Assessment of fish habitat in the Chesapeake Bay watershed

Kelly O. Maloney, Kevin P. Krause, Benjamin Gressler, & John A. Young (EESC)
Matthew J. Cashman (MD/DE/DC WSC)
Wesley Daniel (WARC)
Daniel Wieferich (SAS)
CBP FHAT 06 April 2022

USGS

Objectives

Report on assessment of fish habitat condition for all non-tidal reaches in the Chesapeake Bay watershed

Get feedback and thoughts on web interface tool to present results

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journal homepage: www.elsevier.com/locate/ecolind

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Original Articles

Using fish community and population indicators to assess the biological condition of streams and rivers of the Chesapeake Bay watershed, USA

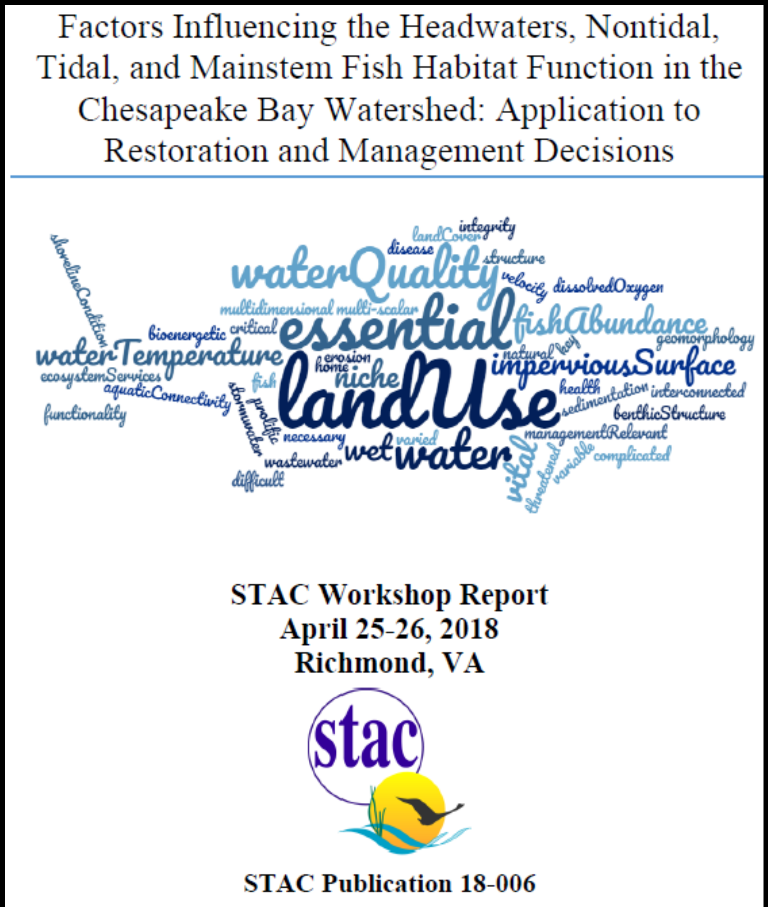
Kelly O. Maloney [a,1,*], Kevin P. Krause [a,1], Matthew J. Cashman [b], Wesley M. Daniel [c], Benjamin P. Gressler [a], Daniel J. Wieferich [d], John A. Young [a]

https://doi.org/10.1016/j.ecolind.2021.108488

History of Assessment Project

FHAT needed an assessment of fish habitat for the watershed

- Recognized national efforts (NFHP) were limited
- More relevant information is available for the watershed
- USGS/NOAA inventoried available data and developed concepts
- 2018 Workshop presented ideas and gather feedback



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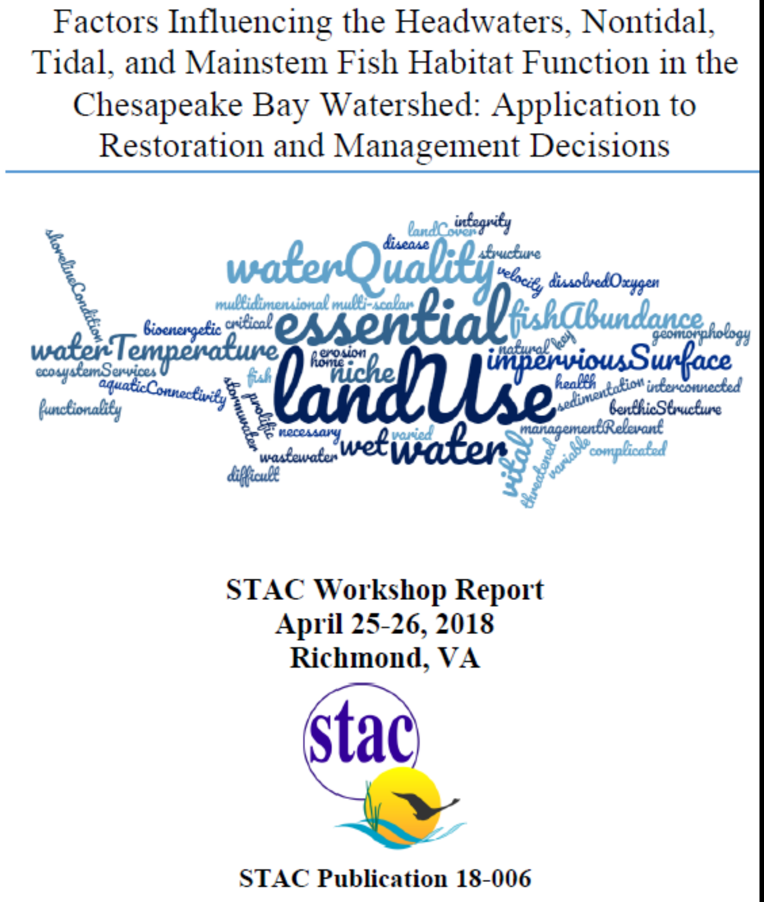
History of Assessment Project

Critical recommendations from 2018 Workshop

- Eventual assessment a fine spatial scale (1:24,000 map scale)
- Data gathering (2018-2019)
- Outreach and Training (2018-present)
- Assessment metrics (2021)
- Pilot assessment (Patuxent 2022-2023)
- Research (communicate research needs)


Factors Influencing the Headwaters, Nontidal, Tidal, and Mainstem Fish Habitat Function in the Chesapeake Bay Watershed: Application to Restoration and Management Decisions

