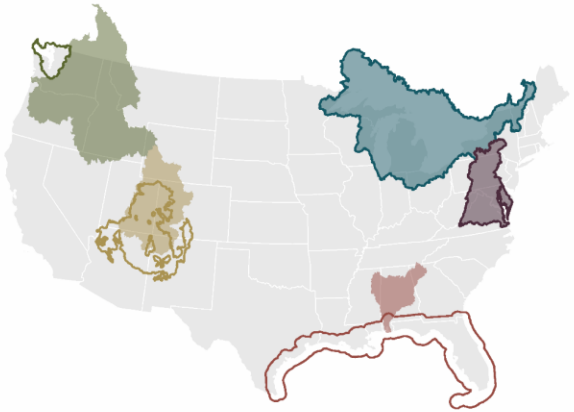
LOW FLOW IMPACTS ON Chesapeake Bay ecological communities (AND BEYOND)



Taylor Woods (*tewoods@usgs.gov*), Matthew Cashman, Timothy Counihan, Sean Emmons, Ken Eng, Mary Freeman, Benjamin Gressler, Joshua Hubbell, Anna Kaz, Kelly Maloney, James McKenna Jr., Jared Smith, Daniel Wieferich, Tanja Williamson, Robert Zuellig, Mike Wieczorek

BIG TEAM EFFORT!!!

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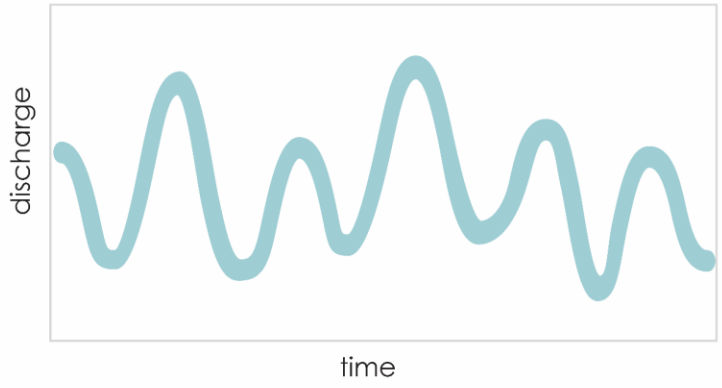

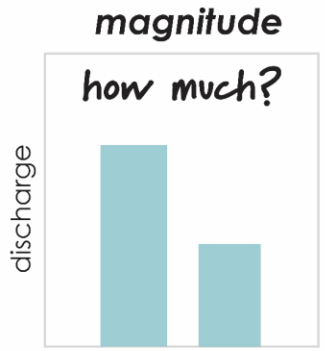

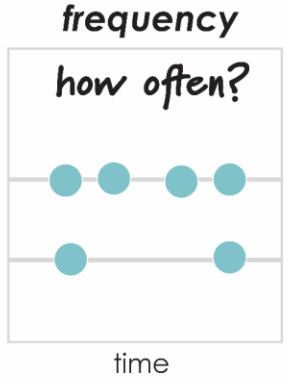

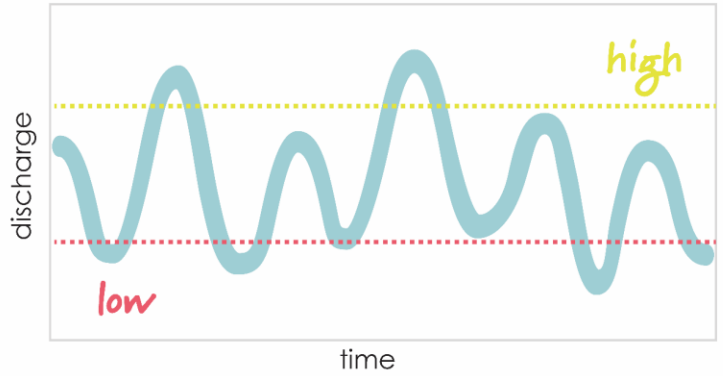

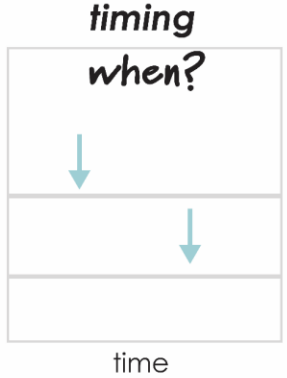

FLOW REGIME

image credits: Ryan Hagerty, USFWS

context

- CHARACTERIZED BY THE MAGNITUDE, DURATION, FREQUENCY, & TIMING OF HIGH & LOW FLOW CONDITIONS
- AQUATIC BIOTA DEPEND ON NATURAL FLOW REGIMES

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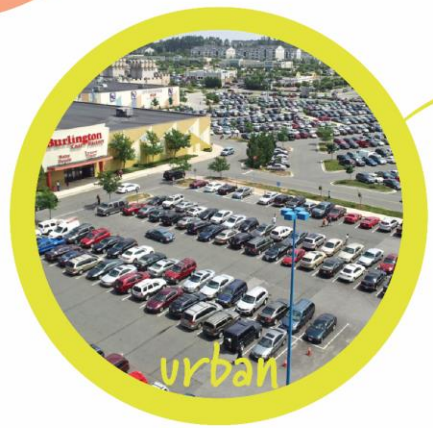
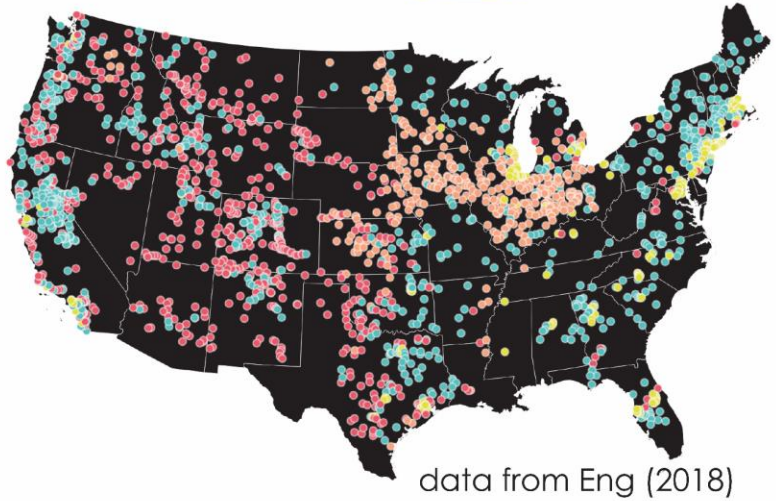
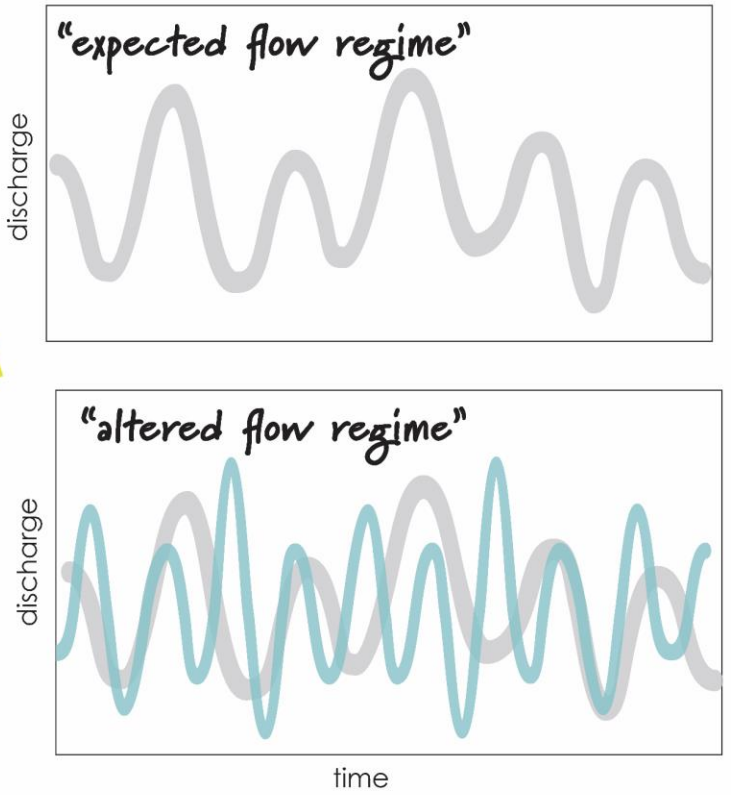
context





