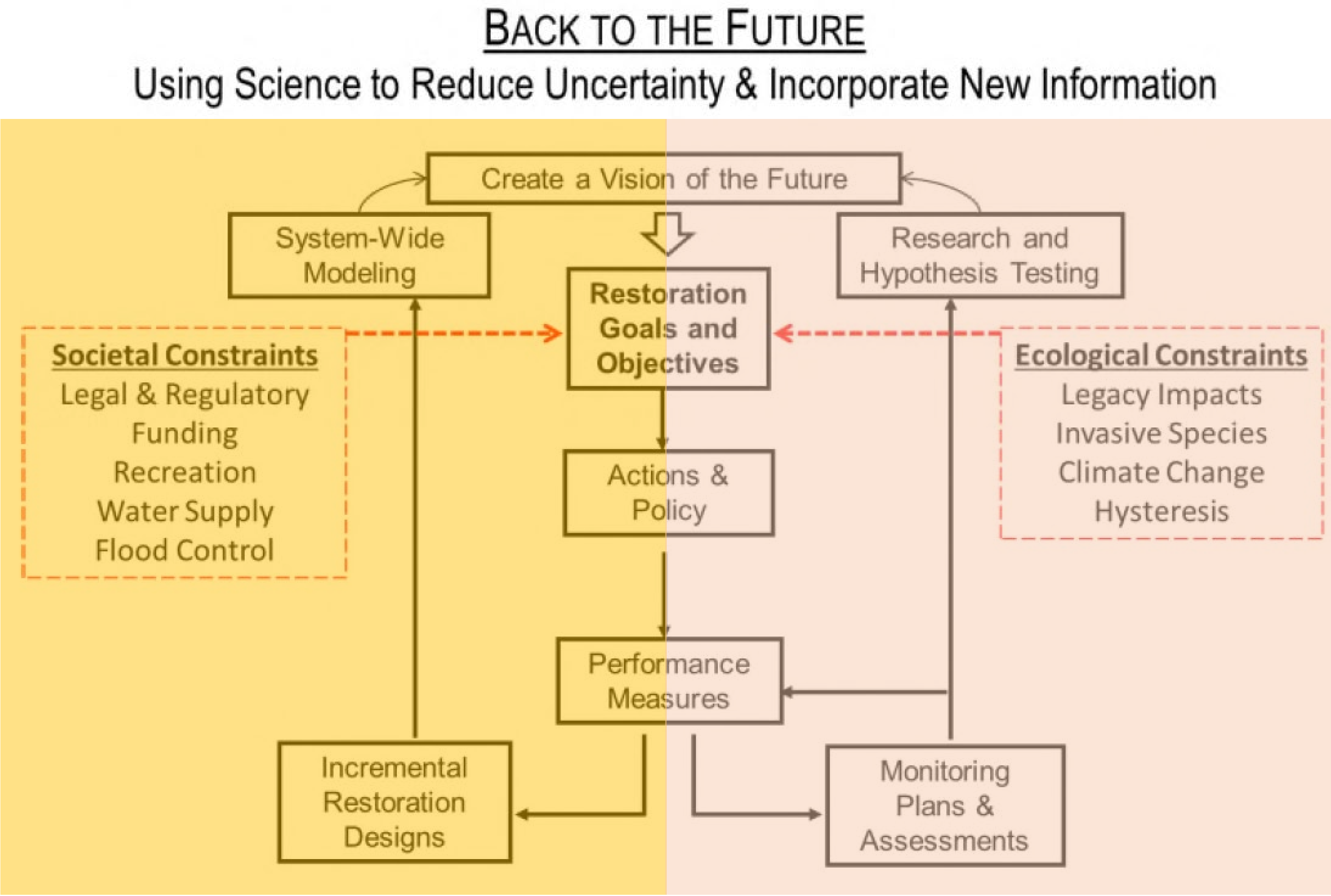


Figure modified from Delta Plan (Delta Stewardship Council, 2013)

System-scale adaptive management cycle

Design flow path

Building social capital promotes progression



Assessment flow path

Reducing knowledge uncertainty promotes progression

From Sklar, 2019

Five phases of adaptive management governance for socio-ecological systems

I. Building of social and scientific capital

↓

II. Scaling up

↓

III. Convergence

↓

IV. Implementation and refinement

↕

V. Rapid response

PHASE I:

- Impetus: legislation
- Knowledge about key driving processes is low
- Invest in understanding processes through experiments and models
- Adaptive management projects local in scale but require some interagency collaboration
- Use of numerical models is focused, by geographic area and/or output variable
- Interagency working groups established
- Much dissent about goals and priorities of management

Five phases of adaptive management governance for socio-ecological systems

I. Building of social and scientific capital

II. Scaling up

III. Convergence

IV. Implementation and refinement

V. Rapid response

PHASE II:

- Less knowledge uncertainty, many experiments to learn from
- Many models available
- Stakeholder discussions advanced. Stakeholders begin to engage with modelers. Agencies find common ground. Some convergence around common goals
- Common goals provide some impetus to develop integrated modeling at larger scale or with more variables
- Develop scenarios
- Transition to this stage facilitated by strong leadership from an agency or interagency group

Five phases of adaptive management governance for socio-ecological systems

I. Building of social and scientific capital

II. Scaling up

III. Convergence

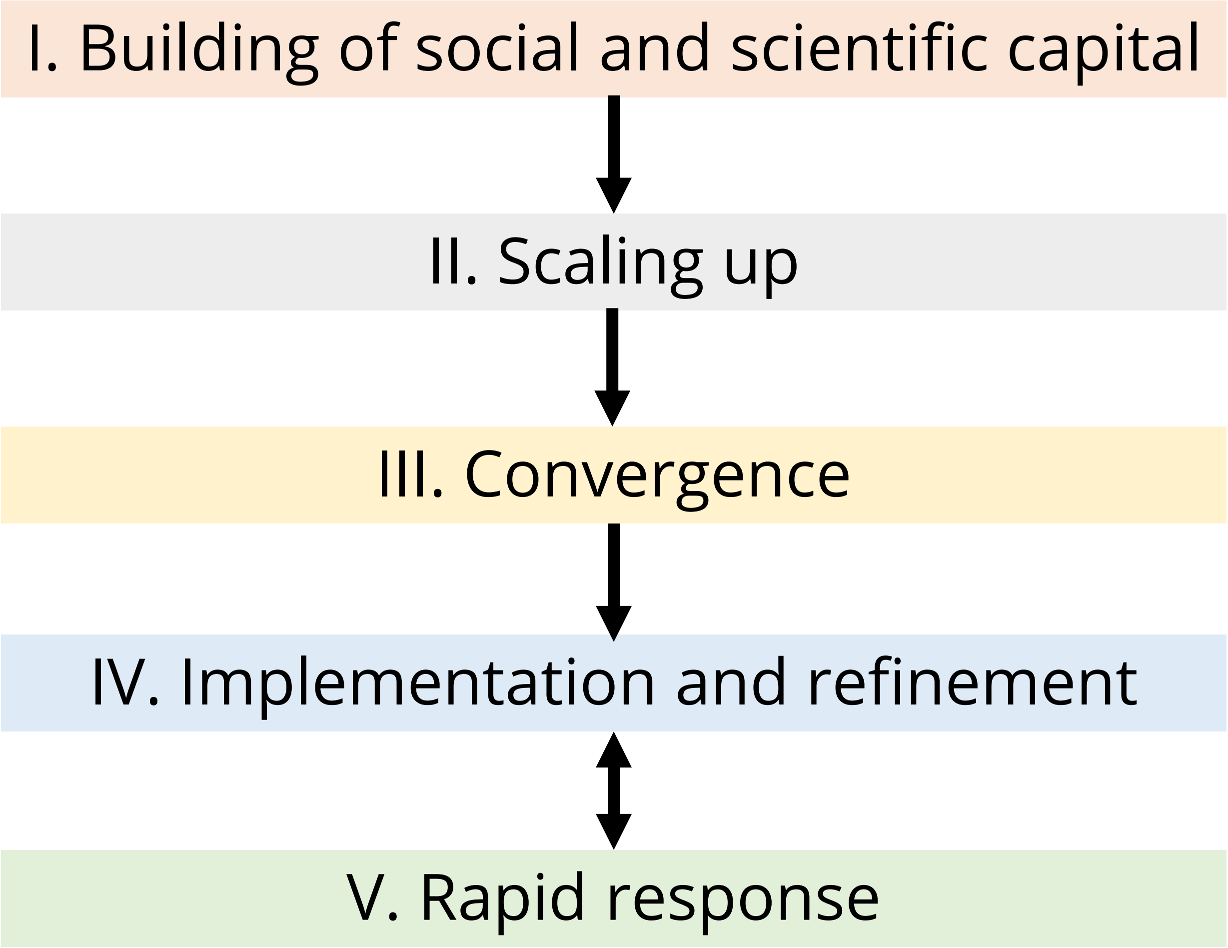
IV. Implementation and refinement

V. Rapid response

PHASE III:

- Integrated modeling facilitates interagency and stakeholder discussions
- Convergence around common strategy to achieve objectives
- Transition to/from this phase may be rapid once organizational architecture from phase II is built

Five phases of adaptive management governance for socio-ecological systems



PHASE IV:

- Transition to this phase may require legislative authorization but may be facilitated by incremental approach
- As implementation progresses, resolution of “randomness uncertainty” is an important stimulus for refinement