STAC Workshop Report
April 25-26, 2018
Richmond, VA

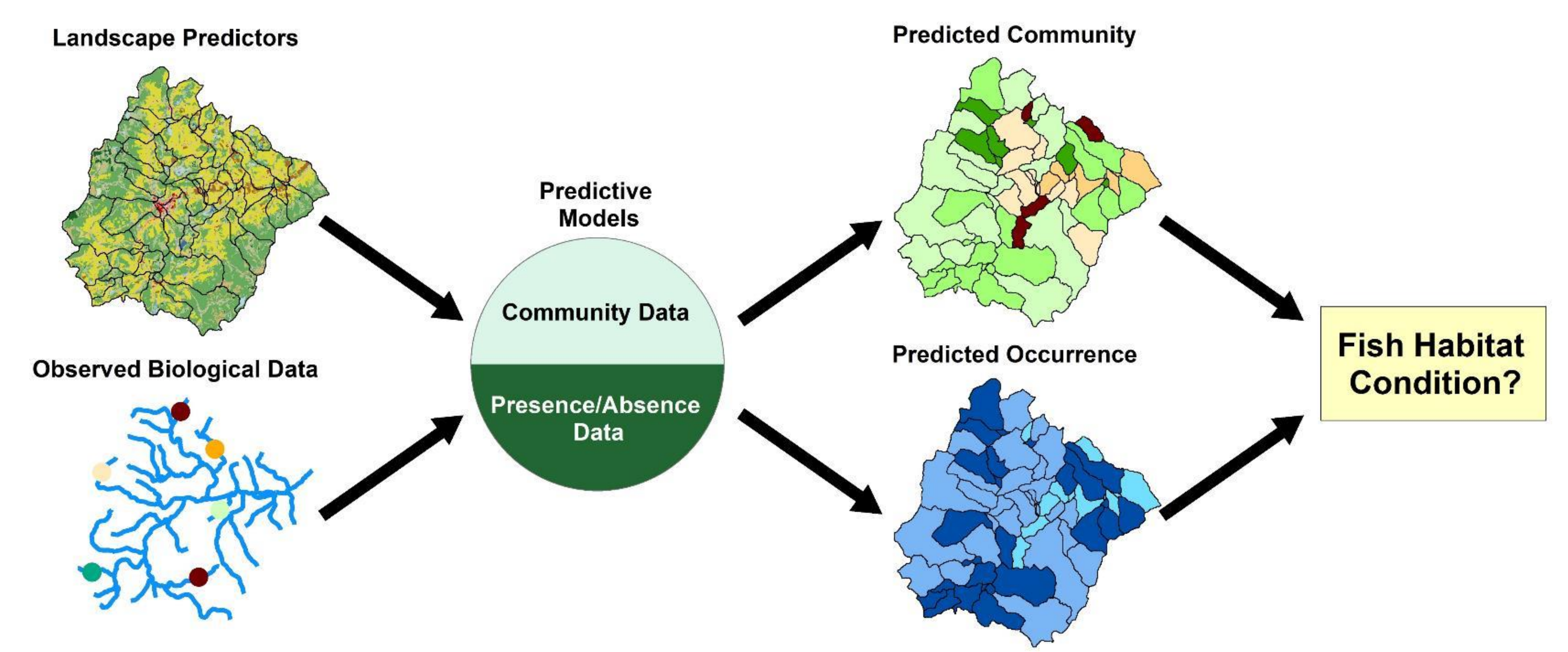
stac

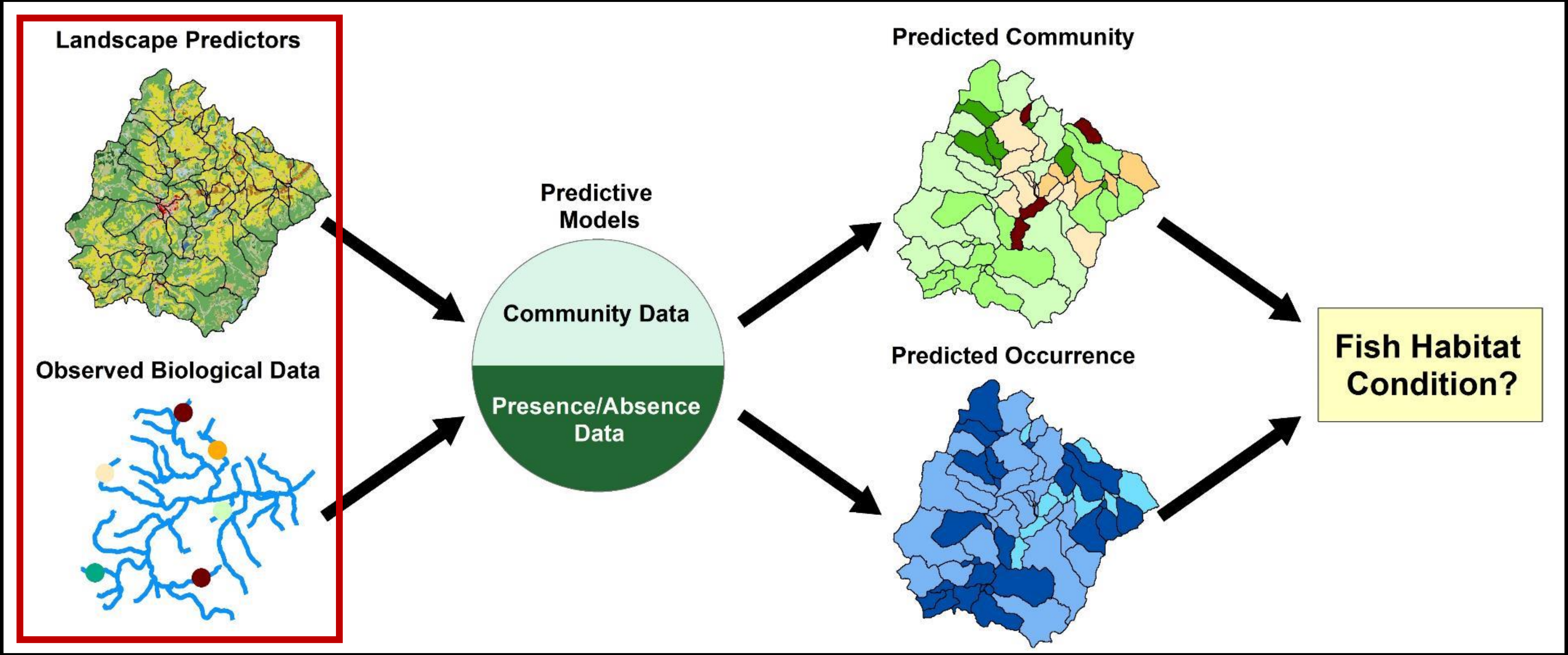
STAC Publication 18-006

Non-tidal Assessment: Two main approaches

	Community		Species
Measure	Metrics often rolled into multimetric indices		Key species or set of species
Breadth	Represents community - richness, diversity, abundance and functional aspects		Single or few species
Strength	Useful for overall condition		Detailed insight into key species
Weakness	Limited insight into individual species		Limited evaluation of overall condition

Non-tidal Assessment: Integrated approach

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Fish Habitat Condition?

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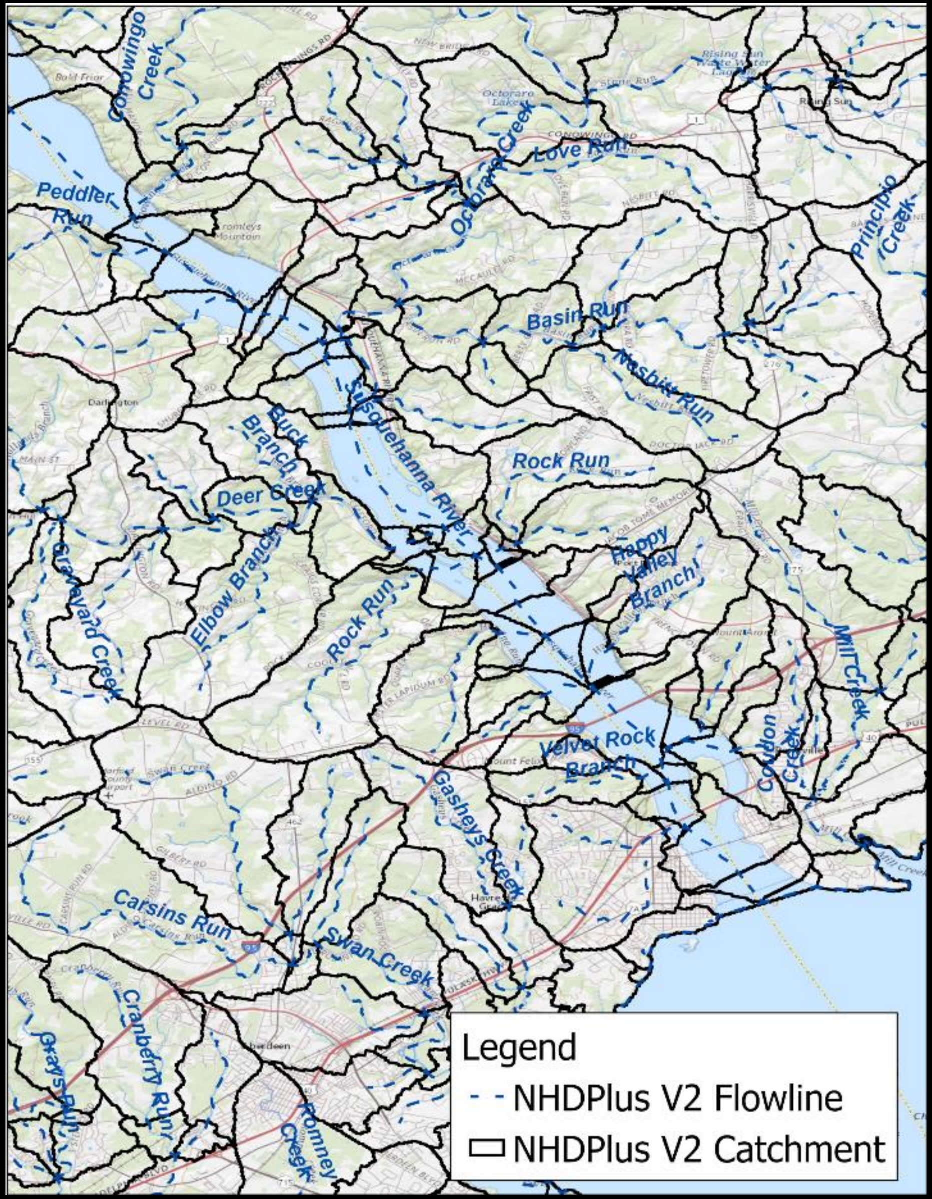
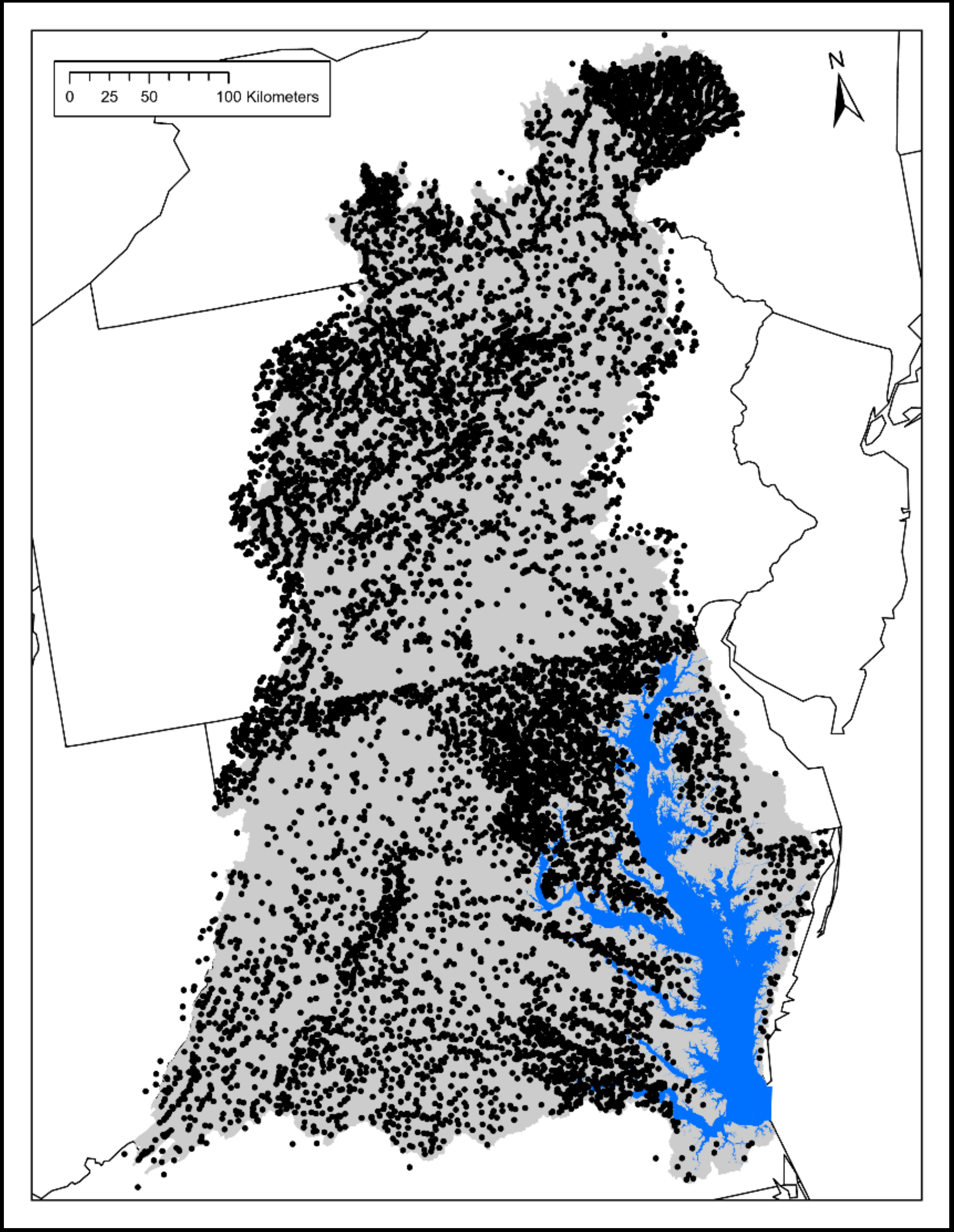
Data

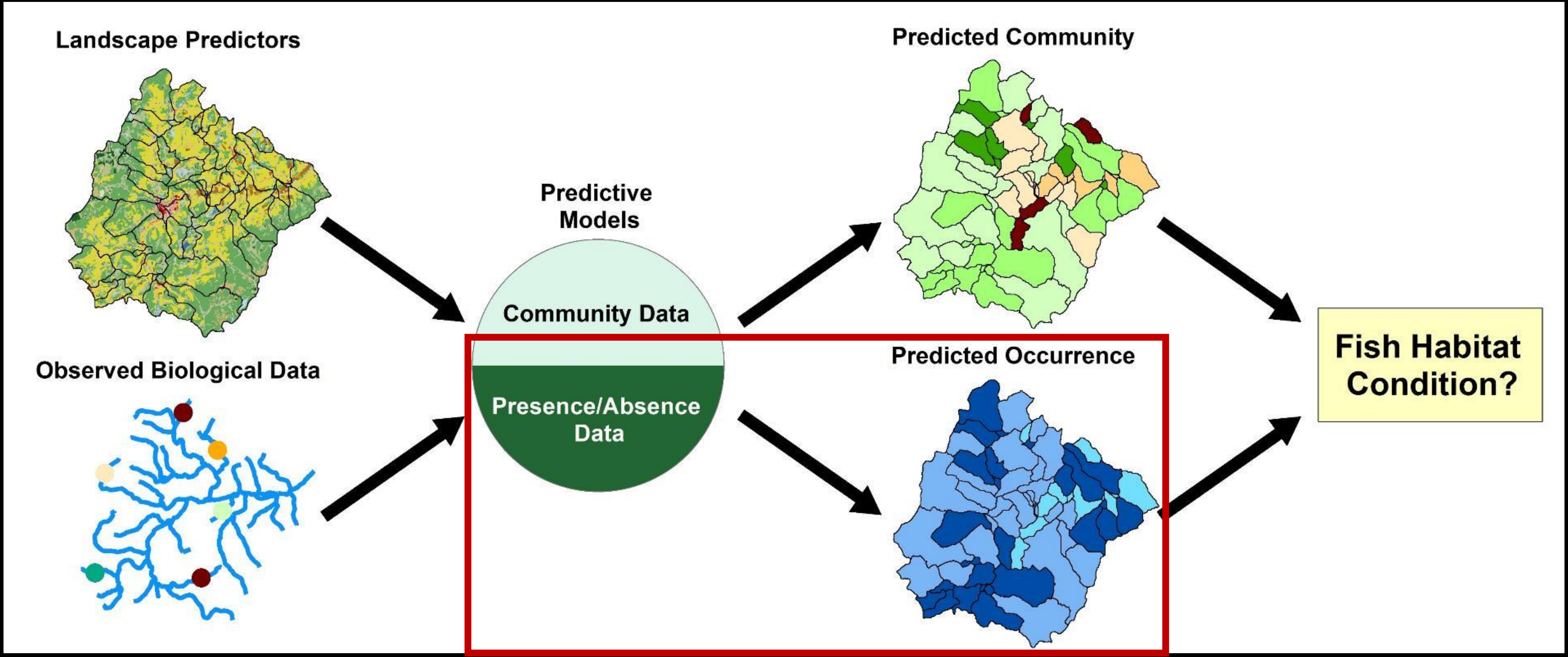
- 56 uncorrelated landscape predictors (upstream accumulated)
  - LULC, climate, topography, geology, soils, human impact
  - From US EPA StreamCat (Hill et al. 2016) and USGS NAWQA (Wieczorek et al. 2018)
- 1:100,000 map scale (NHDPlus v2.1)
  - Next move to 1:24,000 as data become available