data from Eng (2018)
https://doi.org/10.5066/P9ULGVLI



ALTERED FLOWS

- HUMANS ALTER NATURAL FLOW REGIMES IN MANY WAYS
- MANY OF THE NATION'S STREAMS & RIVERS ARE FLOW-ALTERED

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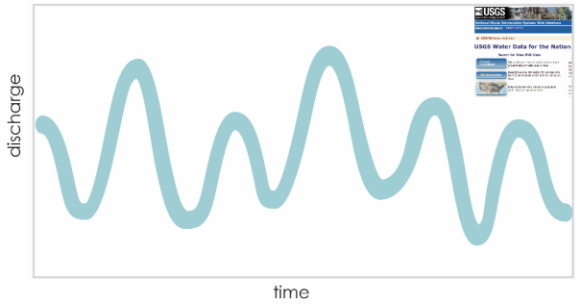
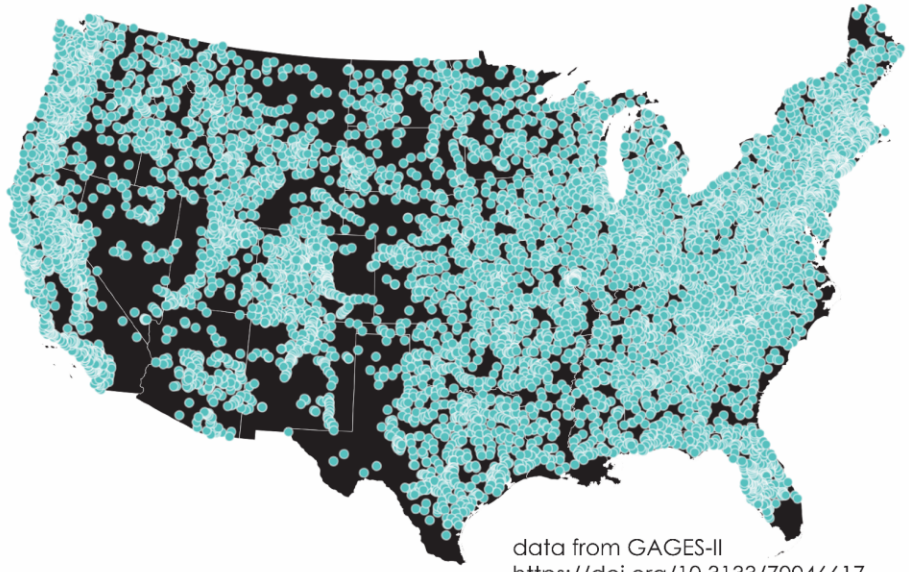
USGS FLOW

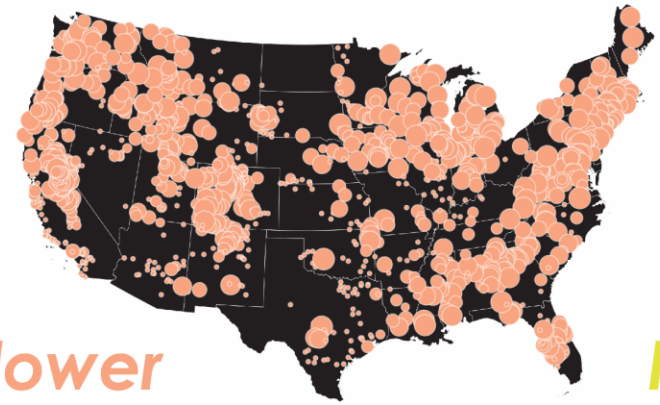
>9,000 GAGES



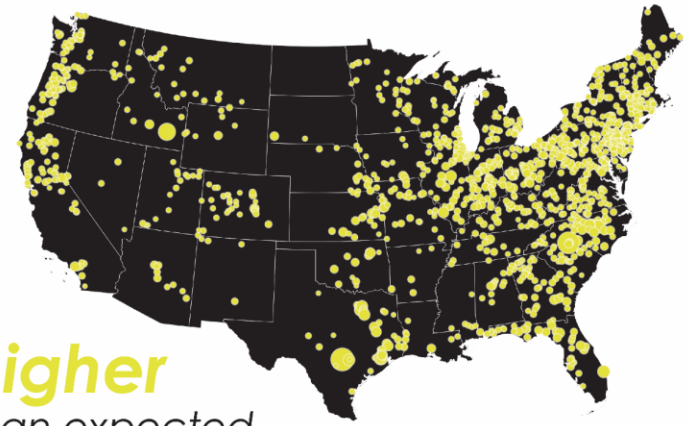


data from GAGES-II
https://doi.org/10.3133/70046617

LOW FLOWS 1980-2014



lower
than expected



higher
than expected

data from Eng (2018)
https://doi.org/10.5066/P9ULGVLI

context

- USGS' EXPANSIVE STREAM GAGING NETWORK
- UNDERSTANDING PATTERNS, TRENDS, & DRIVERS OF STREAMFLOWS ACROSS THE NATION

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knowledge gaps

- PREDICTION AT UNGAGED STREAMS
- SHORTER-TERM CONDITIONS (DYNAMIC)
- FORECASTING FUTURE FLOW ALTERATION
- VULNERABILITY OF AQUATIC BIOTA TO FUTURE FLOW

