

A sunset scene over a body of water with a bright sun low on the horizon, creating a reflection on the water. The sky is a deep orange, and the water is a darker blue. In the distance, there are silhouettes of landmasses.

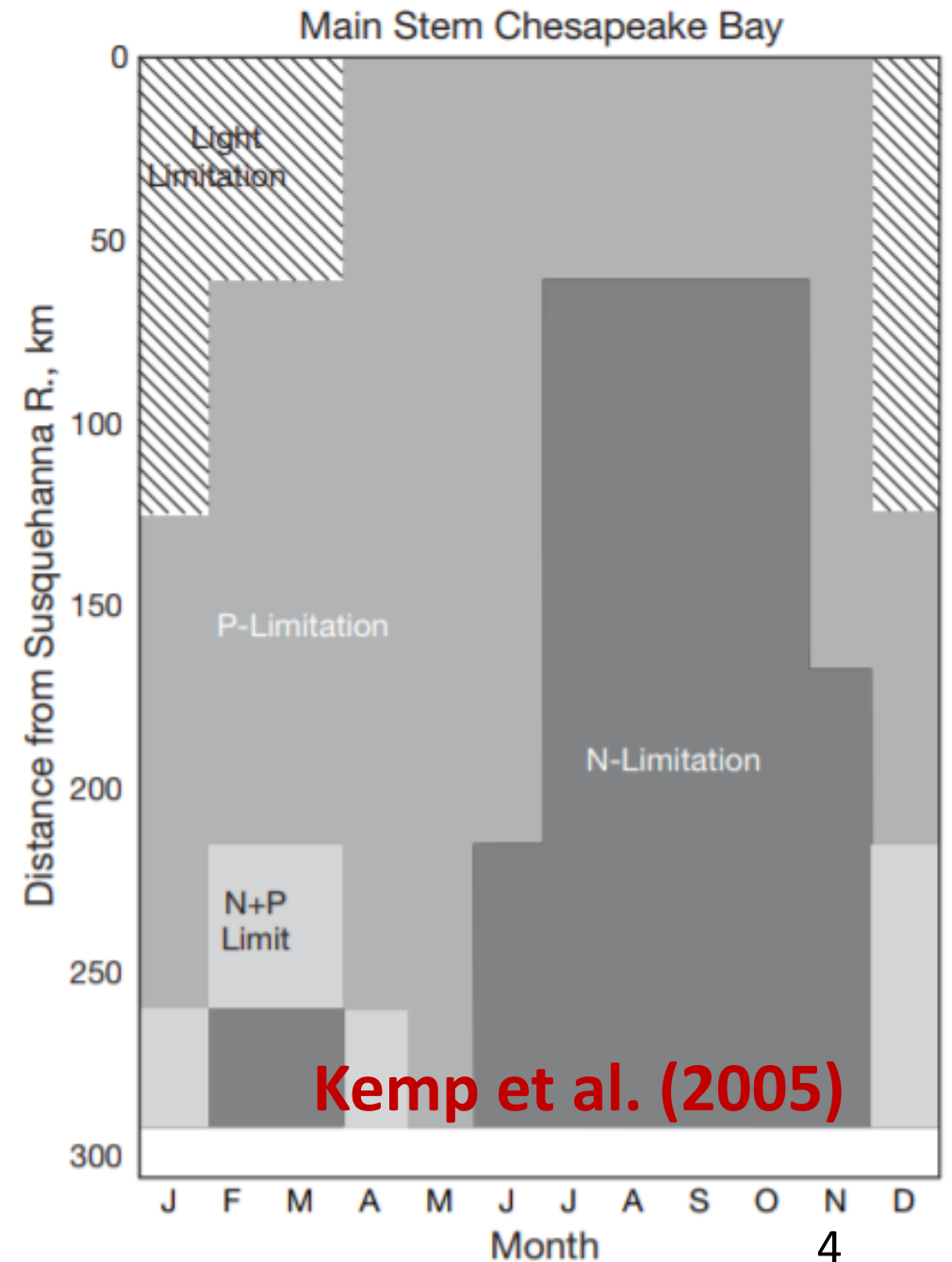
Nutrient Limitation in Chesapeake Bay: A Comparative Analysis of Monitoring and Modeling Data

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Background

- Chesapeake Bay has well-documented seasonal and spatial patterns in nutrient limitation to algal growth (Kemp et al., 2005).
- These patterns were determined using bioassays collected from the 1992-2002 (Fisher et al., 2002, 2005).
- These patterns were used in the calibration of the 2017 Chesapeake Bay estuarine model.