Non-Tidal Fish Database

- Over 20 separate data sources/sampling programs
- Over 30,000 sampling events
- Summary metrics used by NRSA (EPA, 2020), NFHP (2016), and others of interest calculated for Community samples (Krause and Maloney 2021)
- Spatially linked samples to NHDPlus V2.1 where appropriate (Krause et al. 2021)

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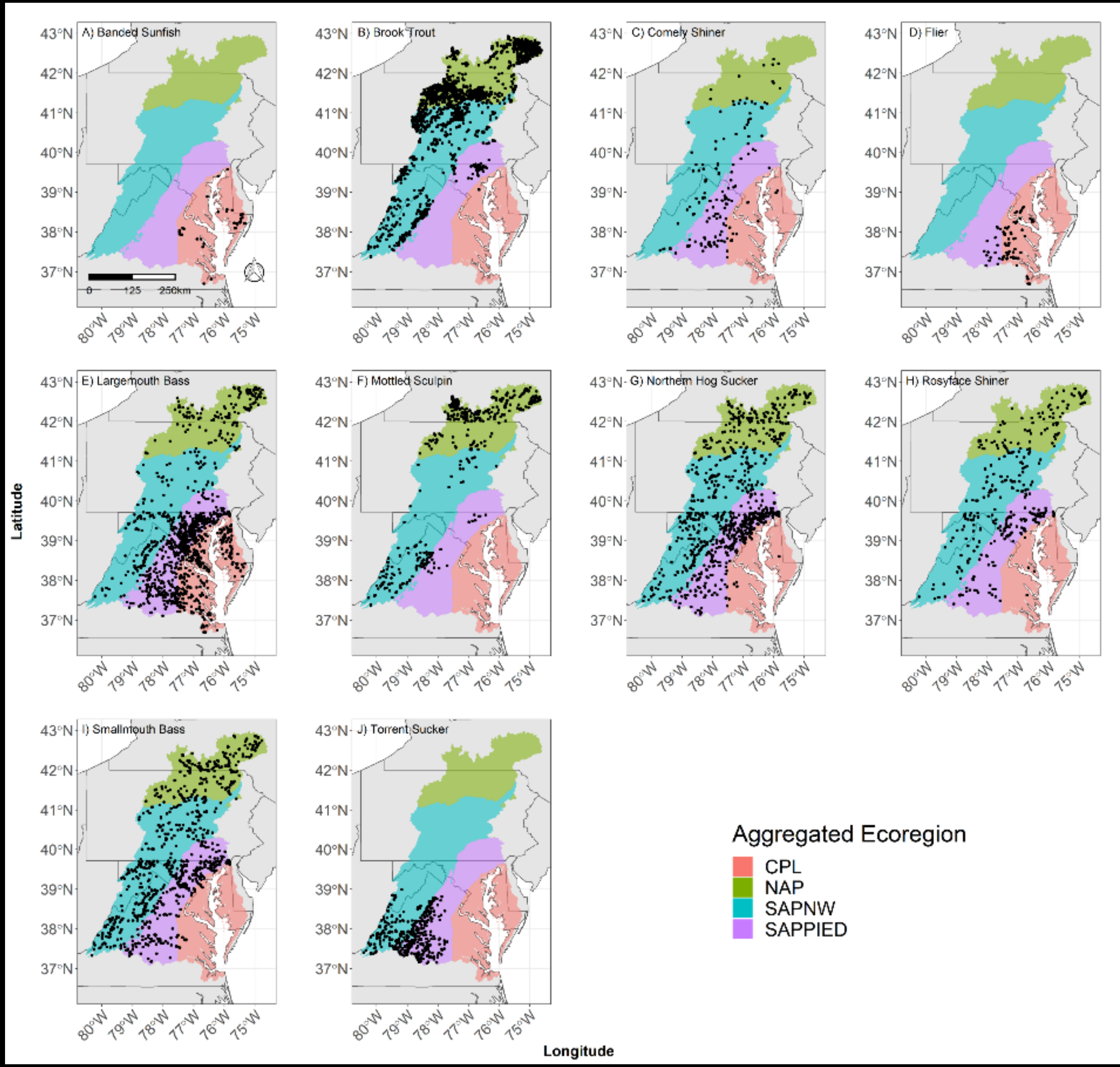
Methods - Species

- Examined species if:
  - > 100 occurrences
  - USEPA identified as sensitive or were gamefish of interest
- Random forest models built for each species
- Modeling extent set by native range and habitat size
- Models for species selected if:
  - Kappa and TSS >0.40 (training and test)
  - Specificity and sensitivity >0.70 (training and test)



Results – 4 Species met all criteria

Brook Trout
(*Salvelinus fontinalis*)

Kevin P. Krause

Kappa	Sens.	Spec.	TSS
0.85	**0.91**	**0.94**	**0.86**

Northern Hog Sucker
(*Hypentelium nigricans*)

Brian Gratwicke (commons.wikimedia.org) ©

Kappa	Sens.	Spec.	TSS
0.58	**0.80**	**0.81**	**0.61**

Smallmouth Bass
(*Micropterus dolomieu*)

U.S. Fish and Wildlife Service

Kappa	Sens.	Spec.	TSS
0.71	**0.74**	**0.94**	**0.68**

Torrent Sucker
(*Thoburnia rhothoeca*)

U.S. Fish and Wildlife Service

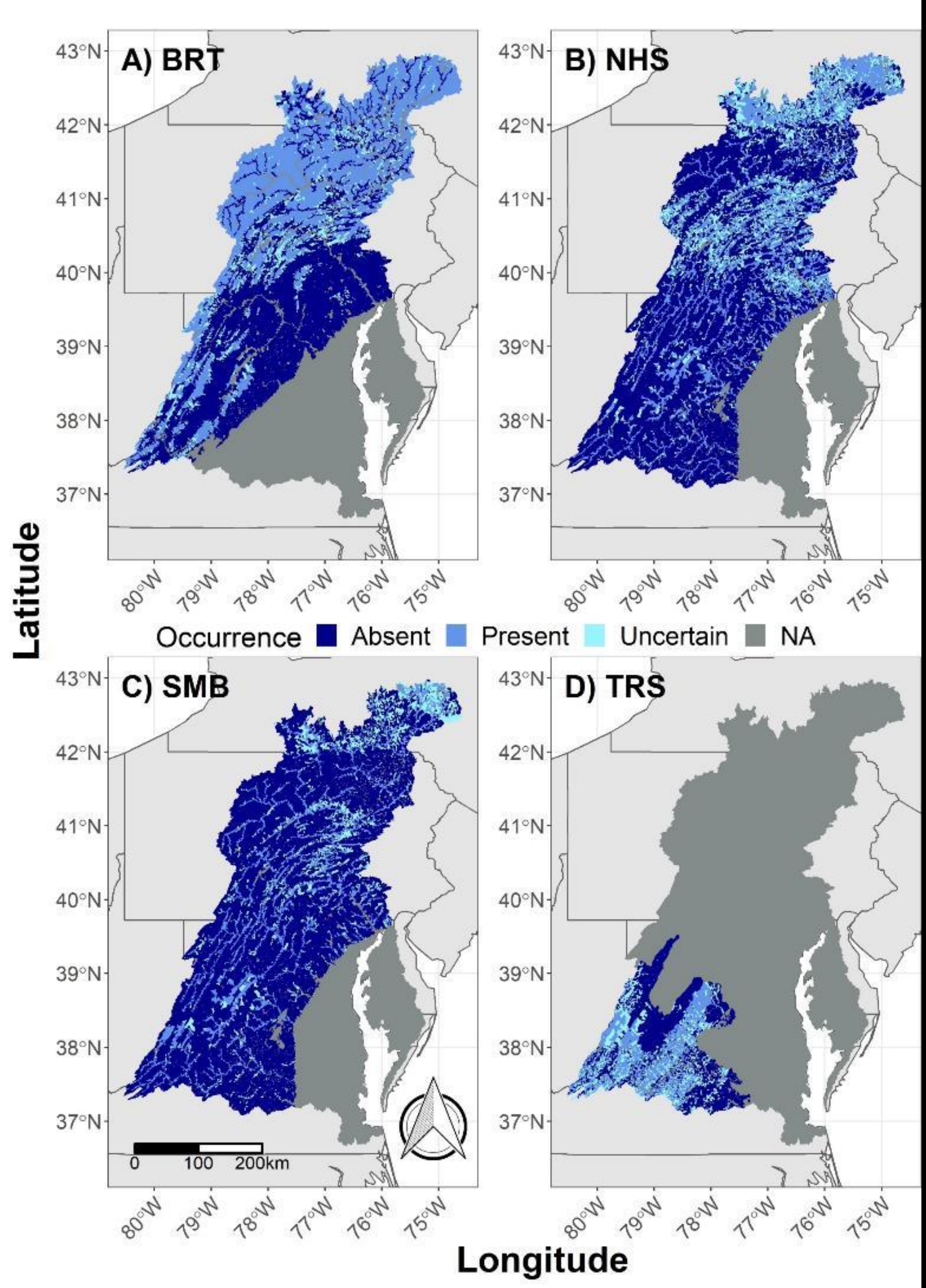
Kappa	Sens.	Spec.	TSS
0.54	**0.82**	**0.72**	**0.54**