Five phases of adaptive management governance for socio-ecological systems

I. Building of social and scientific capital

II. Scaling up

III. Convergence

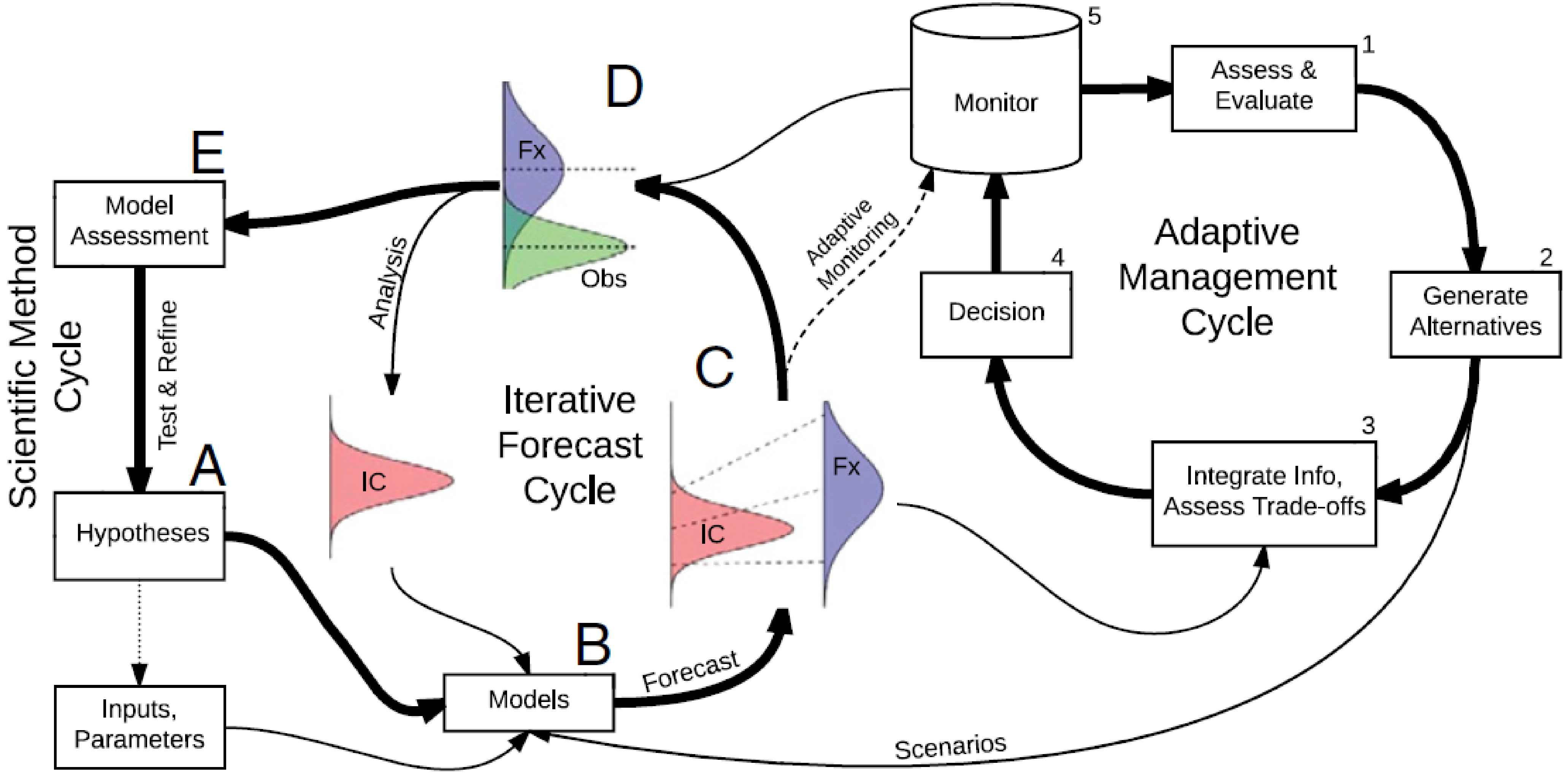
IV. Implementation and refinement

V. Rapid response

PHASE V:

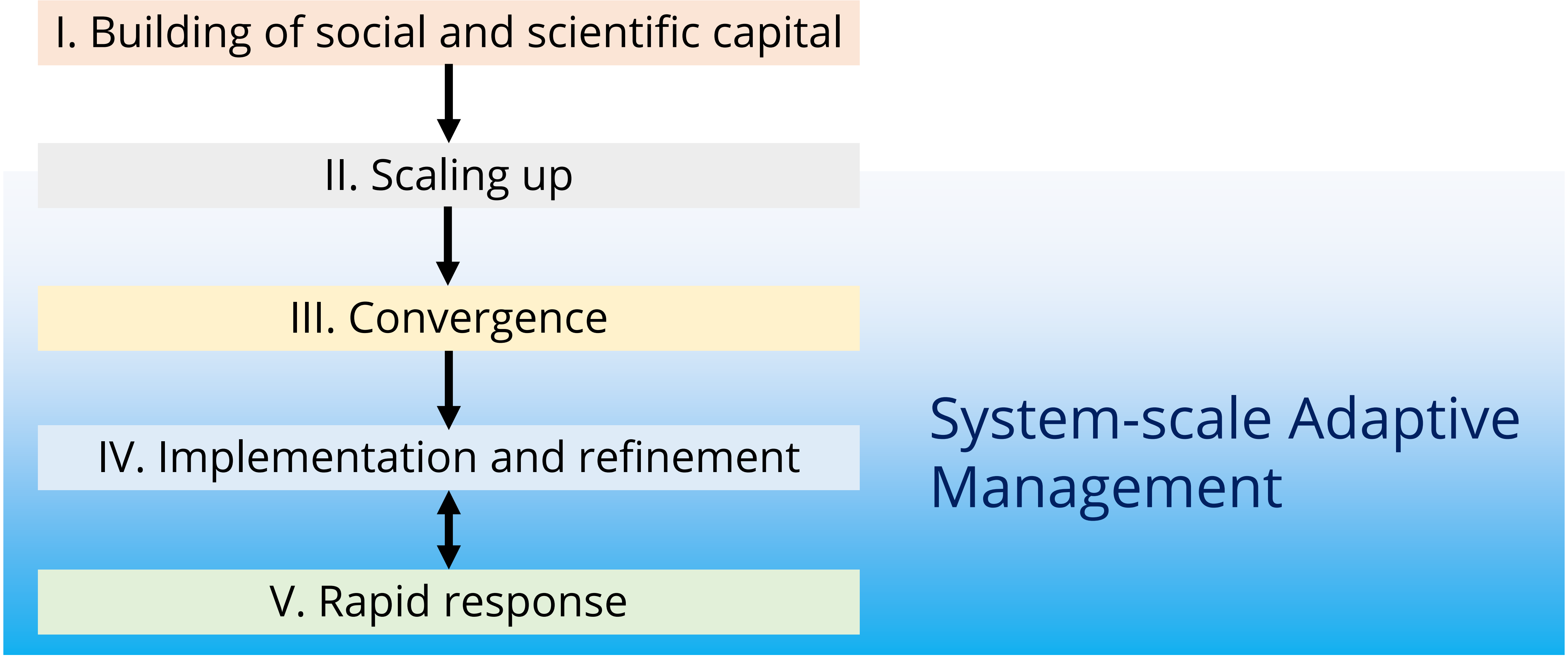
- Operational forecasting
- Governance system develops capacity for near-realtime response to changing conditions

The future: iterative, near realtime, multiscale adaptive management



Dietze et al., *PNAS*, 2018

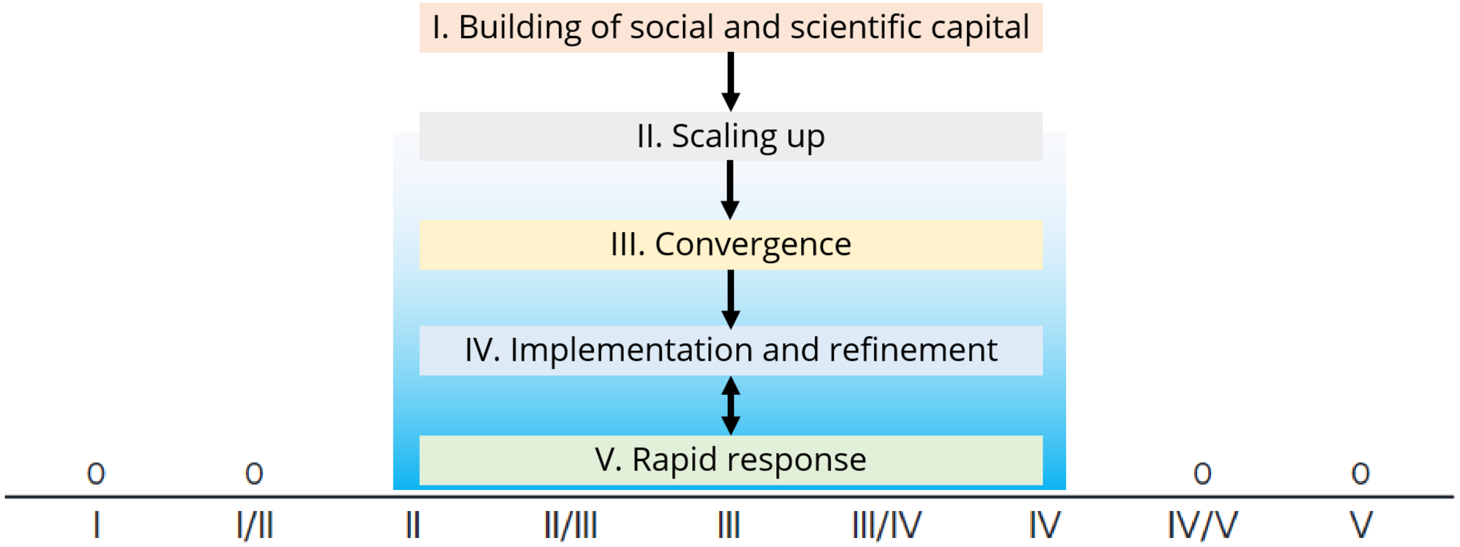
Five phases of adaptive management governance for socio-ecological systems



Go to **www.menti.com** and use the code **85 45 10 4**

What phase of adaptive management governance is the Delta currently in?