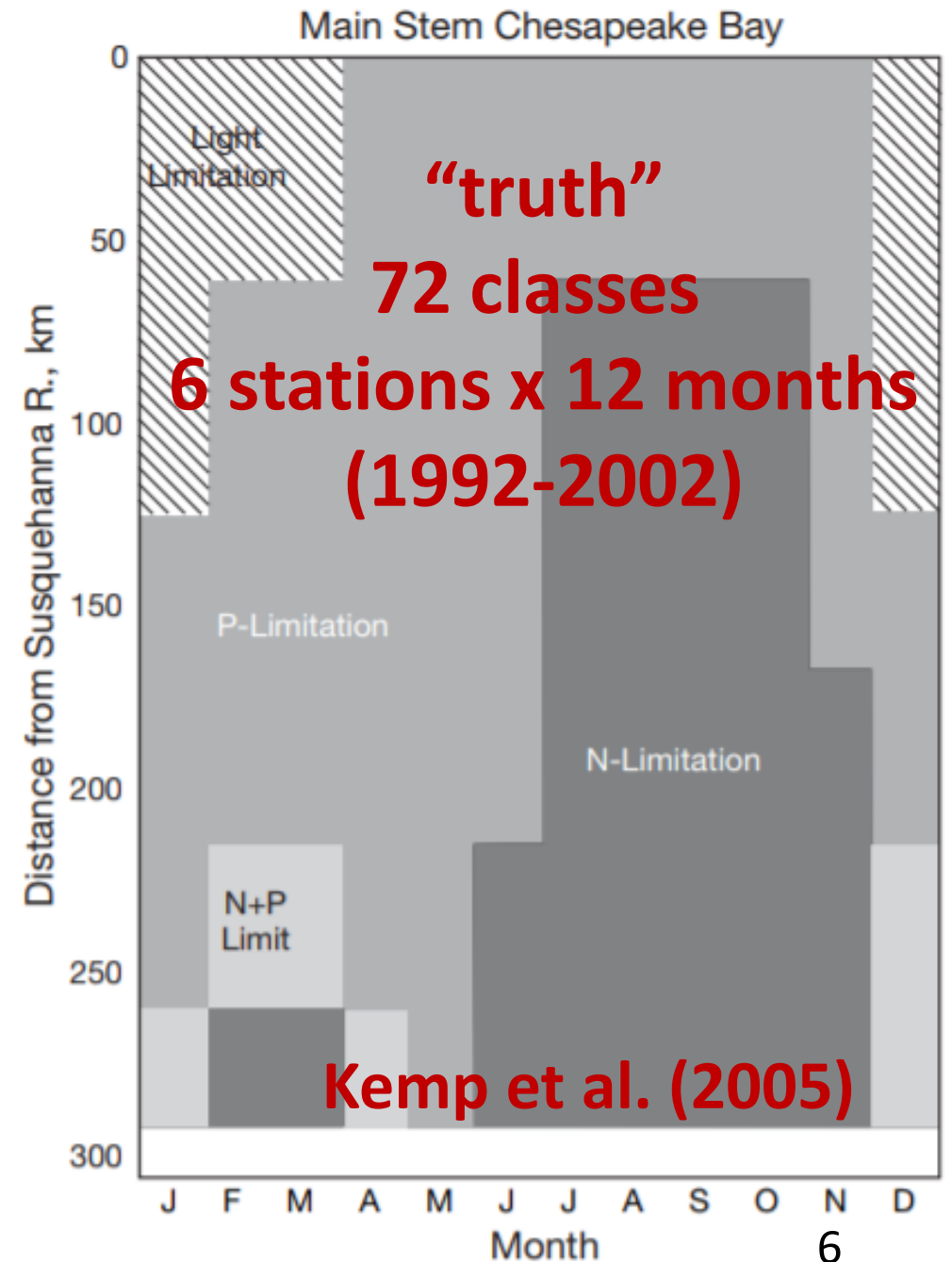
Recent Research*

1. Developed an empirical approach (CART) to relate tidal monitoring data to bioassay-based nutrient limitation in the concurrent period of 1992-2002,
2. Applied the approach to tidal monitoring data in more recent periods to predict nutrient limitation and explore potential changes in limitation in response to altered nutrient loading.