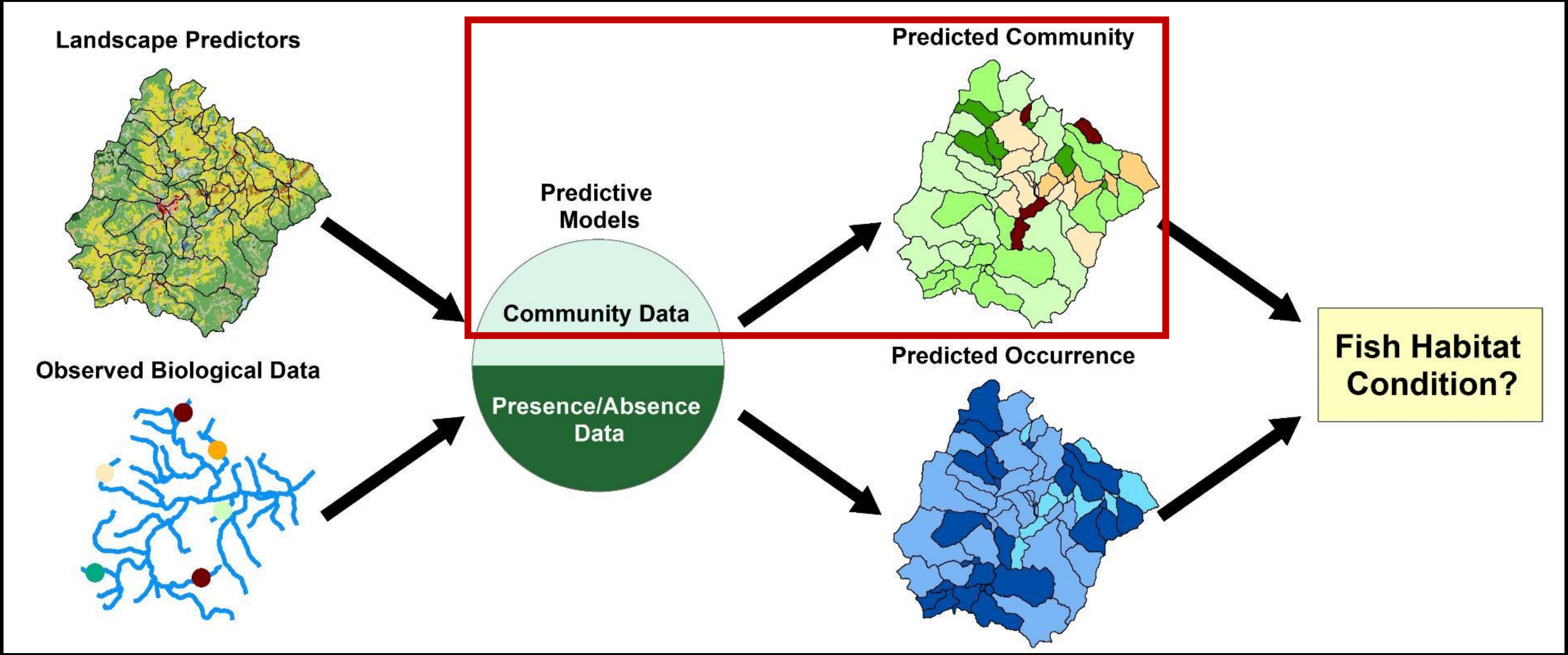
Predicted probability of occurrence (present, absent, uncertain) to unsurveyed reaches (2001, 2006, 2011, 2016)

USGS

Results – Species (2016 only)

- Brook Trout (BRT) predicted to smaller systems in the NAP and SAPNW
- Northern Hog Sucker (NHS) predicted for most stream sizes in CBW except CPL
- Smallmouth Bass (SMB) - predicted for small to large rivers in CBW except CPL
- Torrent Sucker (TRS) – predicted for smaller habitats in HUC8 in the southwest portion

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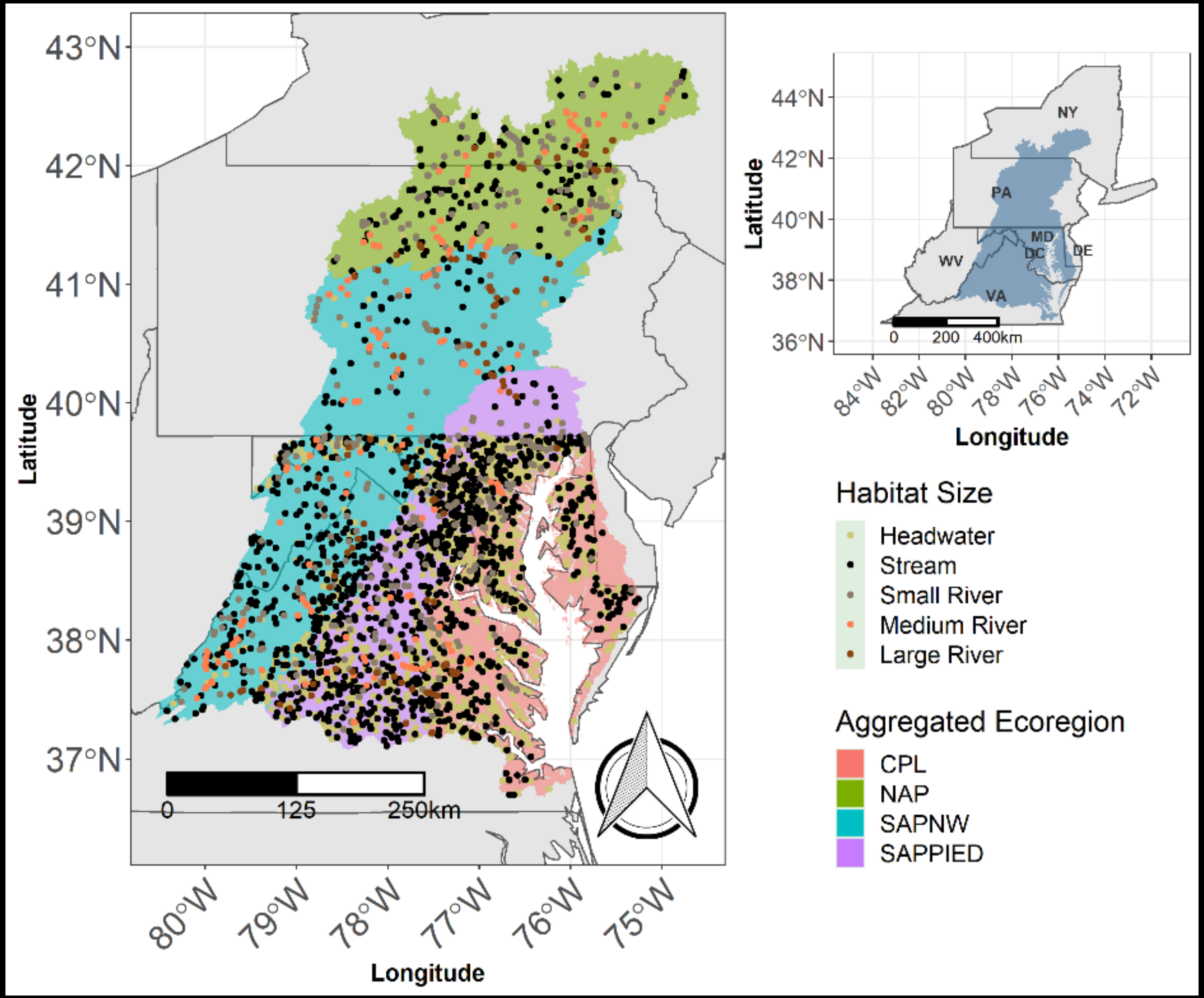
Fish Habitat Condition?

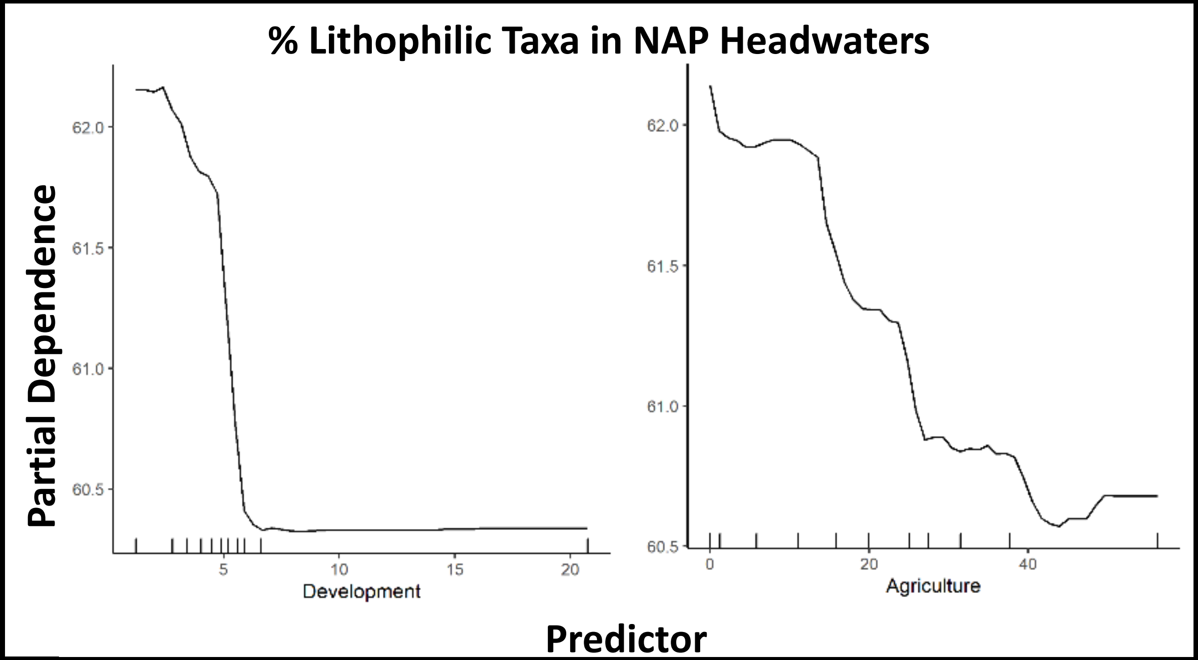
Methods - Community

- Separate analyses by aggregated ecoregion
- Evaluated > 200 metrics
- Unable to develop MMI
- Random forest models built for metrics with sufficient range and variability (screening criteria used by USEPA 2020)



Methods - Community

- Separate analyses by aggregated ecoregion
- Evaluated > 200 metrics
- Unable to develop MMI
- Random forest models built for metrics with sufficient range and variability (screening criteria used by USEPA 2020)
- Selected metrics for ecoregion if:
    - Metric was uncorrelated
    - Model had $R^2 > 0.40$ (training and test)
    - Relationships with development and agriculture were "uni-directional"
- Predicted metrics to unsurveyed reaches (based on 2001, 2006, 2011, 2016 LULC)