Mentimeter



Press S to show image

Go to **www.menti.com** and use the code **85 45 10 4**

How would you rate your reaction to the proposed phases of adaptive management governance for socio-ecological systems?

Mentimeter

Strongly disagree

Strongly disagree: Misses the mark completely. Middle: Agree in principle, but needs "moderate revisions". Strongly agree: This gets it mostly right!

Strongly agree

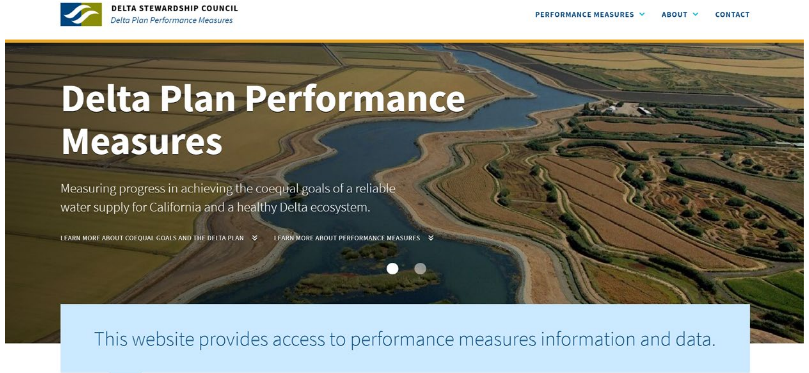
Press S to show image

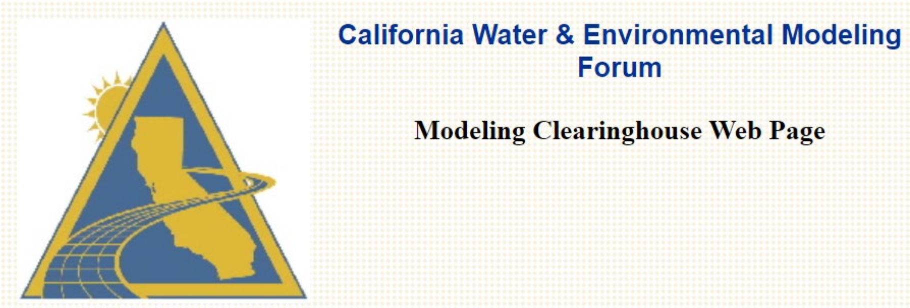
Go to **www.menti.com** and use the code **27 78 92 3**

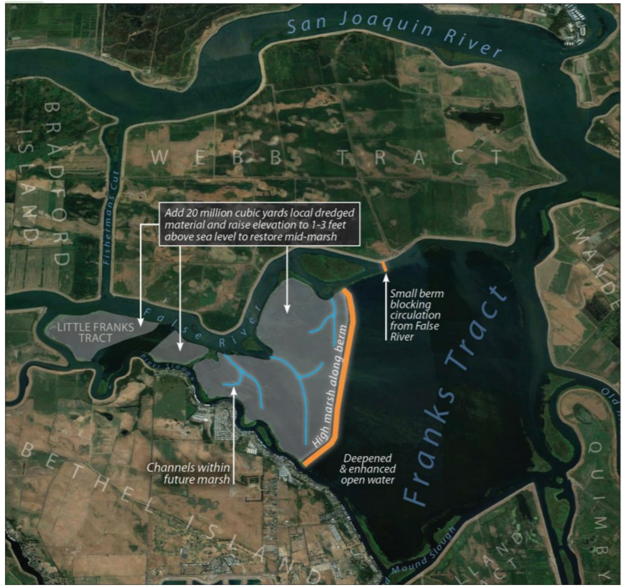
Optional: Submit comments about the proposed phases of adaptive management governance here.