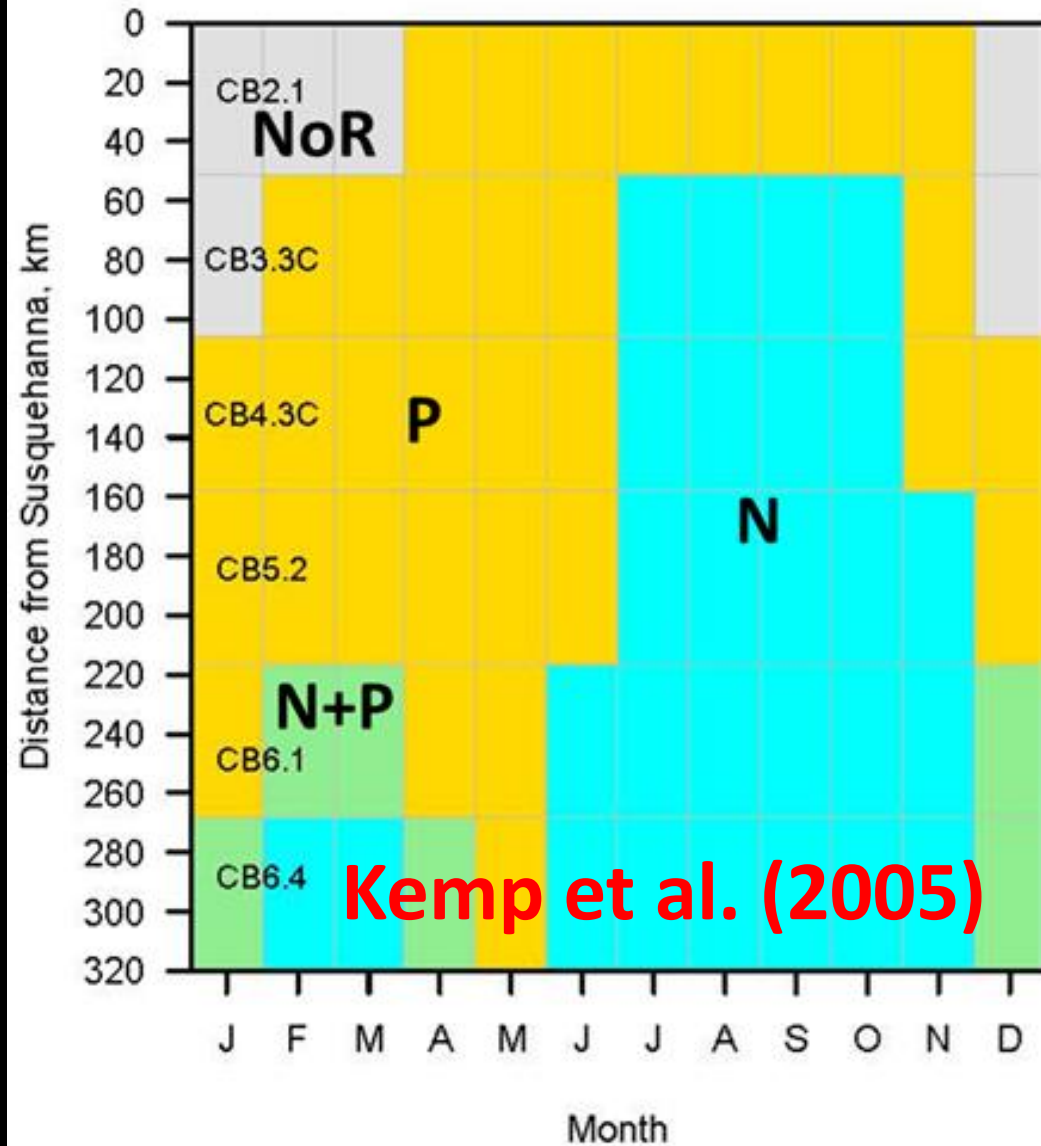
* Zhang, Q., T. R. Fisher, E. M. Trentacoste, C. Buchanan, A. B. Gustafson, R. Karrh, R. R. Murphy, J. Keisman, C. Wu, R. Tian, J. M. Testa and P. J. Tango, 2020. Nutrient limitation of phytoplankton in Chesapeake Bay: Development of an empirical approach for water-quality management. *Water Research*, 116407, [doi: 10.1016/j.watres.2020.116407](https://doi.org/10.1016/j.watres.2020.116407).