Results - Community

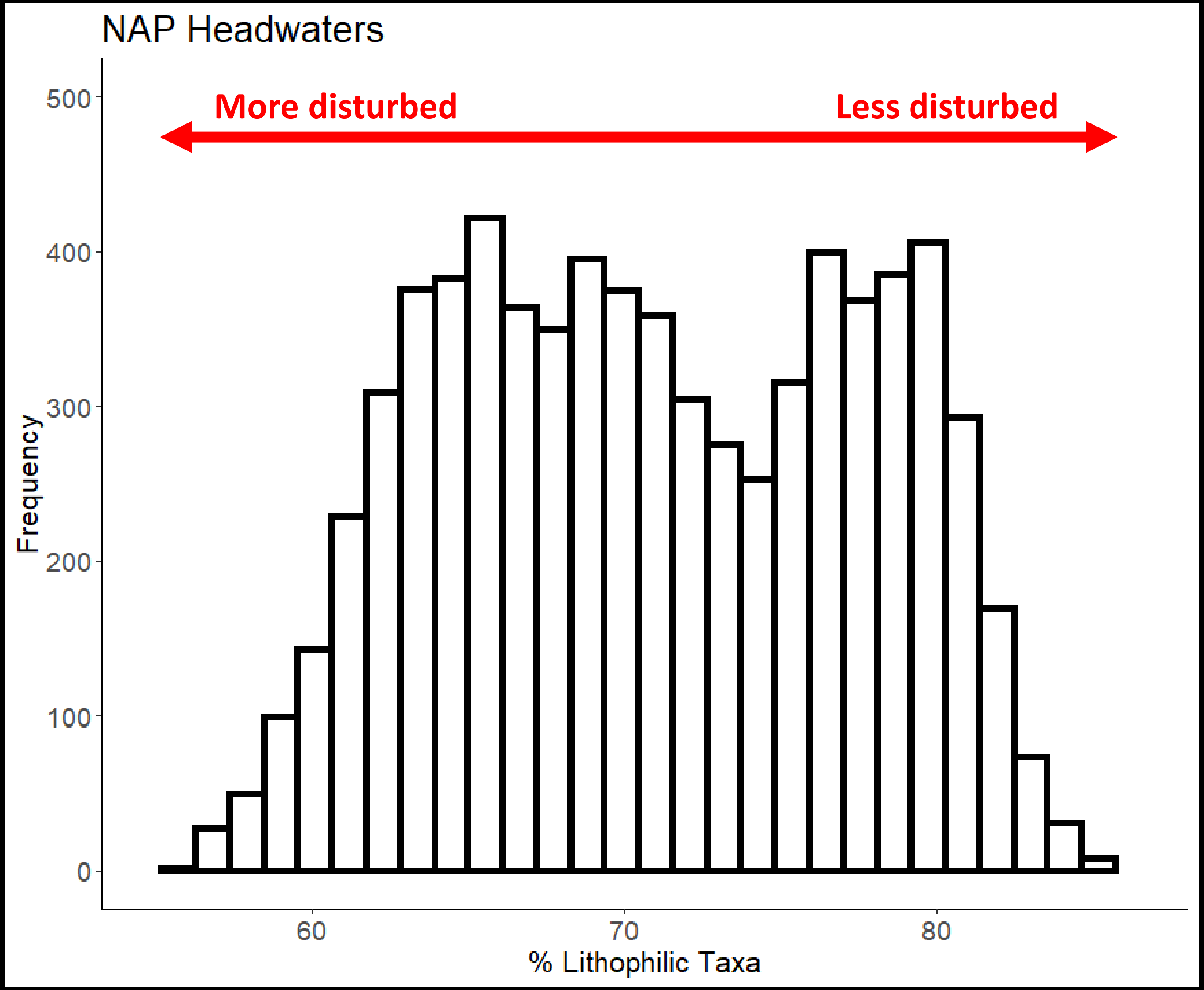
7 metrics in SAPNW, 3 in SAPPIED, 5 in CPL, and 14 in NAP

Region	Metric description	Train n	Num. ind. vars.	R2 (OOB)	Test n	R2 Test	Pattern with Development	Pattern with Agriculture
SAPNW	Number of intolerant lotic taxa	585	47	0.48	147	0.52	↓ to →	↓ to →
	Number of distinct intolerant taxa	585	47	0.48	147	0.52	↓ to →	↓ to →
	Number of native Cyprinidae taxa	585	47	0.49	147	0.53	↑ to →	↑
	% native taxa as intolerant lotic	585	47	0.41	147	0.42	↓ to →	↓ to →
	% Intolerant native taxa	585	47	0.41	147	0.42	↓ to →	↓ to →
	% native taxa as intolerant rheophilic	585	47	0.45	147	0.43	↓ to →	↓ to →
	Number of distinct Tolerant taxa	585	47	0.62	147	0.61	↑	↑
SAPPIED	% large river taxa	1108	51	0.52	278	0.54	rapid ↑ to → to ↓ at extremes	rapid ↑ then slow ↓
	Number of native rheophilic taxa	1108	51	0.52	278	0.53	↑	↑
	Number of distinct Tolerant native taxa	1108	51	0.49	278	0.49	rapid ↓ to ↑	↑
CPL	Number of lithophilic taxa	687	49	0.53	172	0.60	↑	↑
	Number of lotic taxa	687	49	0.46	172	0.56	↑	↑
	Number of native benthic invertivore taxa	687	49	0.43	172	0.41	↑	↑
	Number of native Cyprinidae taxa	687	49	0.53	172	0.63	↑	rapid ↓ then ↑
	Number of distinct Tolerant taxa	687	49	0.41	172	0.51	↑	↑

Region	Metric description	Train n	Num. ind. vars.	R2 (OOB)	Test n	R2 Test	Pattern with Development	Pattern with Agriculture
NAP	Number of Cyprinidae taxa	252	44	0.43	63	0.56	↑	↑
	% lithophilic taxa	252	44	0.46	63	0.53	↓	↓
	% large river taxa	252	44	0.73	63	0.74	↑	↑
	Number of native benthic invertivore taxa	252	44	0.51	63	0.58	↑	↑
	% native individuals as Centrarchidae	252	44	0.55	63	0.47	↑	↑
	% native individuals as coldwater	252	44	0.72	63	0.56	↓	↓ to → to ↑ at extremes
	% native individuals as intolerant rheophilic	252	44	0.47	63	0.43	↓	↓
	Number of native invertivores taxa	252	44	0.44	63	0.57	↑	↑
	Number of native lotic taxa	252	44	0.50	63	0.57	↑	↑
	Number of native non-tolerant benthic taxa	252	44	0.48	63	0.64	↑	↑
	% native individuals as rheophilic	252	44	0.45	63	0.56	↓	↓ to slight ↑ to ↓
	% native taxa as rheophilic	252	44	0.57	63	0.60	↓	↓
	% native taxa as salmonid	252	44	0.65	63	0.81	↓ to → to light ↑	↓ to → to ↑ at extremes
	Number of distinct Tolerant taxa	252	44	0.48	63	0.53	↑	↑

Methods - Community

- Unable to develop MMI
- Developed different method:
  - Metric relationship with development and agriculture
  - Binned each metric into deciles (within habitat size class)
    - <10th decile = lowest metric values
    - >90th decile = highest metric values



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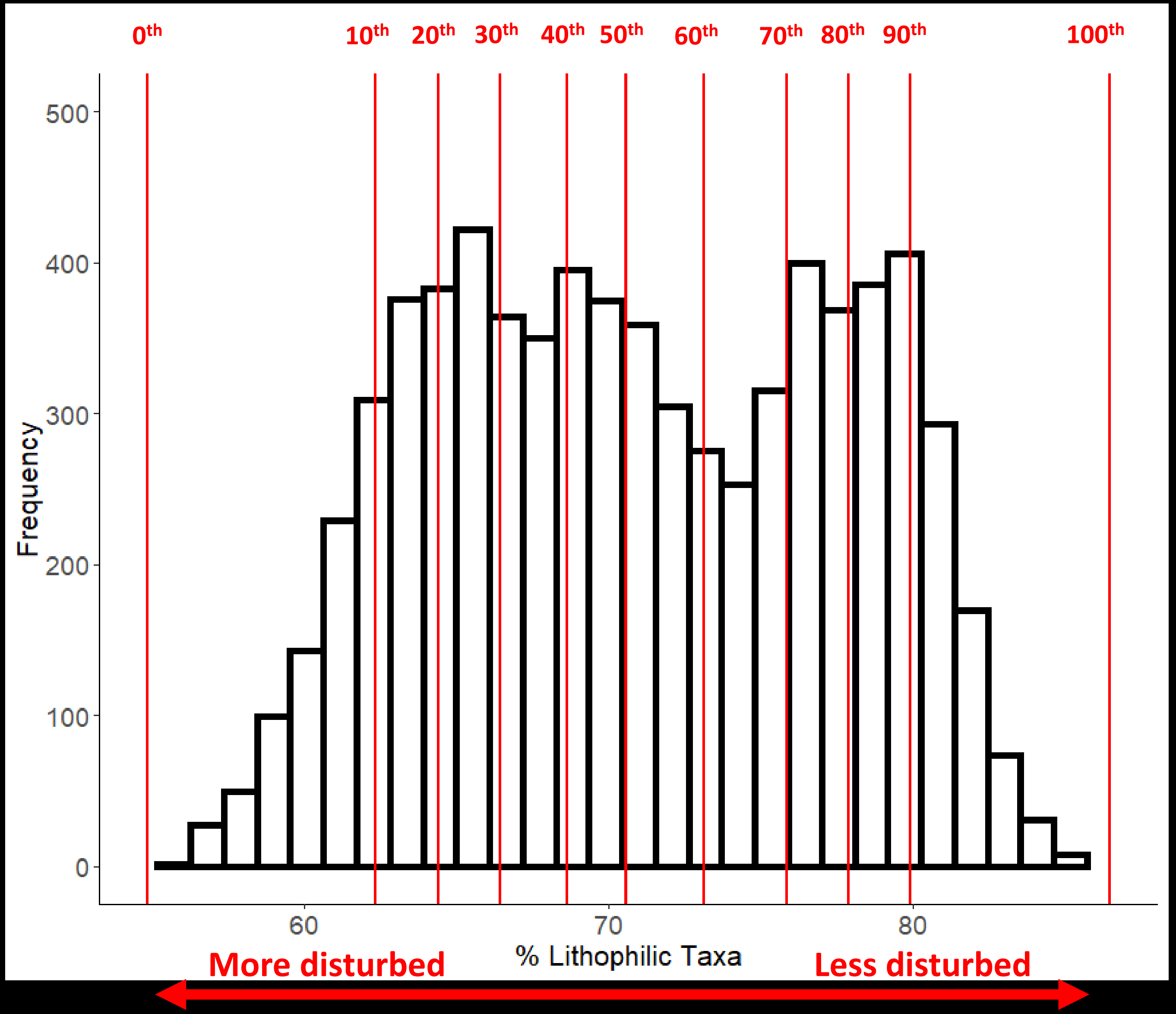


Methods - Community

- Unable to develop MMI
- Developed different method:
  - Metric relationship with development and agriculture
  - Binned each metric into deciles (within habitat size class)
    - <10th decile = lowest metric values
    - >90th decile = highest metric values
  - Calculate mean of decile scores across suitable metrics
    - Used as condition indicator