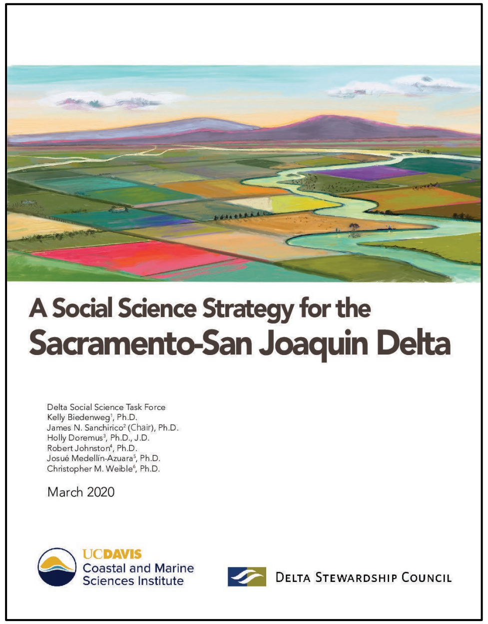
Mentimeter

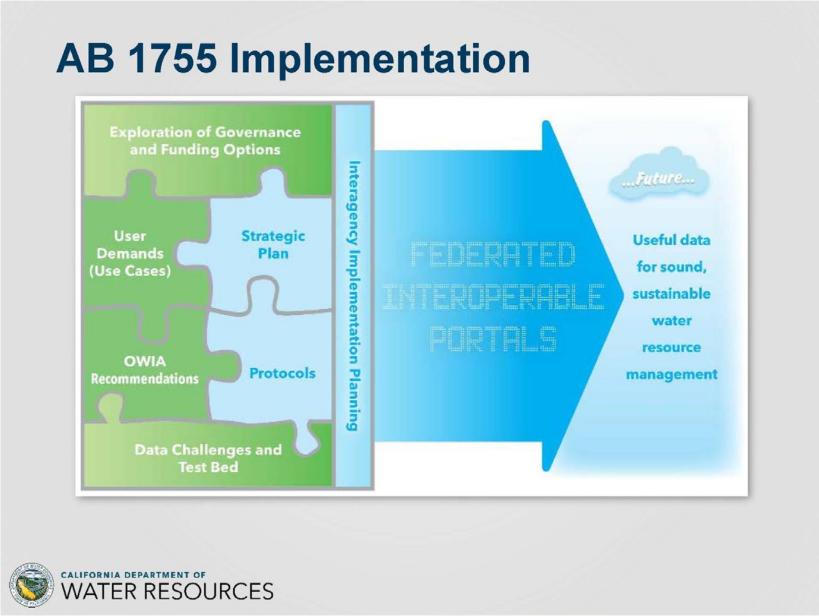
Many recent and ongoing efforts promote transition to system-scale adaptive management