Study Sites & Data

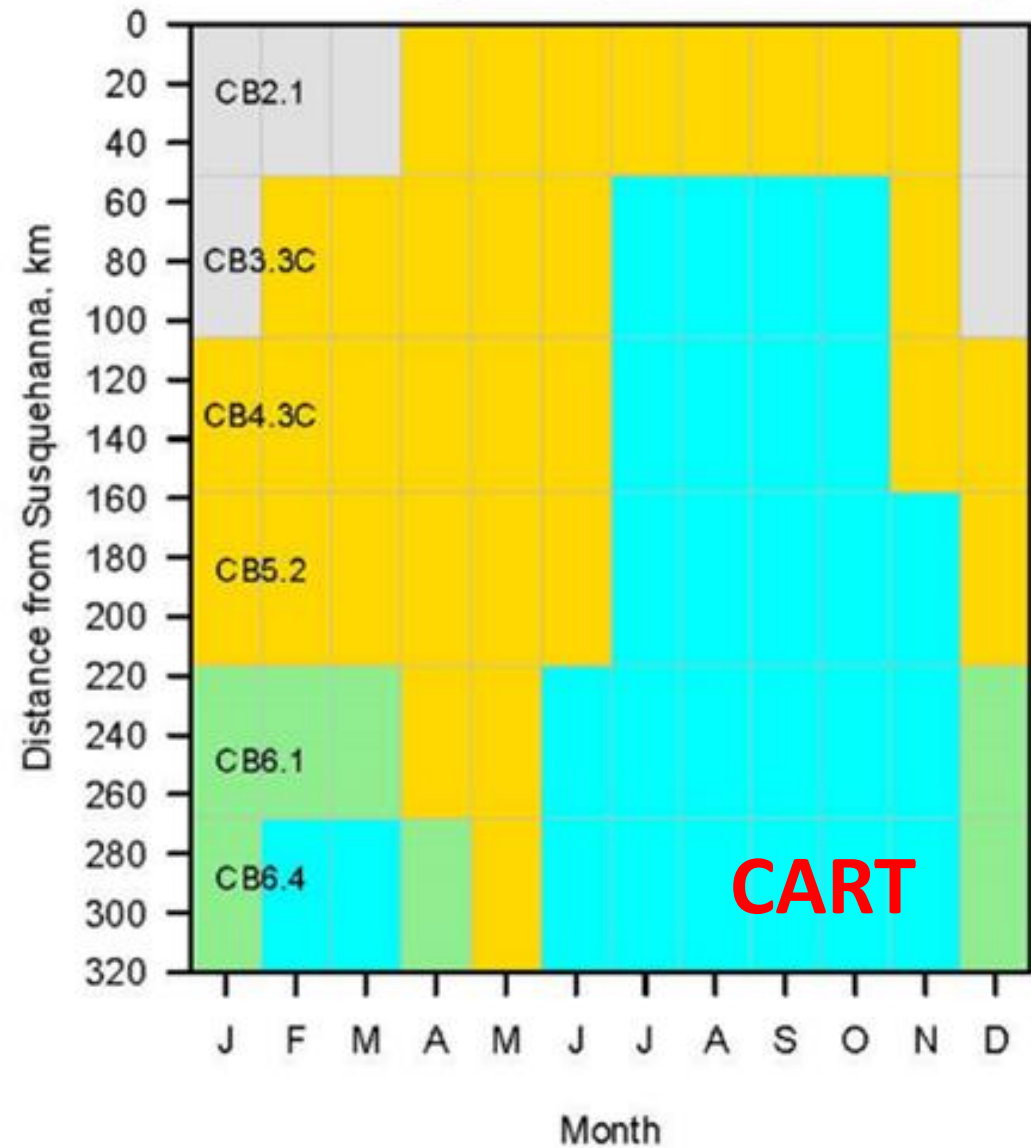
- Bioassay-based Limitation Classes for 1992-2002
 - ❑ 6 stations x 12 months
- Tidal WQ Monitoring Data in 1990-2018 (21 Stations)
 - ❑ Chesapeake Bay Program Data Hub (> 3,000,000 values)
 - ❑ Aggregated 1992-2002 data to the same size as bioassay classes
 - ❑ 6 stations x 12 months



**Mainstem Chesapeake Bay (1992–2002)
Bioassay Data**



**Mainstem Chesapeake Bay (1992–2002)
Monitoring Data (CART – Full Data)**



Research Goals

1. Compare nutrient limitation predicted by the monitoring data and the WQSTM model data for the 1991-2000 period:
 - ❖ Tidal WQ monitoring data in 1991-2000.
 - ❖ WQSTM model data for days matched with the monitoring data.
 - ❖ WQSTM model data for all days in 1991-2000.
2. Compare nutrient limitation predicted by the WQSTM model data under different scenarios for the 1991-2000 period:
 - ❖ No Action
 - ❖ WIP3
 - ❖ E3
 - ❖ Forest

Analysis of the WQSTM Data

- I. Compute the probability of each limitation class for each station-month pair.

Station	Month	p_N	p_P	p_NP	NoR	Class
X	May	0.0	0.2	0.1	0.7	???
X	May	0.2	0.3	0.2	0.3	???
X	May	0.4	0.1	0.4	0.1	???
X	May	0.6	0.0	0.0	0.4	???