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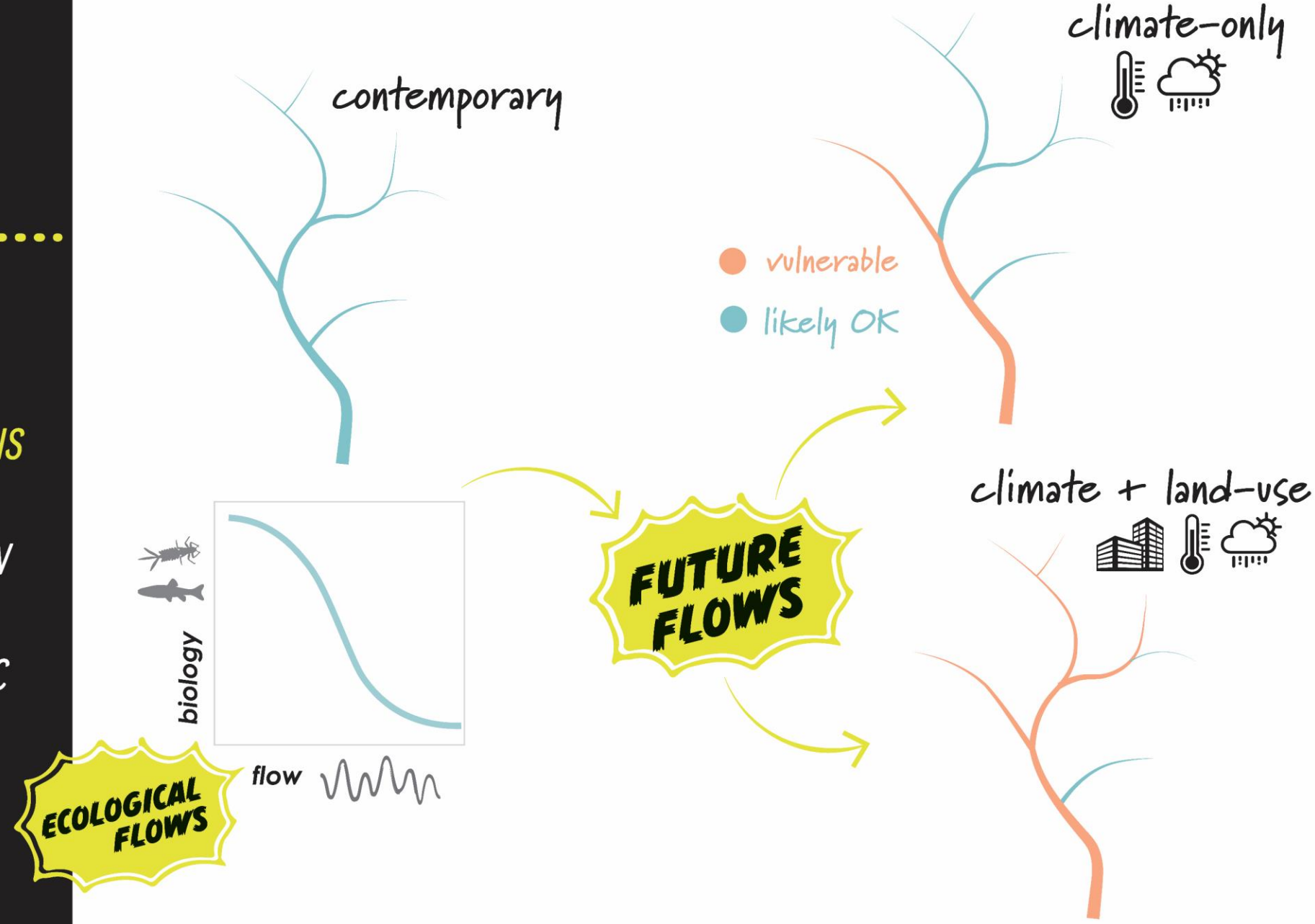

science objectives

- *PREDICT* STREAMFLOW ALTERATION *AT ALL STREAMS 1980–2100 BASED ON* CLIMATE & LAND-USE
- *IDENTIFY* THRESHOLDS IN FISH RESPONSES *TO FLOW*
- *ASSESS* VULNERABILITY OF FISH COMMUNITIES *TO FUTURE FLOW ALTERATION*

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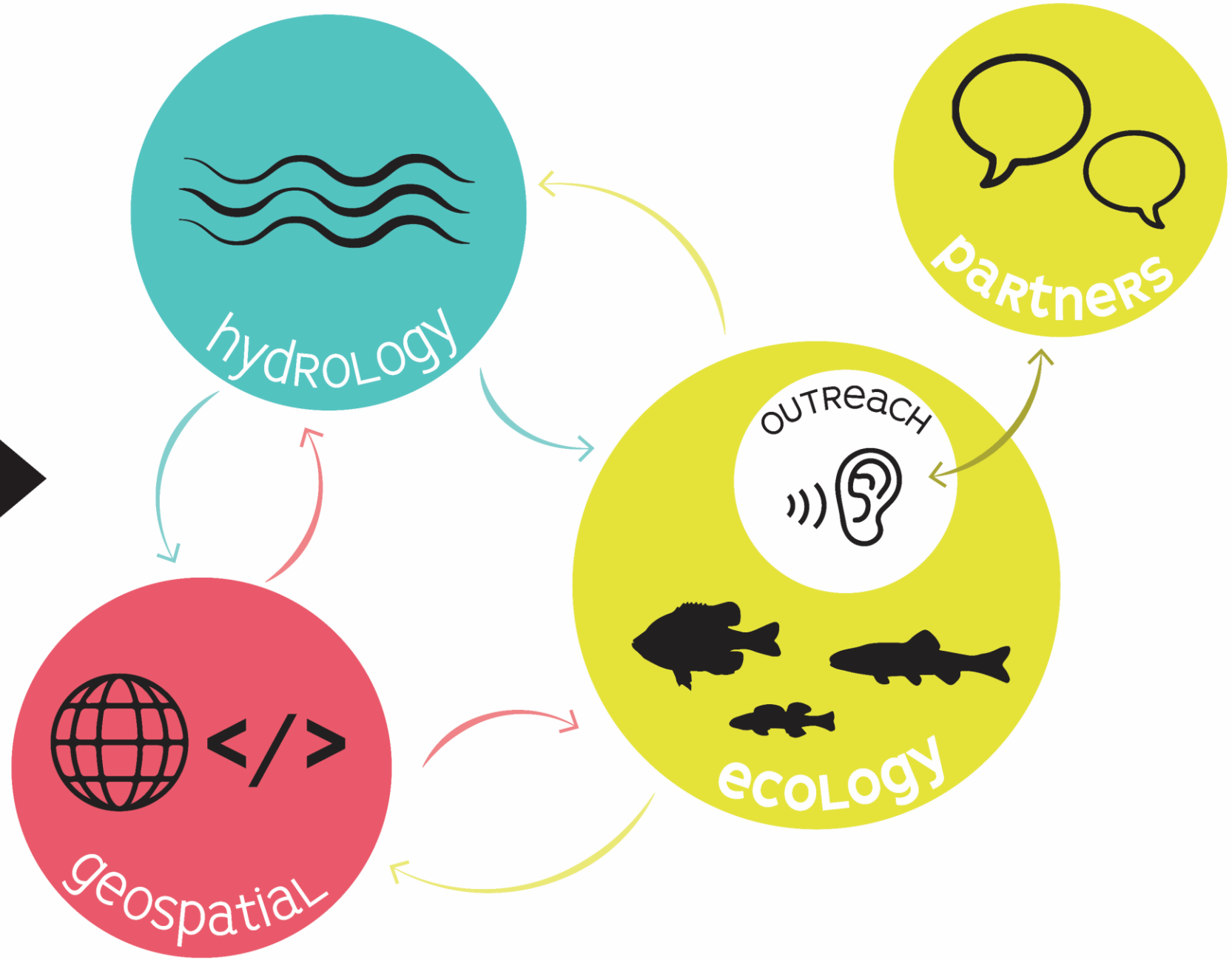
assemble team



ecology team

- *LOCAL EXPERTS ON* MULTI-AGENCY FISH DATASETS
- *INFORMED BY &* CONNECTED WITH LOCAL PARTNERS
- *COLLABORATE ON* ECOLOGICAL FLOW VULNERABILITY ASSESSMENTS



















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FISH DATASETS

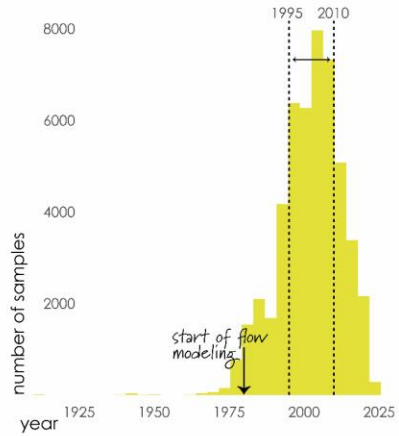
- *HARMONIZING* MULT-AGENCY FISH DATASETS *ACROSS REGIONS*
- *STANDARDIZATION OF* TAXONOMY, SAMPLING METHODS, *& MANY MORE!!*