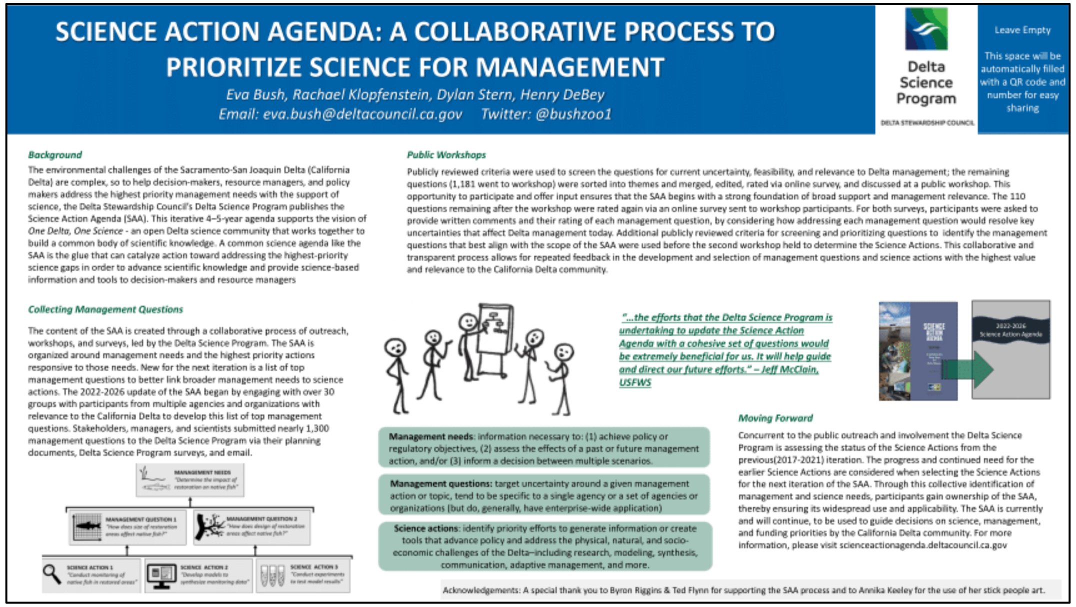












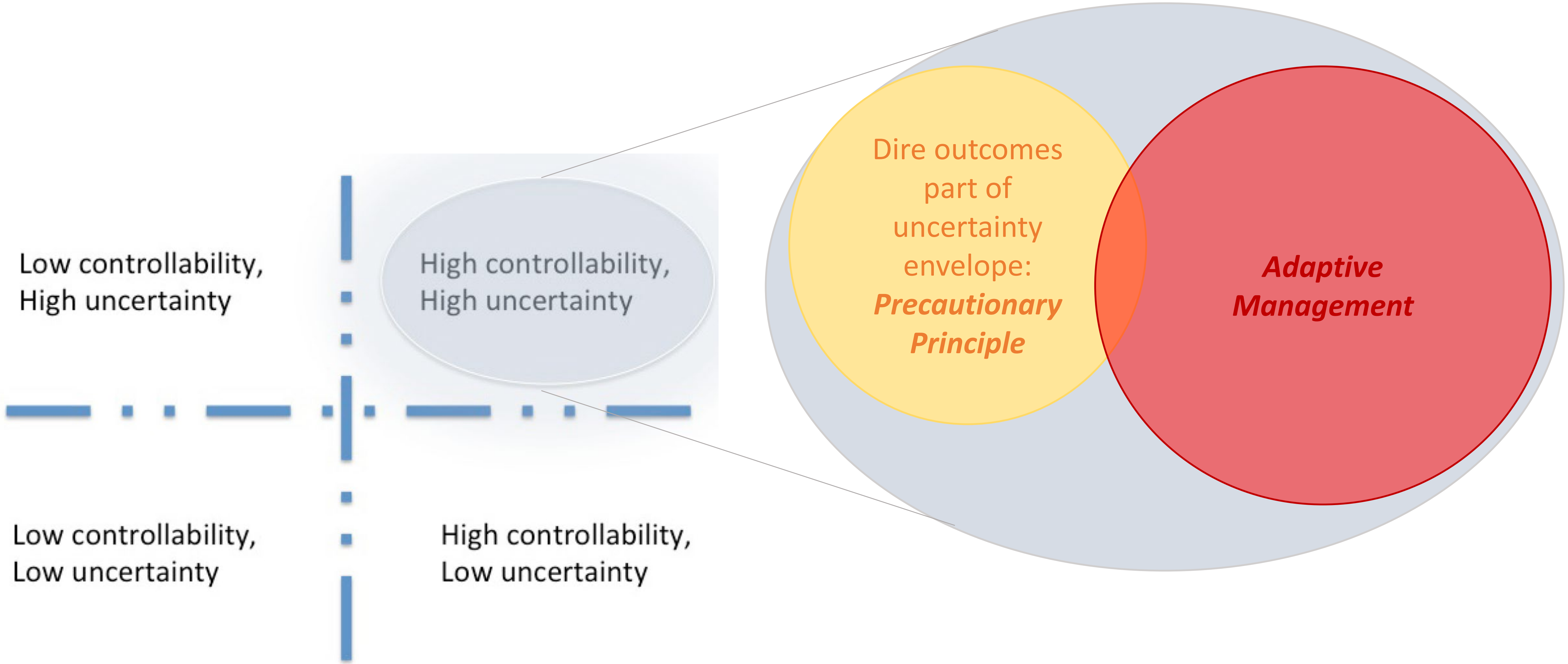
Conclusions: Priorities for transitioning to system-scale adaptive management

- Prioritize interoperable, integrated modeling efforts
- Integrate modeling efforts with building social capital (e.g., stakeholder and manager involvement)
- Clear communication of uncertainty and risk is needed to build the trust that is foundational to system-scale adaptive management and lay the foundation for action, despite remaining uncertainty
- Meanwhile, continue to develop data dashboards, deep learning and AI tools, and pathways for user-friendly data assimilation to build readiness for rapid transition to final phase of system-scale adaptive management

A recap of the ISB's 2016 recommendations

1. Convene a workshop or review panel to determine how to coordinate and assist adaptive management in the Delta
2. Support adaptive management with funding that is dependable and flexible
3. Design and support monitoring
4. Integrate science and regulations to enhance flexibility
5. Develop a framework for setting decision points or threshold that will trigger a management response
6. Use restoration sites to test adaptive-management and monitoring protocols
7. Capitalize on unplanned experiments
8. Recognize when and where adaptive management is not appropriate