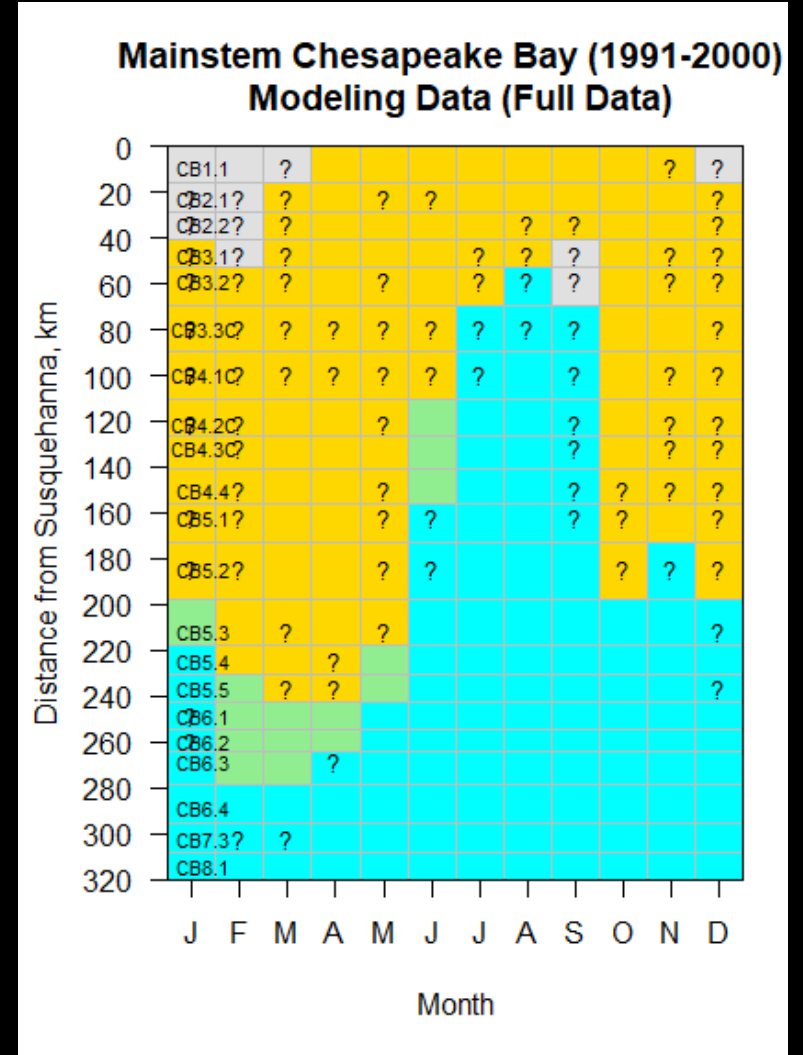
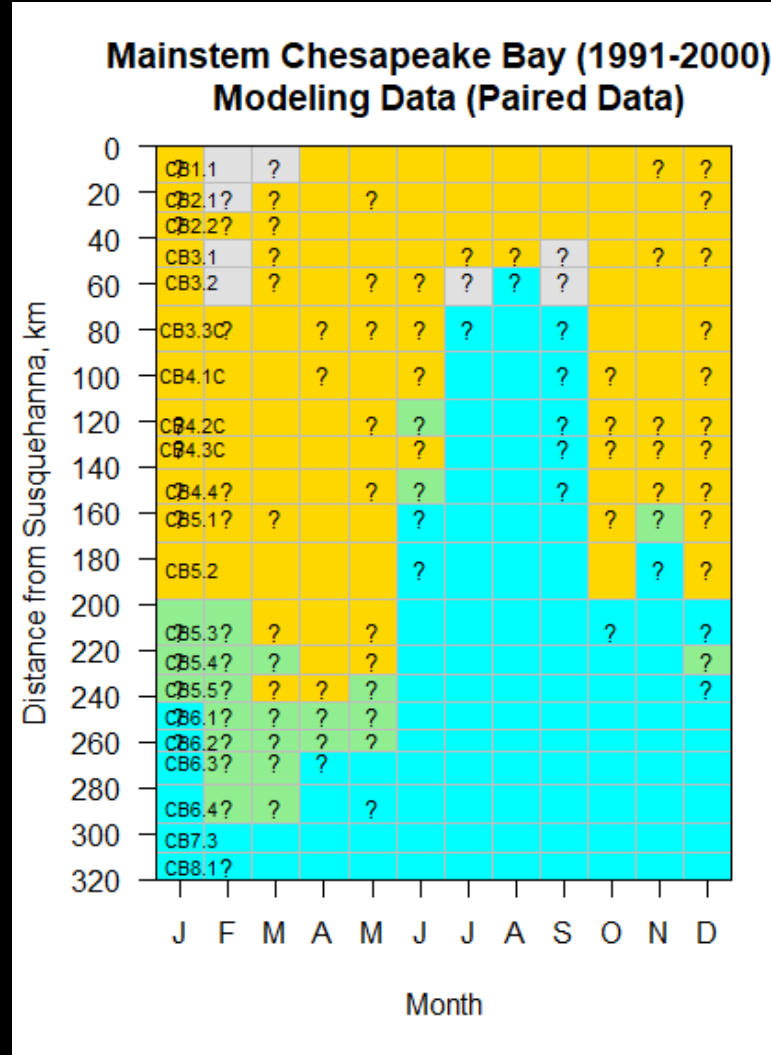
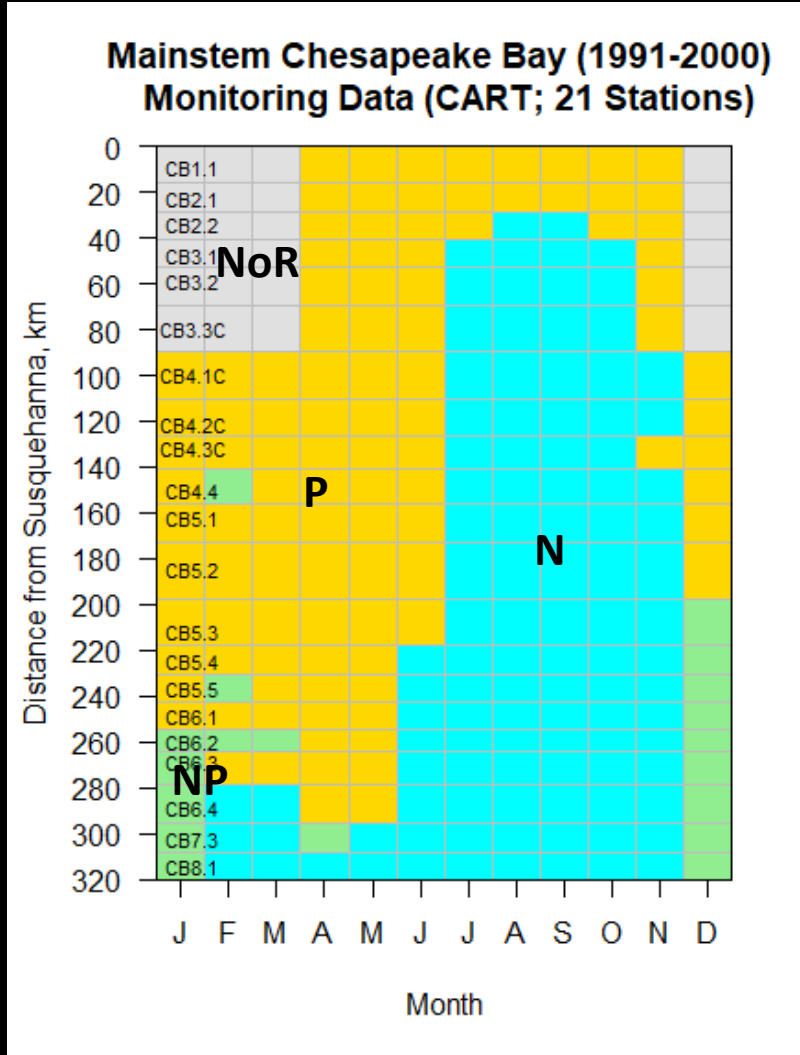
- II. Convert the computed probabilities to indices.