50,000 *sampling events*

> 50 *agencies*

450 *species*

> 15,000 *stream reaches*



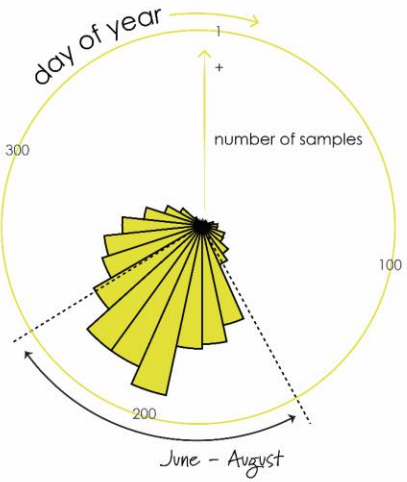


image credits: Ryan Hagerty, Roger Tabor, USFWS

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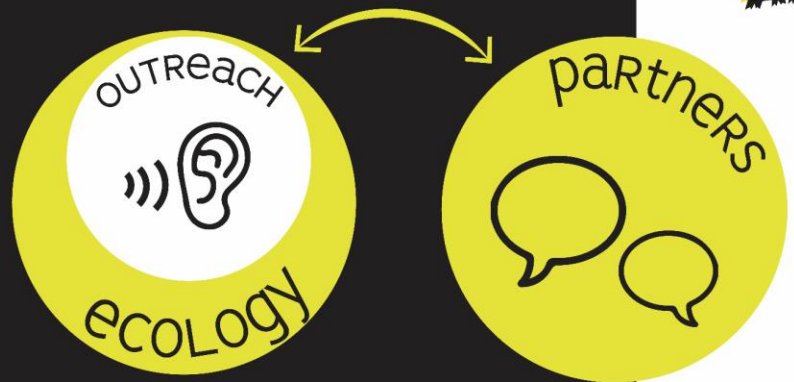
Local partners

- *WHAT ARE YOUR CONCERNS ABOUT CLIMATE & LAND-USE CHANGE EFFECTS ON STREAM FLOWS & FISHES?*



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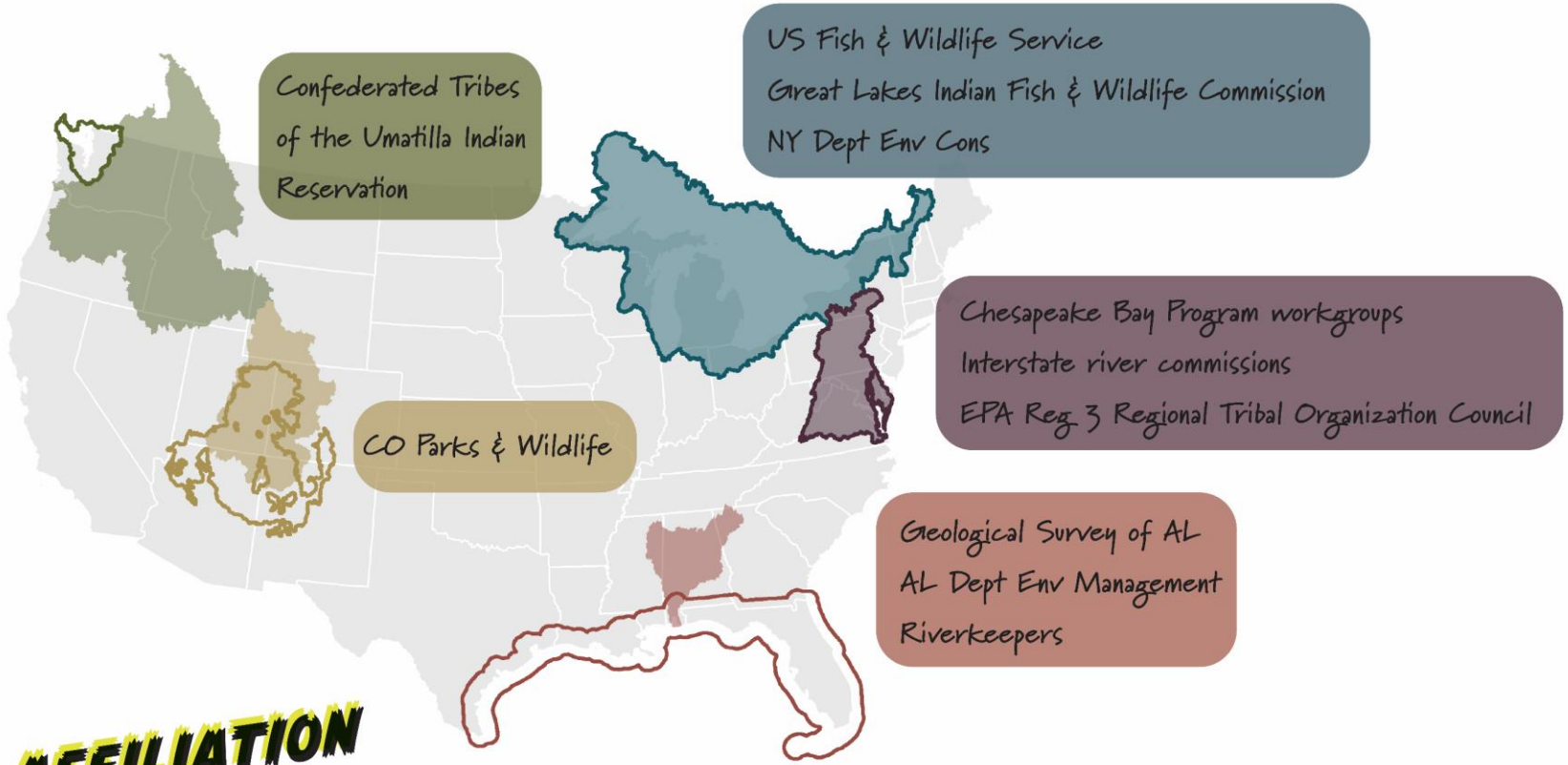


AFFILIATION

TRIBAL
GOVERNMENTAL
NON-GOVERNMENTAL

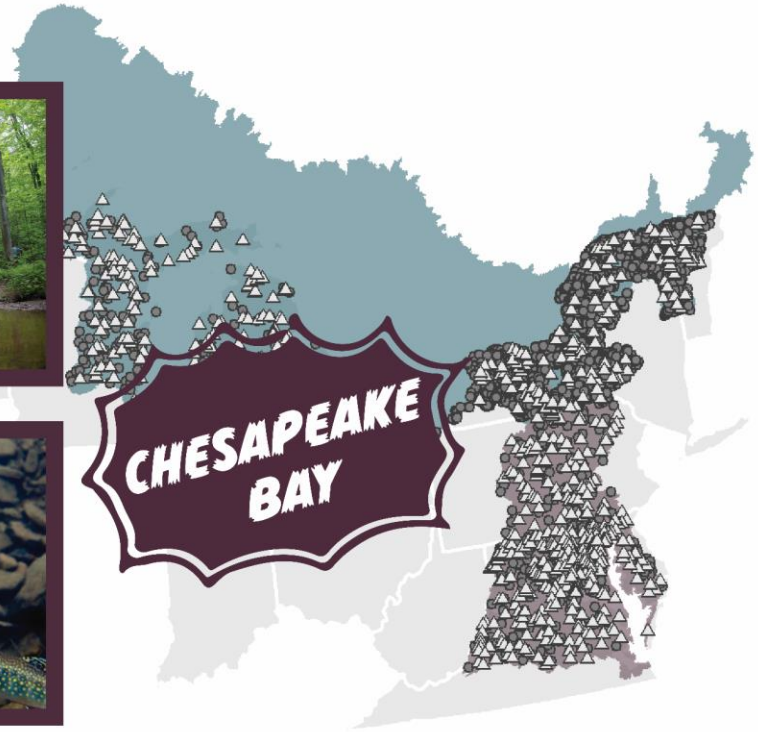
SCALE

LOCAL
STATE
REGIONAL
NATIONAL

sean emmons
EESC
(semmons@usgs.gov)

KNOWLEDGE LEARNED

SNOWBALLING



Chesapeake Bay Program workgroups
Interstate river commissions
EPA Reg 3 Regional Tribal Organization Council