Lower mean deciles = poorer relative condition

Higher mean deciles = better relative condition

Reach mean metric decile = 40th-50th

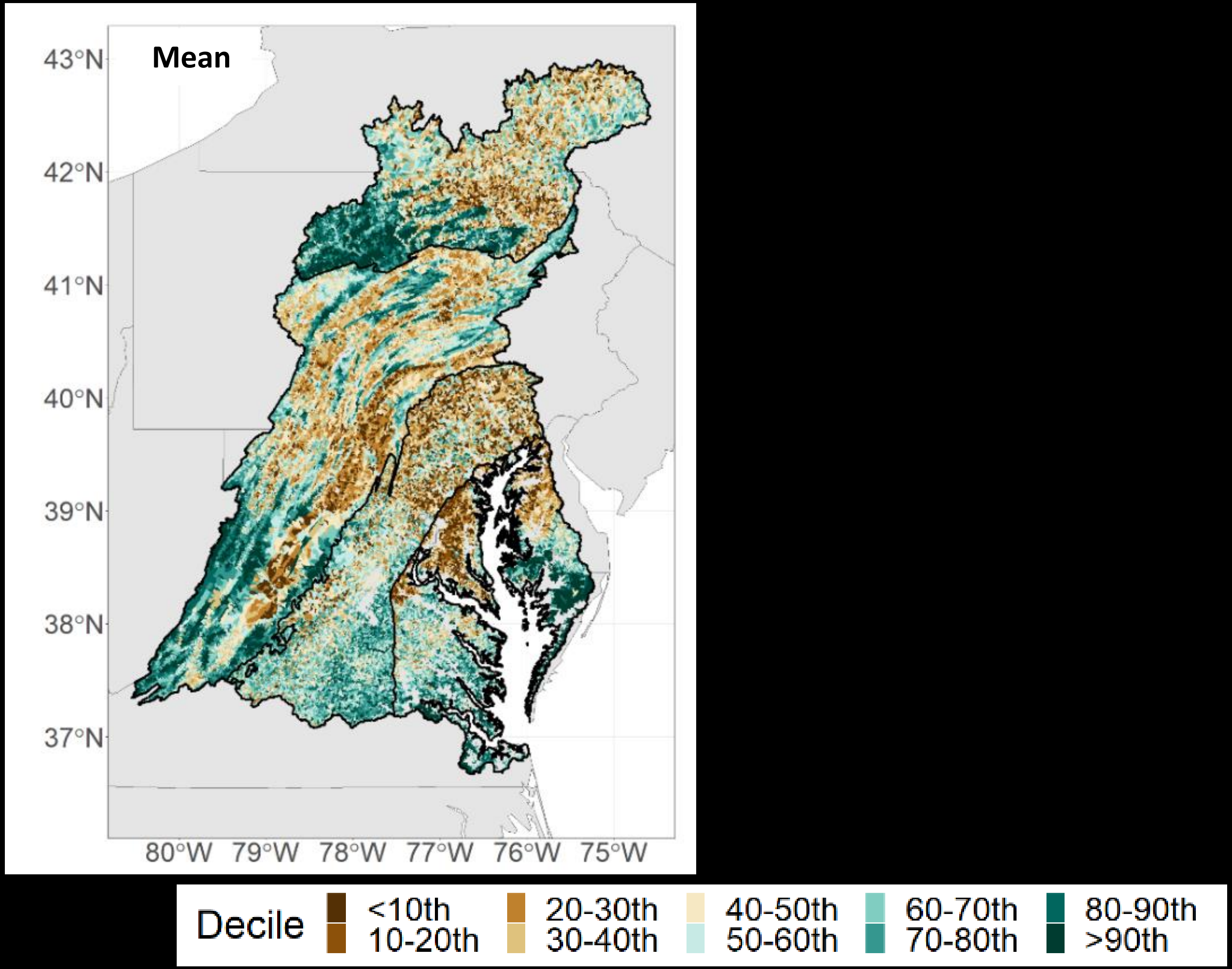
Region	Metric description	Decile	Decile position
NAP	Number of Cyprinidae taxa	20th – 30th	3
	% lithophilic taxa	40th – 50th	5
	% large river taxa	20th – 30th	3
	Number of native benthic invertivore taxa	20th – 30th	3
	% native individuals as Centrarchidae	60th – 70th	7
	% native individuals as coldwater	70th – 80th	8
	% native individuals as intolerant rheophilic	40th – 50th	5
	Number of native invertivores taxa	50th – 60th	6
	Number of native lotic taxa	50th – 60th	6
	Number of native non-tolerant benthic taxa	40th – 50th	5
	% native individuals as rheophilic	50th – 60th	6
	% native taxa as rheophilic	40th – 50th	5
	% native taxa as salmonid	40th – 50th	5
	Number of distinct Tolerant taxa	70th – 80th	8

Results – Community (2016 only)

Mean of metric deciles for each aggregated ecoregion

Lower deciles = poorer relative condition

Higher deciles = better relative condition



Results – Community (2016 only)

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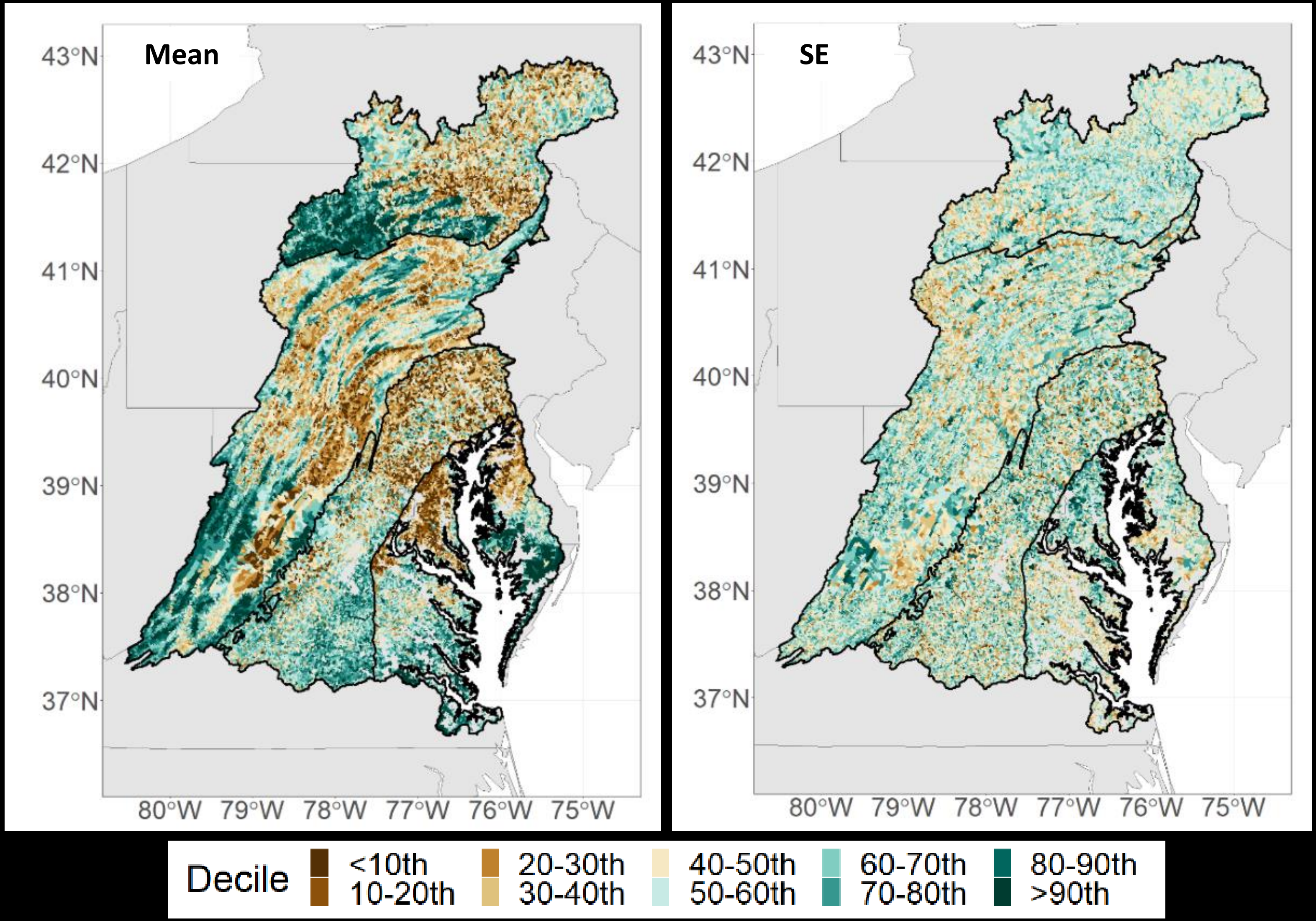


Mean standard error of metric deciles for each aggregated ecoregion

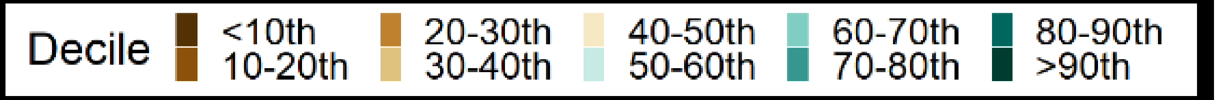
Lower deciles = lower SE

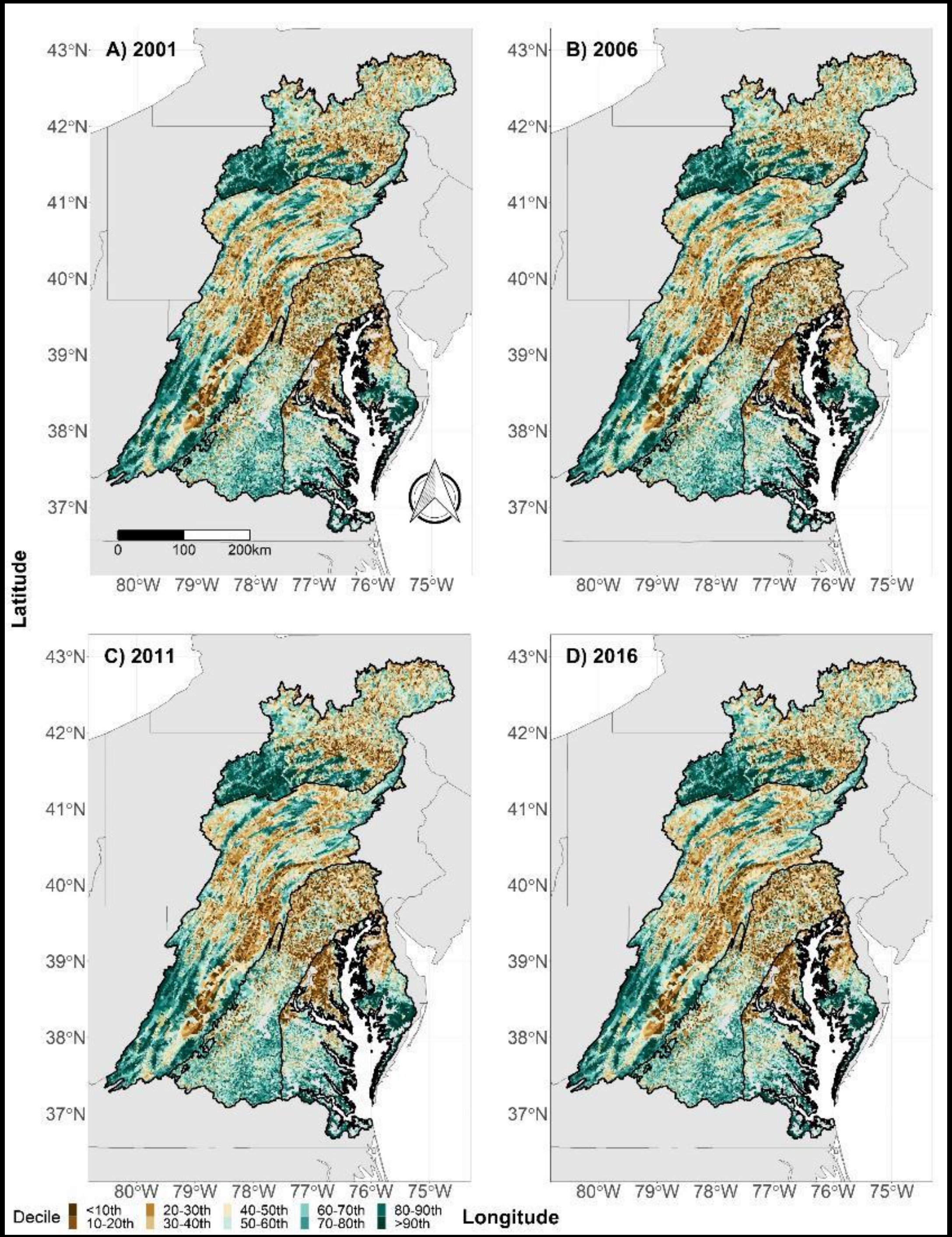
Higher deciles = higher SE

Results – Community (4 years)