Uncertainty plays key role in appropriateness of adaptive management



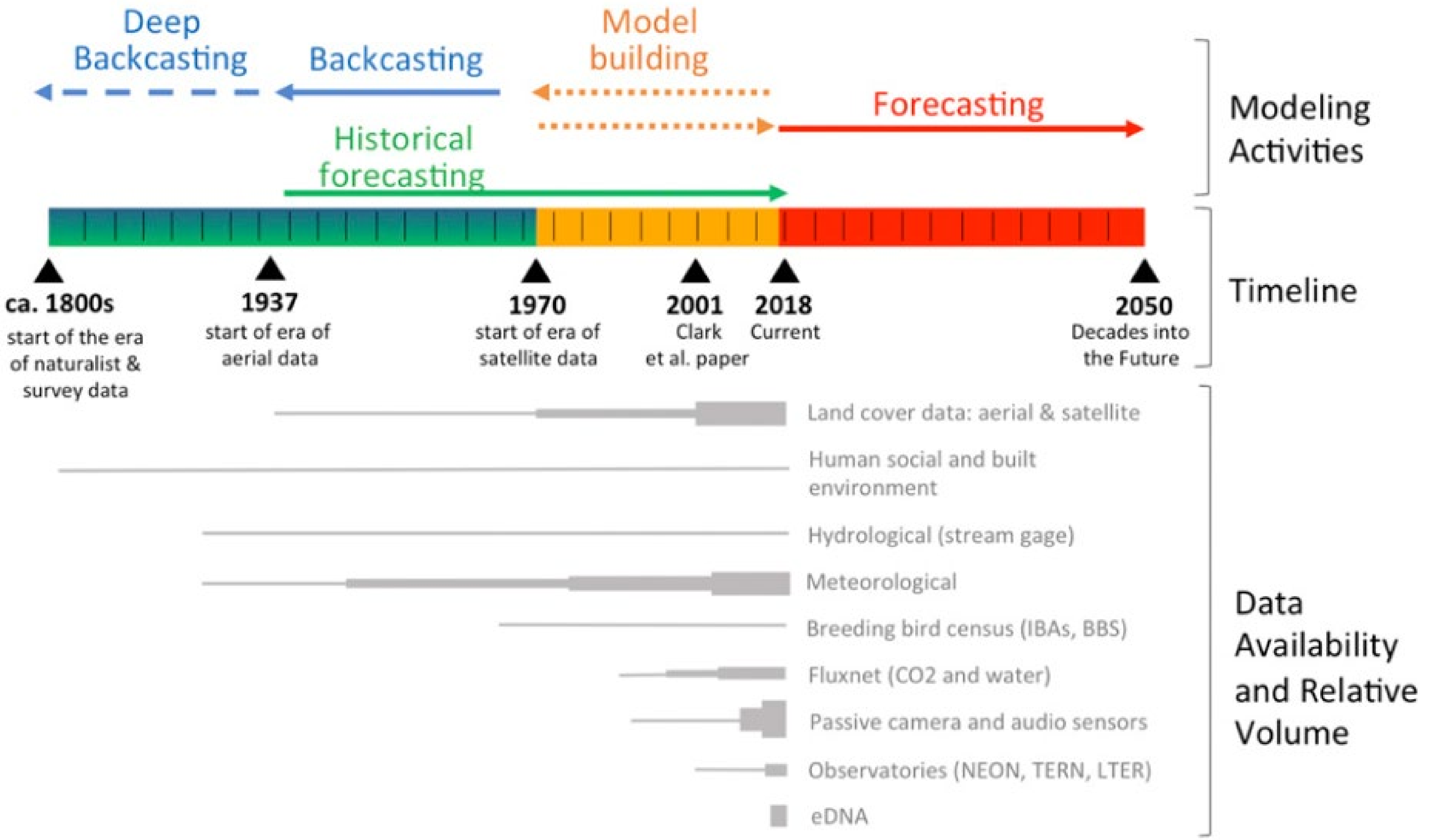
Modified from Wiens et al., *SFEWS*, 2017

Approval of a restoration plan for the Everglades requires compliance with these laws, policies, and regulatory constraints

Sklar, 2019, in *The Coastal Everglades: The Dynamics of Social-Ecological Transformation in the South Florida Landscape*

- Anadromous Fish Conservation Act
- Archaeological Resources Protection Act of 1979
- American Indian Religious Freedom Act
- Bald and Golden Eagle Protection Act
- Clean Air Act of 1972
- Clean Water Act of 1972
- Coastal Barrier Resources Act and Coastal Barrier Improvement Act of 1990
- Coastal Zone Management Act of 1972
- Endangered Species Act of 1973
- Estuary Protection Act of 1968
- Federal Water Project Recreation Act/Land and Water Conservation Fund Act
- Fish and Wildlife Coordination Act of 1958, as amended
- Farmland Protection Policy Act of 1981
- Magnuson-Stevens Fishery Conservation and Management Act
- Marine Mammal Protection Act of 1972
- Marine Protection, Research and Sanctuaries Act
- National Environmental Policy Act of 1969
- National Historic Preservation Act of 1966
- Native American Graves Protection and Repatriation Act
- Resource Conservation and Recovery Act, as amended by the Hazardous and Soils Waste Amendments of 1984, CERCLA as amended by the 5.26.21 Superfund Amendments and Reauthorization Act of 1996, Toxic Substances Control Act of 1976
- Rivers and Harbors Act of 1899
- Submerged Lands Act of 1953
- Wild and Scenic River Act of 1968
- E.O. 11514, Protection of the Environment
- E.O. 11593, Protection and Enhancement of the Cultural Environment
- E.O. 11988 Flood Plain Management
- E.O. 11990 Protection of Wetlands
- E.O. 12962, Recreational Fisheries
- E.O. 12898 Environmental Justice
- E.O. 13007 Indian Sacred Sites
- E.O. 13045 Protection of Children
- E.O. 13089 Coral Reef Protection
- E.O. 13122 Invasive Species
- E.O. 13175 Consultation and Coordination with Indian Tribal Governments
- E.O. 13186 Responsibilities of Federal Agencies to Protect Migratory Birds
- Memorandum on Government to Government Regulations with Native American Tribal Governments
- Seminole Indian Claims Settlement Act of 1987

Adaptive forecasting built on foundation of models and data



Dietze et al., *PNAS*, 2018