- effects of climate & land-use on the duration & magnitude of low flows
- changes to flow regime affect persistence of coldwater refugia
- expansion of invasives negatively affects native fishes
- flooding & sea level rise on tribal lands

Geological Survey of AL
AL Dept Env Management
Riverkeepers

- variation in climate & land-use among physiographic regions & longitudinal gradients
- effects of deforestation & increasing development on high & low flows
- spawning runs are fragmented by dams & flow alteration
- rivers are drying out & dewatering more often

geospatial team

- NATIONAL HYDROGRAPHY DATASET VERSION 2 (NHDV2) CATCHMENTS & WATERSHEDS
- SUMMARIZE MASSIVE AMOUNTS OF DATA
- LEVERAGE EXISTING TOOLS/SCRIPTS INTO REPRODUCIBLE WORKFLOWS

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land-use/land-cover


annual 1980-2100
4 future scenarios

climate


annual monthly 1980-2100
16 future scenarios

water balance

annual monthly 1980-2100
16 future scenarios

reservoir operations

annual monthly 1980-2020

PREDICTORS

FLOW MODELS

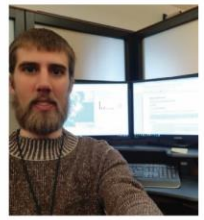
hydrology

geospatial

THAT'S A TON OF DATA!



taylor woods, sean emmons, ben gressler
EESC



daniel wieferich
CSS

mike wieczorek
MD-DC-DE WSC

Temperature summaries

- WARMER ENVIRONMENTS ACROSS ALL SEASONS
- DEGREE OF WARMING VARIES BY GCM & RCP
- GREATEST INCREASES UNDER RCP 8.5

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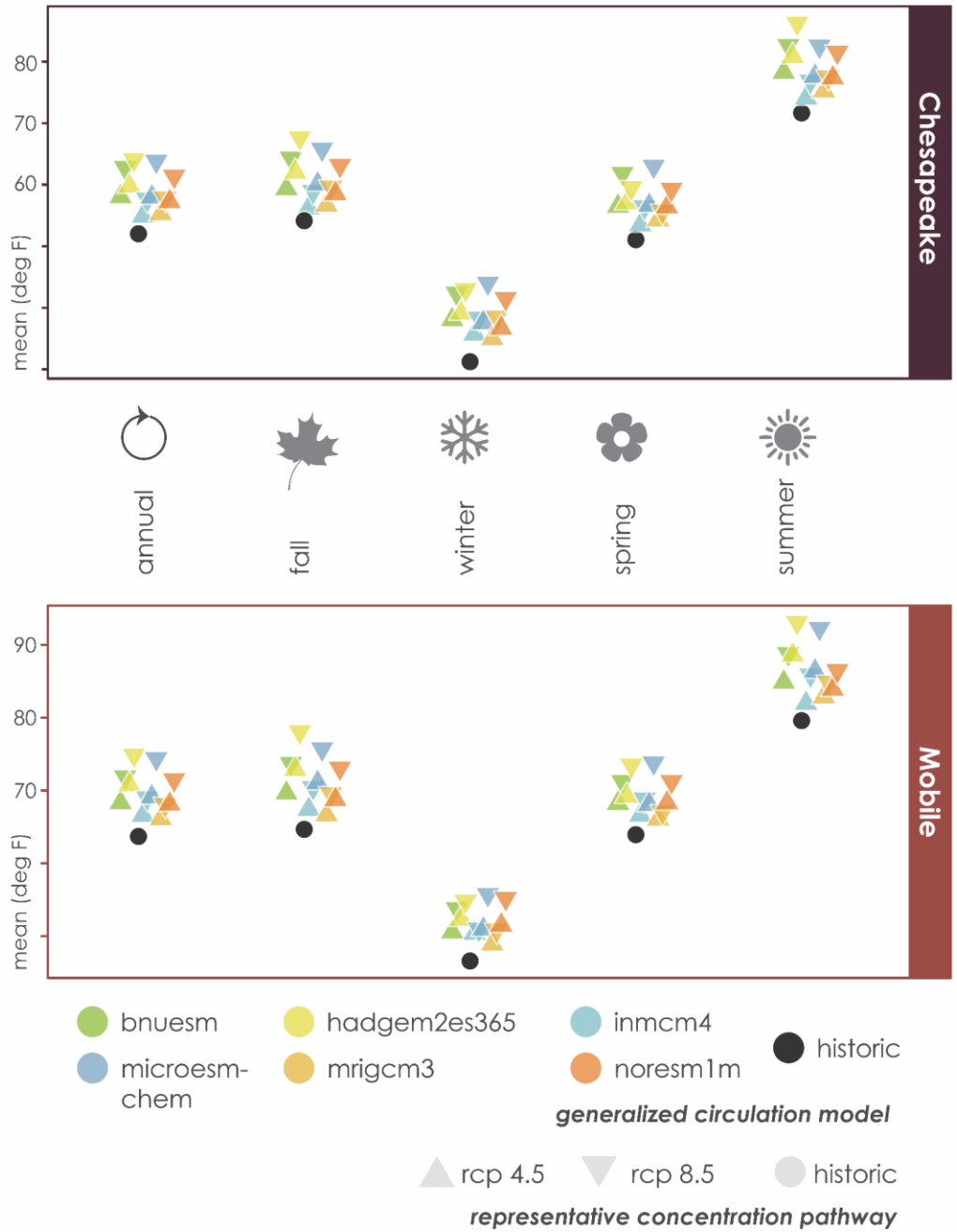

data published!

2080 - 2090
'future'
(color gradients)

2000 - 2010
'historic'
(black circle)

Precipitation summaries

- Wetter environments generally
- Degree of wetting/drying varies seasonally
- Wetter fall - springs, drier summers

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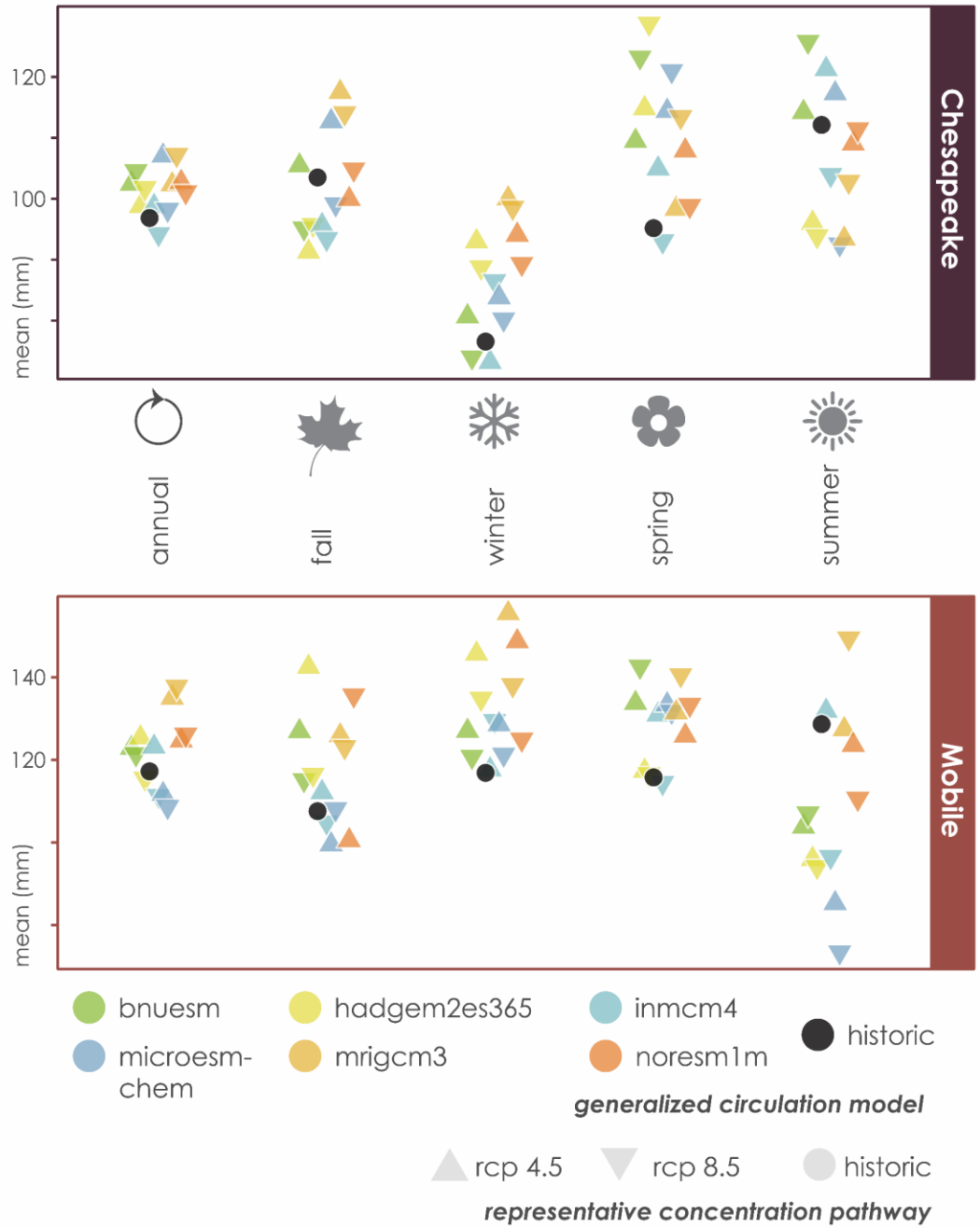