Have predicted values and uncertainty (SEs) for 4 periods where NLCD were available

Allows a change between periods analysis

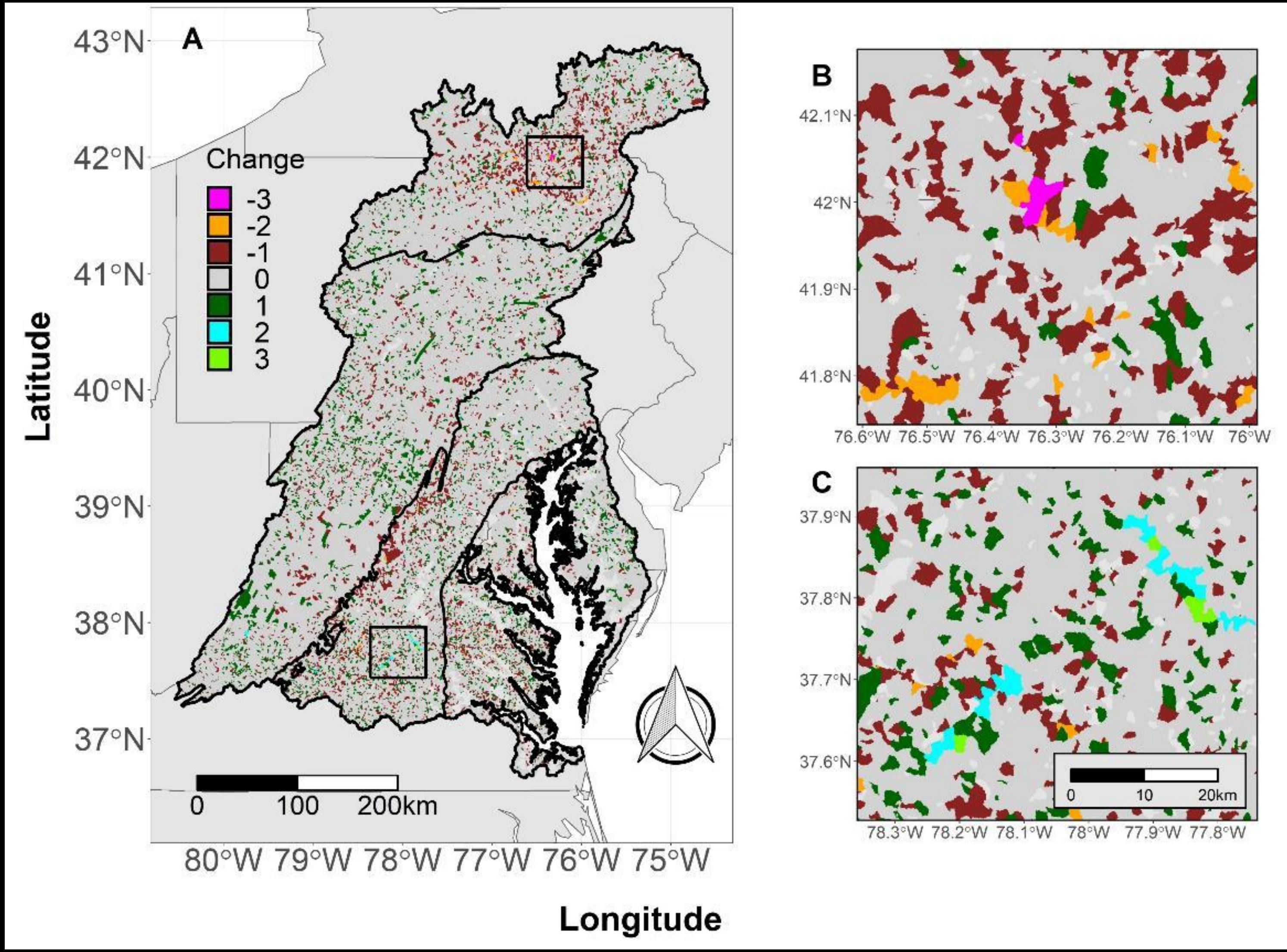


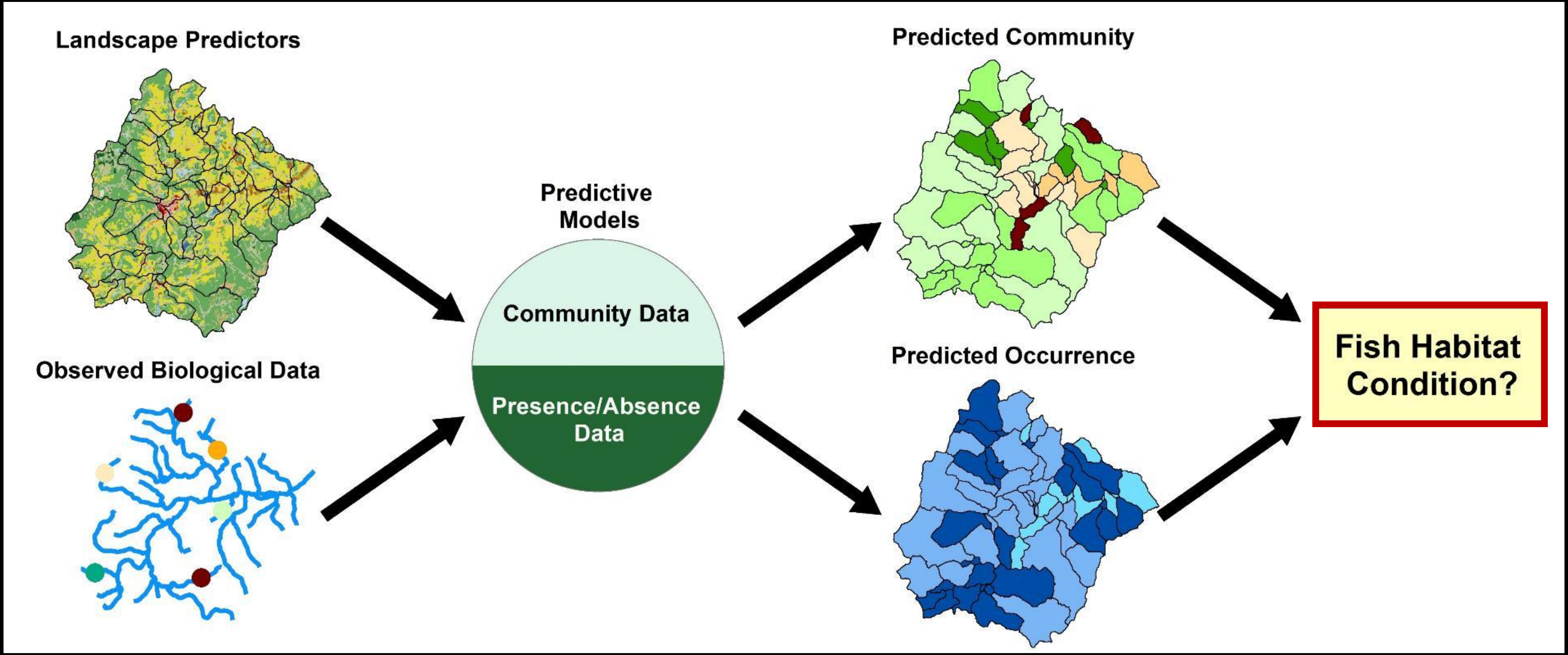


Results - Community

Change 2001 to 2016:

- When displayed spatially results can be used to identify locations with changes
- Those with a large positive change may be areas that have responded to management actions (future research need)
- Those with large negative changes may be areas requiring better management or restoration

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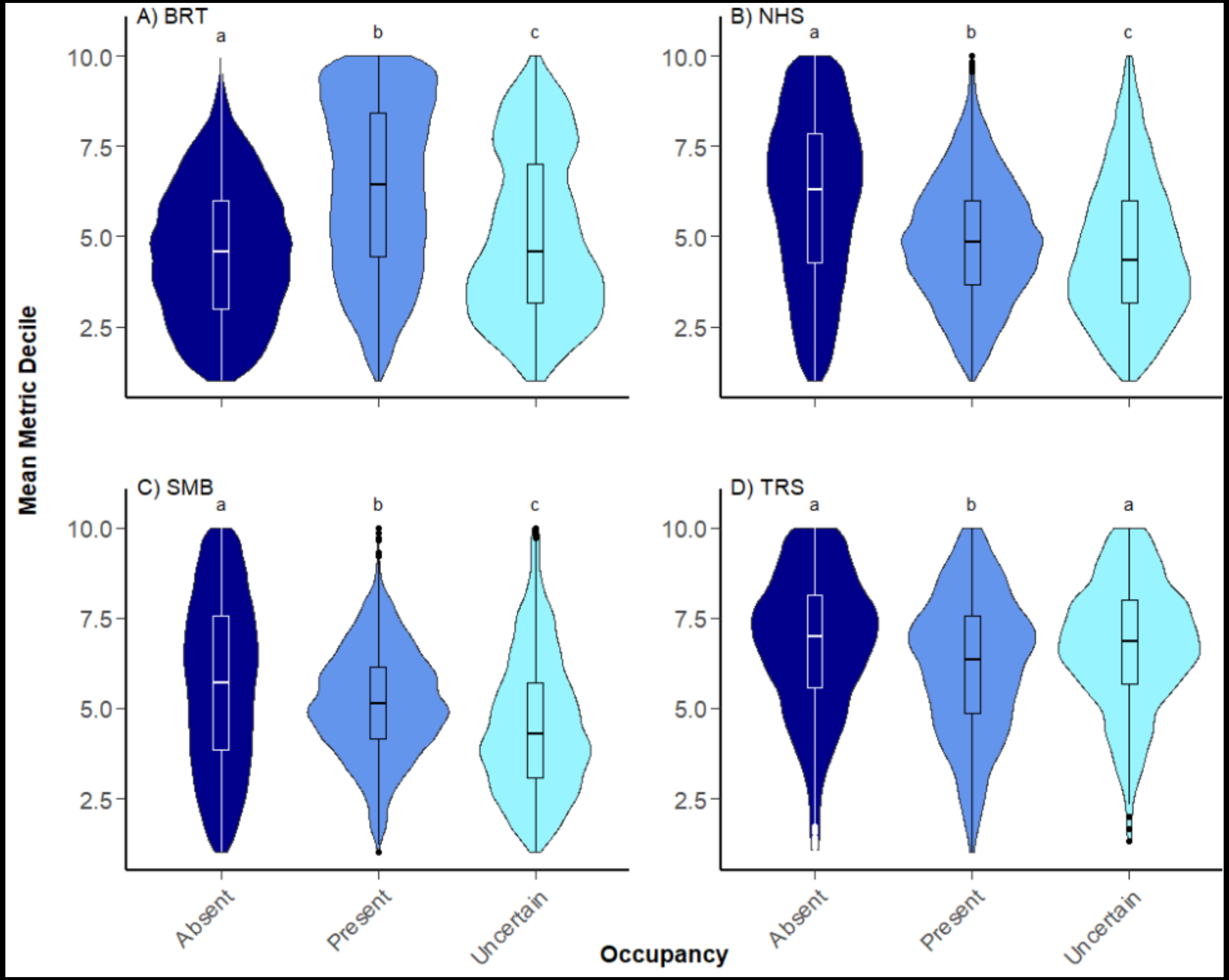
Results – Community vs. Species