- $N\text{-index} = p_N + p_{NP} * 0.5$
- $P\text{-index} = p_P + p_{NP} * 0.5$
- $L\text{-index} = p_{NoR}$ (Note: $L\text{-index} = 1 - N\text{-index} - P\text{-index}$)

- III. Determine the nutrient limitation class using indices.

- N if $N\text{-index} \geq 0.4$
- P if $P\text{-index} \geq 0.4$
- NP if $N\text{-index} \geq 0.4$ and $P\text{-index} \geq 0.4$
- NoR otherwise.

1. Monitoring Data vs. WQSTM (Calibration)



1. Monitoring Data vs. WQSTM (Calibration)

Confusion Matrix and Statistics

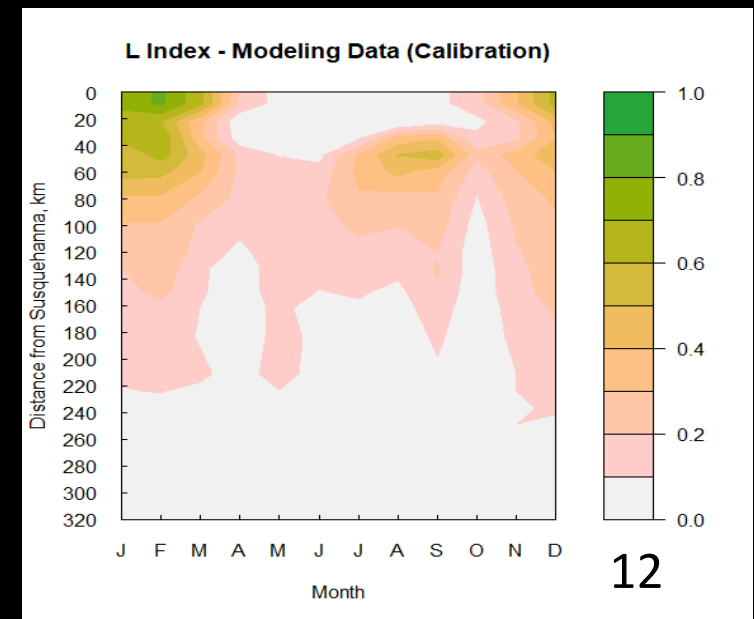
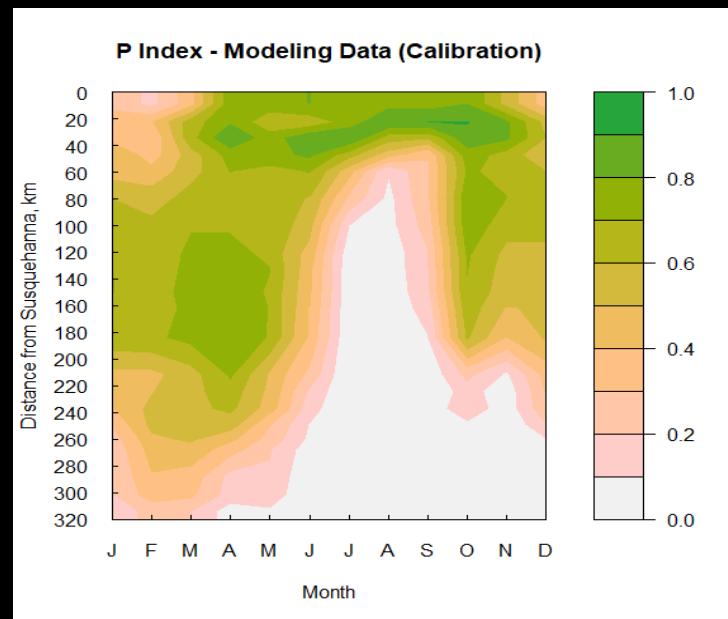
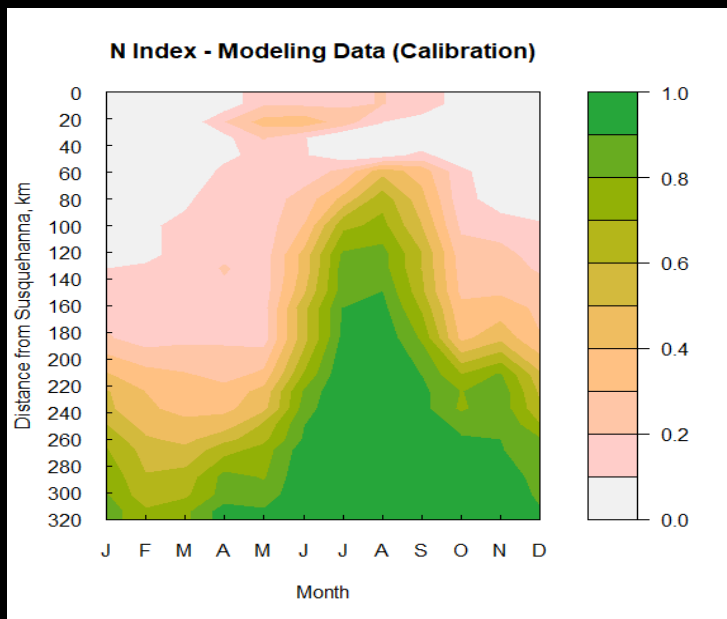
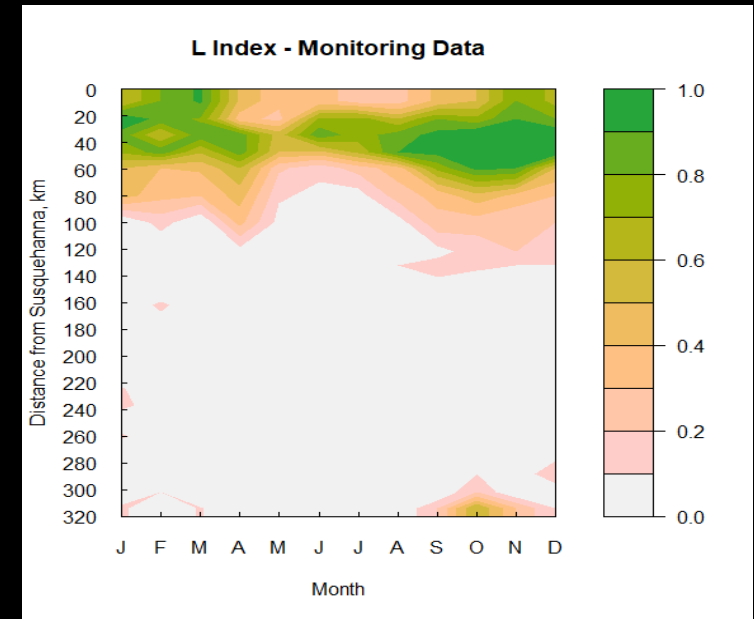
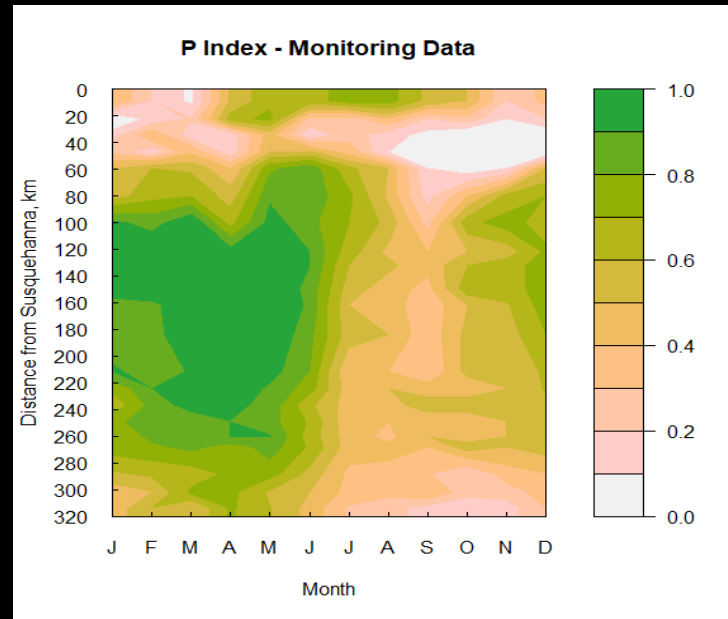
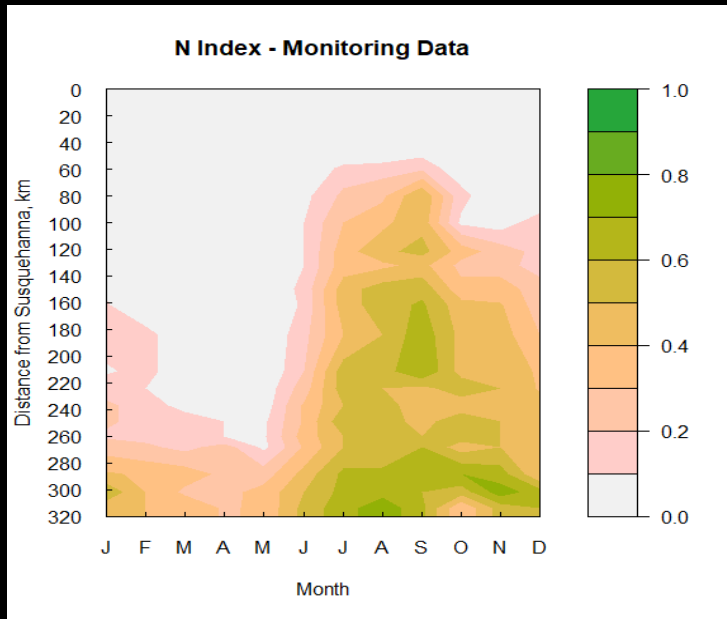
Monitoring
(References)