data published!

2080 - 2090
'future'
(color gradients)

2000 - 2010
'historic'
(black circle)

Land-use Land-cover summaries

- MORE DEVELOPED, LESS FORESTED ENVIRONMENTS ACROSS ALL SCENARIOS
- AGRICULTURAL EXPANSION VARIES BY SCENARIO - SPLIT BETWEEN INCREASES & DECREASES

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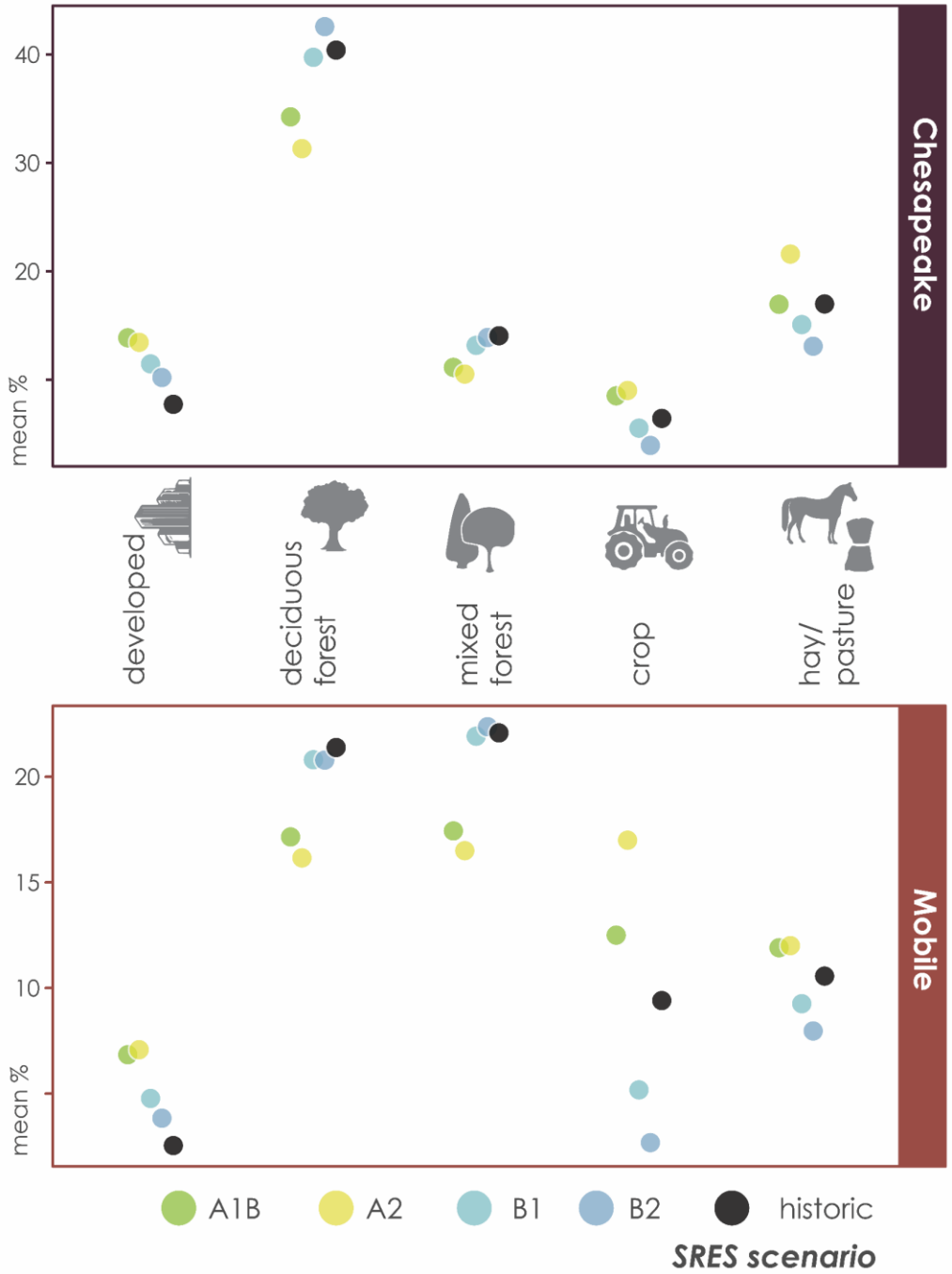

data published!

2070
'future'
(color gradients)

2005
'historic'
(black circle)

hydrology team

- IDENTIFY PREDICTOR VARIABLES FOR FLOW MODELS
- PREDICT FLOW METRICS AT GAGED & UNGAGED REACHES 1980-NOW
- FORECAST FLOW METRICS NOW-2100