- Do community and species predictions align?
  - Expect mean metric decile and sensitive species to align

	Community	Species
Measure	Metrics often rolled into multimetric indices	Key species or set of species
Breadth	Represents community - richness, diversity, abundance and functional aspects	Single or few species
Strength	Useful for overall condition	Detailed insight into key species
Weakness	Limited insight into individual species	Limited evaluation of overall condition

Results – Community vs. Species

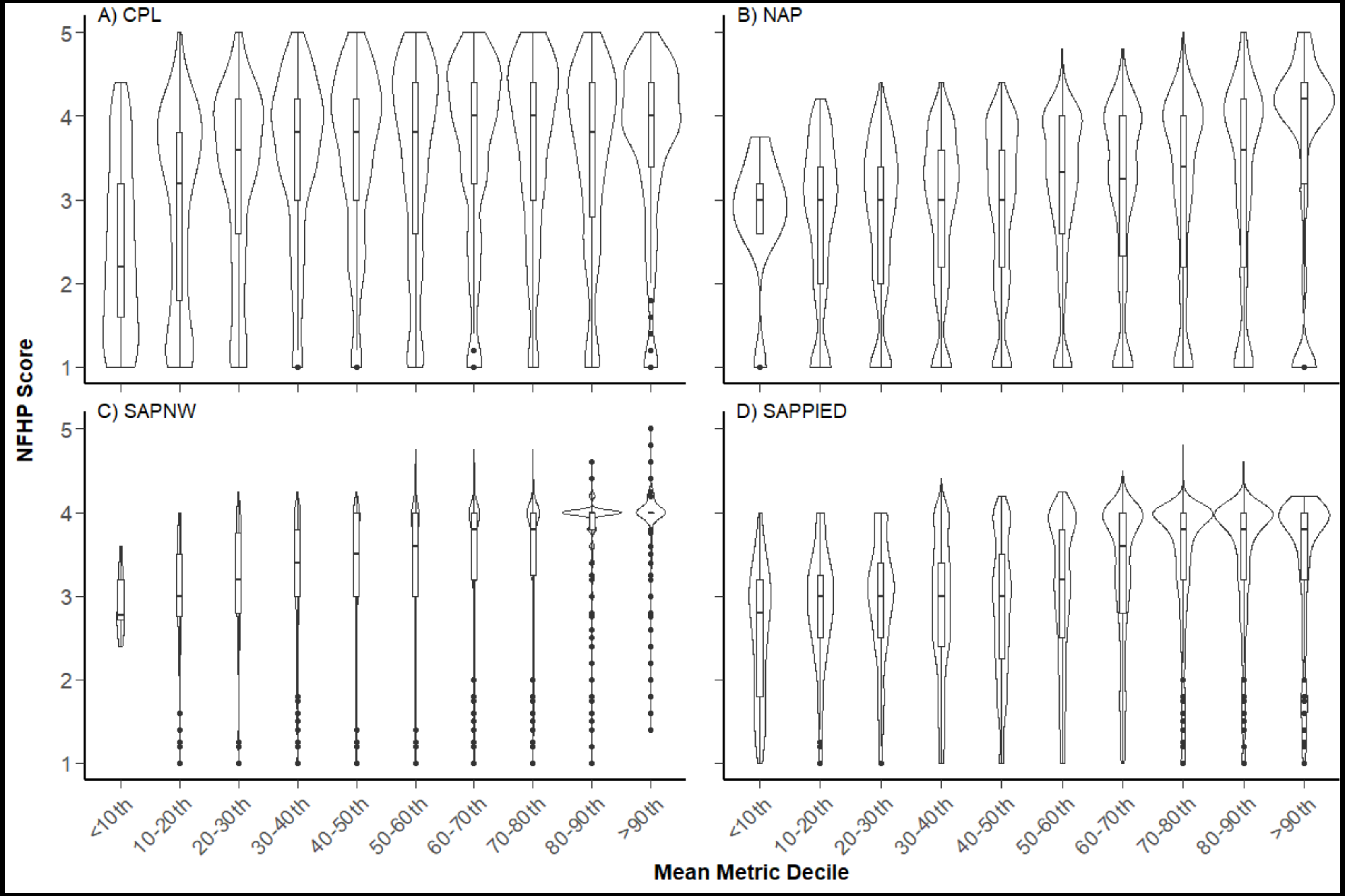
- Do community and species predictions align?
  - Expect mean metric decile and sensitive species to align
- Brook Trout predicted presences were in reaches with a higher mean deciles
- All other three species showed opposite pattern with predicted presences being higher in reaches with lower mean deciles



Comparison to NFHP

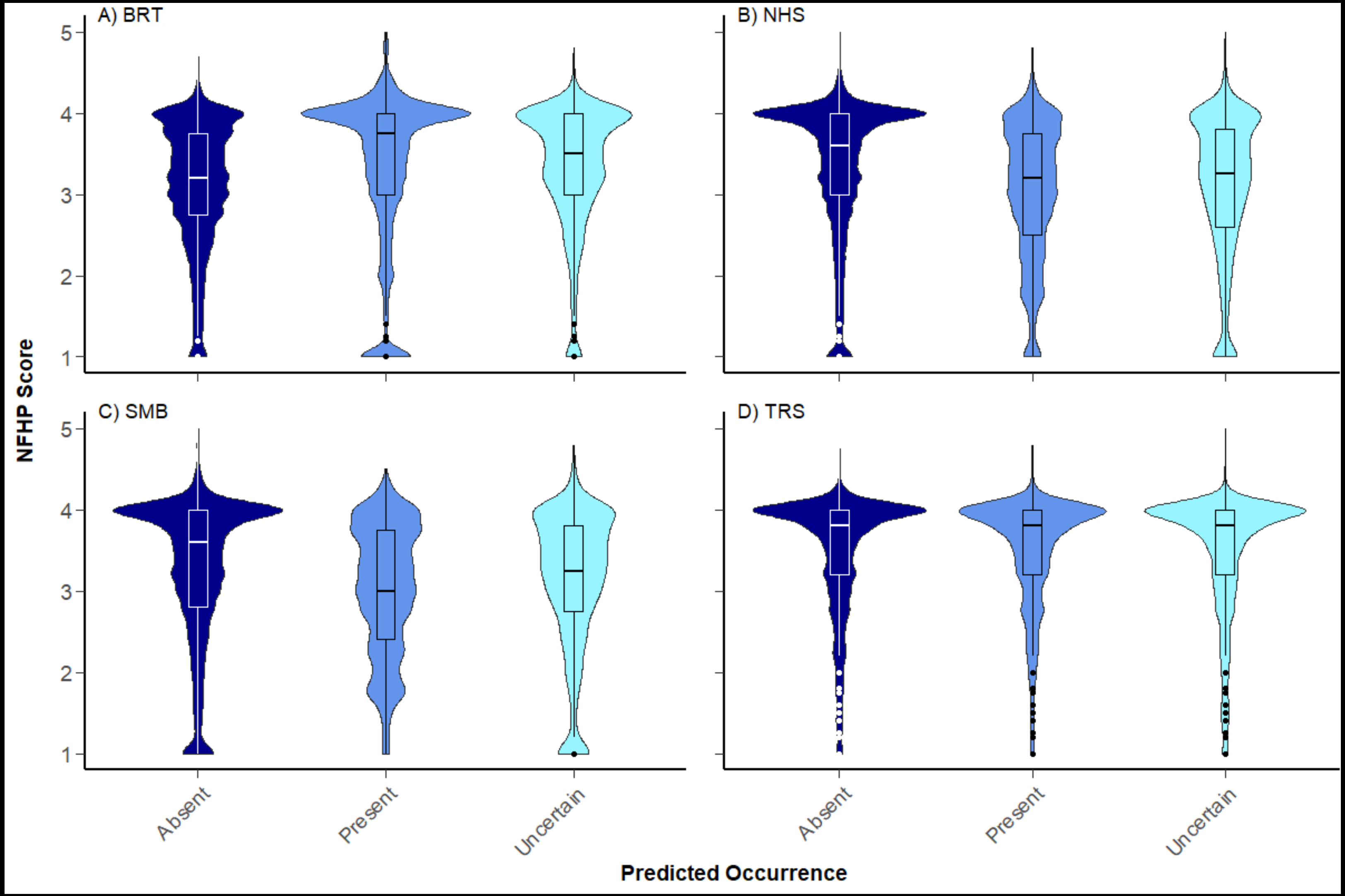
Community vs NFHP

Mean decile and NFHP ratings generally agree but high variability



Species vs NFHP

Brook Trout (BRT) agrees with NFHP, other sensitive species do not, all show high variability



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Summary

- Examined individual species habitat suitability
- Developed approach to identify habitat condition for 4 regions based on community metrics and mean deciles
- Community and species levels agreed for one sensitive species (Brook Trout); other two species may be less sensitive than USEPA suggests
- Using both approaches simultaneously may offer more insight into reach conditions
- Results from both approaches generally agree with the NFHP, but lots of variability was found

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Future Work

- Migrate to a 1:24,000 map scale framework
- Investigate finer resolution land use (e.g., 1 m) and summarization methods (e.g., distance-weighting)
- Incorporate future climate and land use scenarios

USGS

Future Work

- Migrate to a 1:24,000 map scale framework
- Investigate finer resolution land use (e.g., 1 m) and summarization methods (e.g., distance-weighting)
- Incorporate future climate and land use scenarios
- Develop a data visualization web-based application

Request feedback on development of this application to increase usefulness/relevance

Data Visualization

- Static Storymap – only narrative with embedded figures and tables

  [Endocrine Disrupting Compounds in the Chesapeake (arcgis.com)]

- Interactive Dashboard – users can query and select data that figures and tables display

  [EcoSHEDS | USGS]

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Acknowledgements

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- **Thank you to Karen Blocksom (EPA)**
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- New York Department of Environmental Conservation
- Pennsylvania Department of Environmental Protection
- Pennsylvania Fish and Boat Commission
- West Virginia Department of Environmental Protection
- West Virginia Department of Natural Resources
- Maryland Department of the Environment
- Maryland Department of Natural Resources; Resource Assessment Service
- Maryland Department of Natural Resources; Fishing and Boating Services
- Anne Arundel County (MD) Department of Public Works
- Baltimore County (MD) Department of Environmental Protection and Sustainability
- Frederick County (MD) Sustainability and Environmental resources
- Howard County (MD) Storm Water Management Division
- Montgomery County (MD) Department of Environmental Protection
- Virginia Department of Game and Inland Fish
- Virginia Commonwealth University
- Virginia Department of Environmental Quality
- Fairfax County (VA) Department of Public Works & Environmental Sciences
- National Parks Service Shenandoah National Park
- Susquehanna River Basin Commission
- United States Environment Protection Agency
- United States Geological Survey

Thank you!

Contact Information:

Assessment of fish habitat:

Kelly Maloney (kmaloney@usgs.gov)

Kevin Krause (kkrause@usgs.gov)

Data Visualization:

Kelly Maloney (kmaloney@usgs.gov)

Stephanie Gordon (sgordon@usgs.gov)

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Data releases: http://dx.doi.org/10.5066/P9B4BMAG
http://dx.doi.org/10.5066/P9D6JU4X
http://dx.doi.org/10.5066/P9C1PX4P

Science Summary:
Assessing the habitat conditions to support freshwater fisheries in the Chesapeake Watershed | U.S. Geological Survey (usgs.gov)