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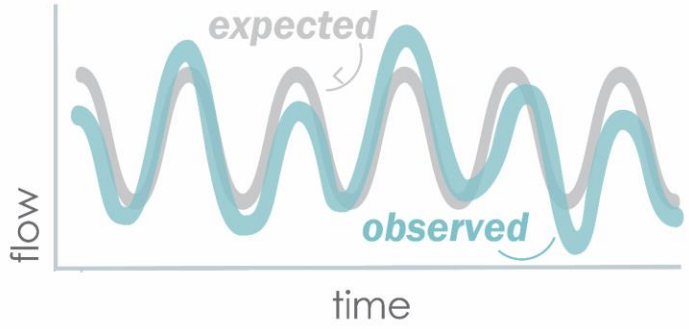
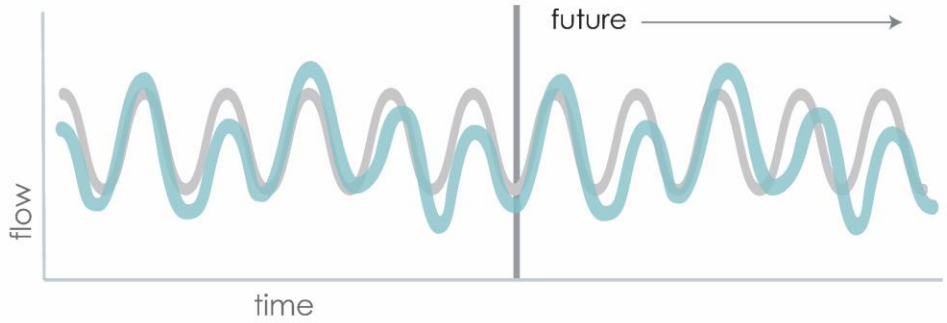
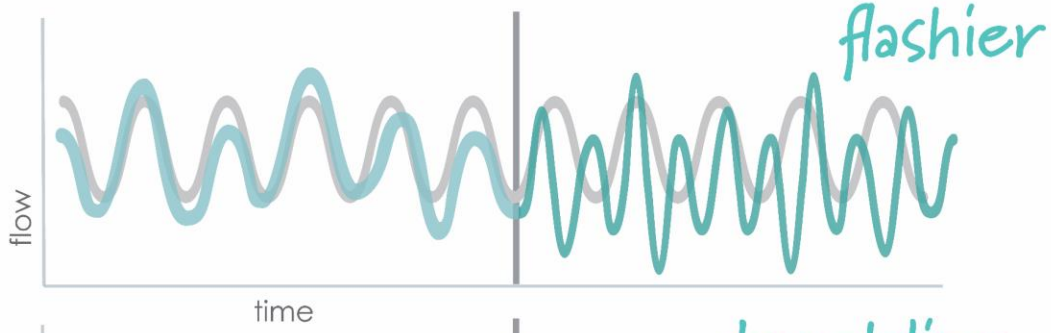
ken eng WMA

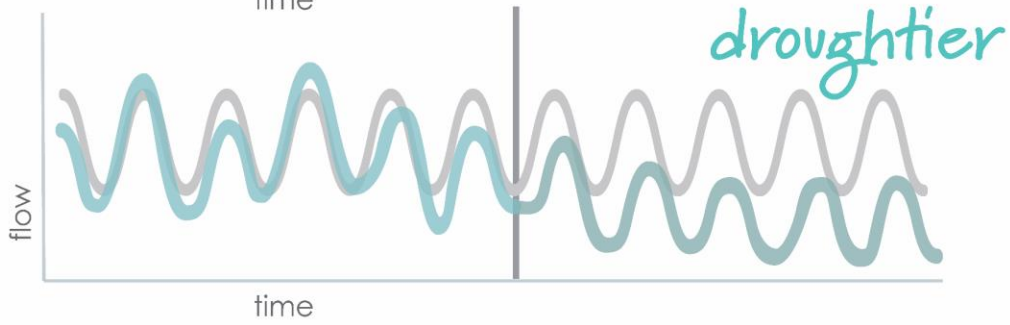
jared smith WMA

tanja williamson
OH-KY-IN WSC









FLOW MODELS

- MACHINE LEARNING MODELS TO PREDICT MONTHLY FLOWS 1980-2020 AT ALL NHDV2 REACHES
- OUTPUTS ARE MONTHLY MINIMUM, MEAN, MAXIMUM FLOW
- FORECAST MONTHLY FLOWS WITH FUTURE SCENARIOS 2021-2100

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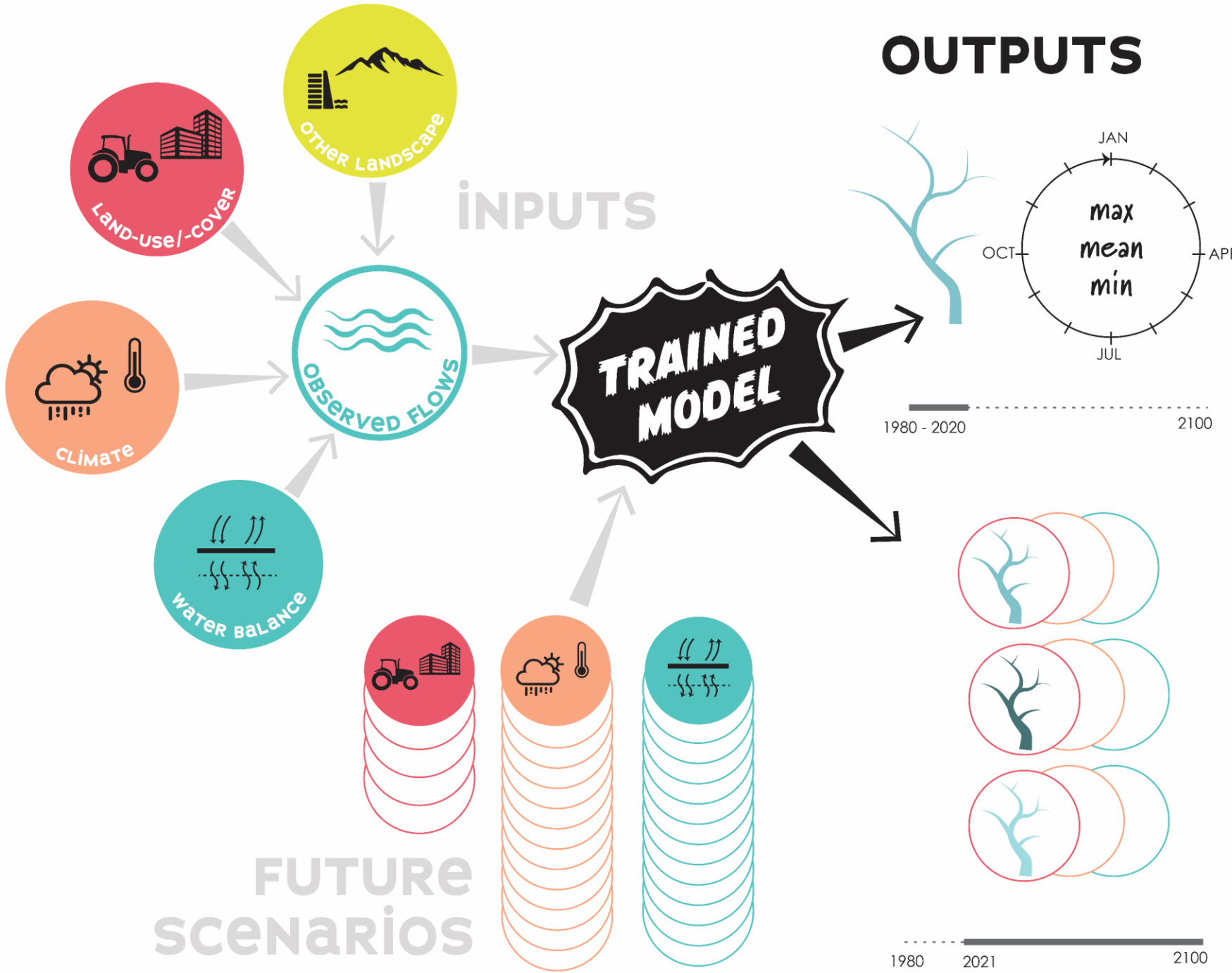
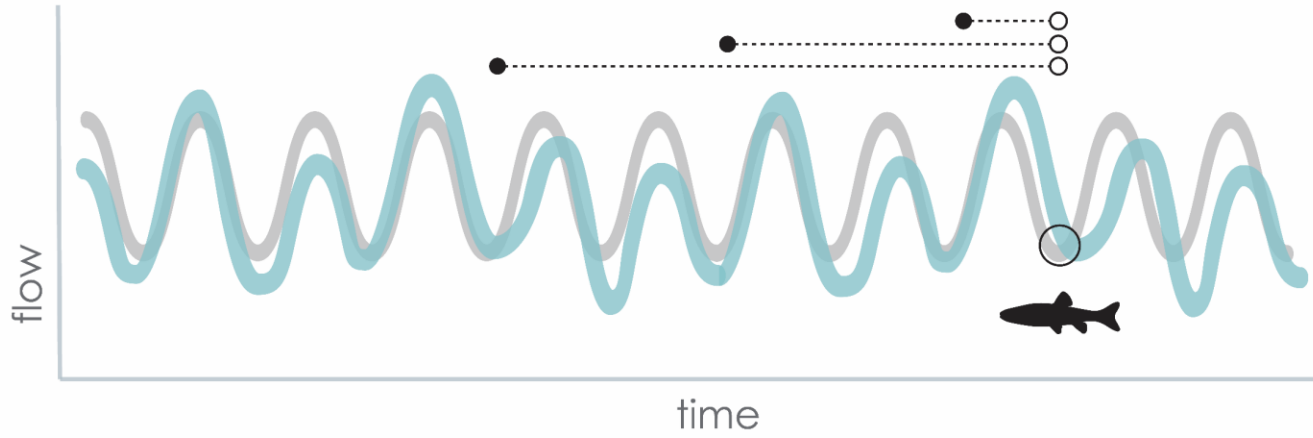
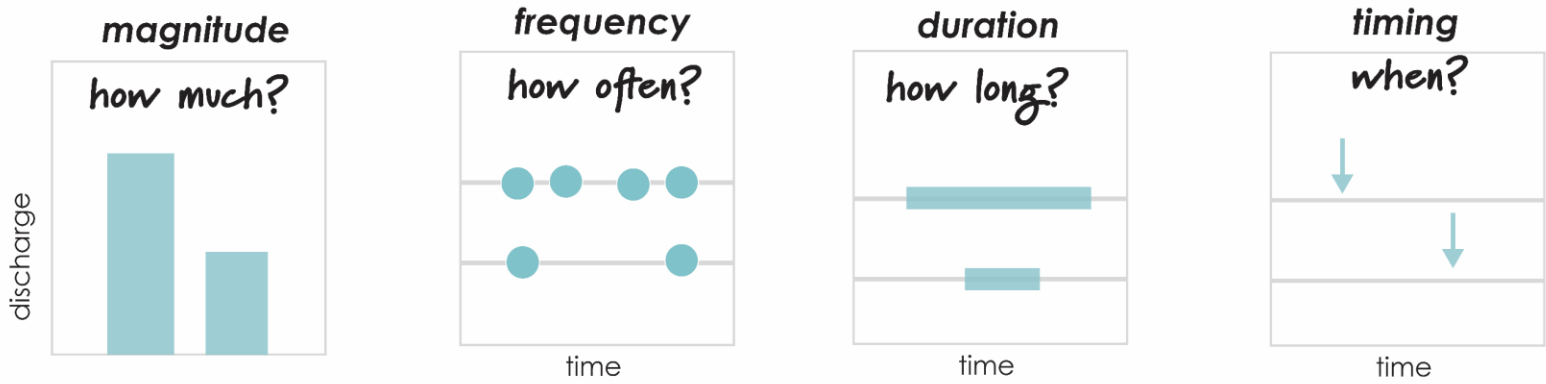


FLOW MODELS

- AGGREGATE MONTHLY FLOWS TO CHARACTERIZE FLOW REGIME COMPONENTS
- MONTHLY OUTPUT ALLOWS FOR DYNAMIC, RATHER THAN STATIC LONG-TERM, FLOW METRICS





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Next steps

- Identify thresholds in ecological responses to flow
- Pair thresholds with flow forecasts to assess future vulnerability

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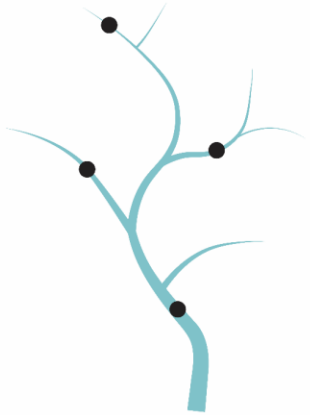
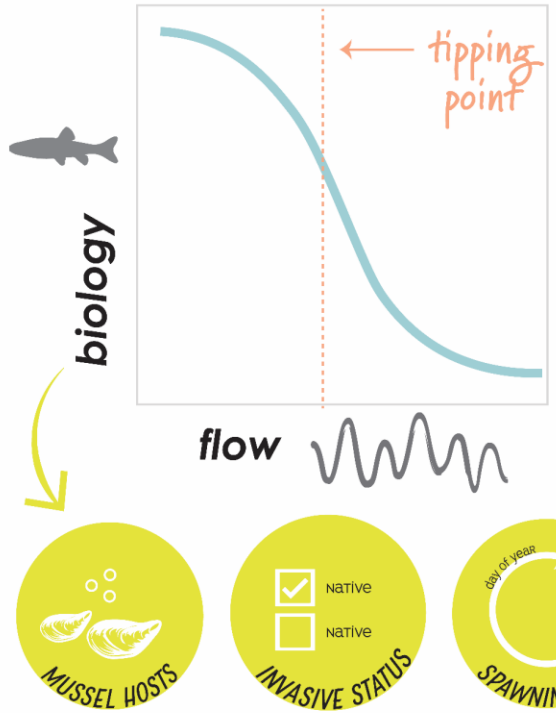


1

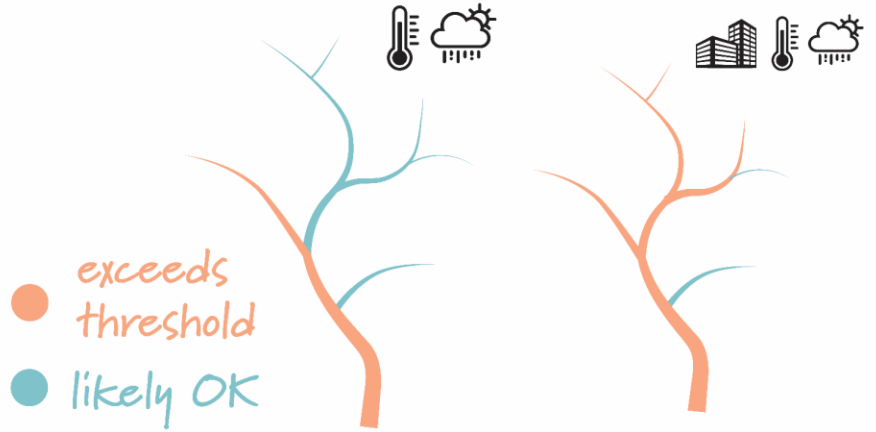
reference fish samples to contemporary flow predictions



2

determine thresholds in fish responses to flow

endpoints informed by partner needs



VULNERABILITY INDEX

3

use forecasts to identify vulnerable streams as those where future flow may surpass ecological thresholds

Lessons (so far...)

DIVERSE NEEDS

OTHER STRESSORS

MODEL INPUTS

INTERDISCIPLINARY TEAMS

THANK YOU!!!!

ecosystems mission area
large landscape
coordinators

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project team

Anna Kaz, Sean Emmons, Ken Eng, Jared Smith, Matt Cashman, Timothy Counihan, Mary Freeman, Benjamin Gressler, Joshua Hubbell, Kelly Maloney, James McKenna Jr., Daniel Wieferich, Tanja Williamson, Robert Zuellig, Mike Wieczorek

partners

Confederated Tribes of the Umatila Indian Reservation, CO Parks & Wildlife, Great Lakes Indian Fish & Wildlife Commission, NY Department of Environmental Conservation, US Fish & Wildlife Service, Chesapeake Bay Program Working Groups, Interstate Commission for the Potomac River Basin, Susquehanna River Basin Commission, EPA Region 3 Regional Tribal Organization Committee, Geological Survey of AL, AL Department of Environmental Management, Black Warrior Riverkeeper