##	WQSTM	N	NoR	NP	P	
##	N	85	0	15	12	112
##	NoR	2	9	0	0	11
##	NP	0	0	3	12	15
##	P	18	15	1	80	114
##		105	24	19	104	252

Overall Accuracy: 0.70
(177 out of 252 cases)

##	Class: N	Class: NoR	Class: NP	Class: P
##	0.81	0.38	0.16	0.77

1. Monitoring Data vs. WQSTM (Calibration)

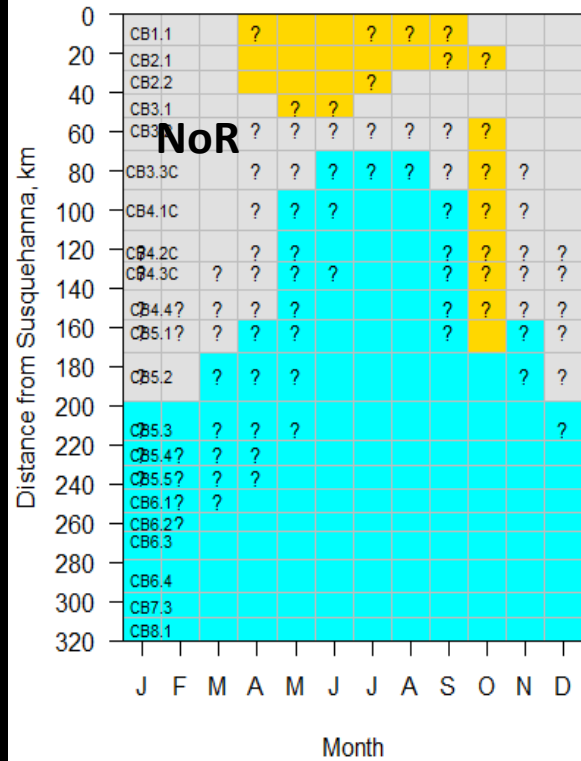


Research Goals

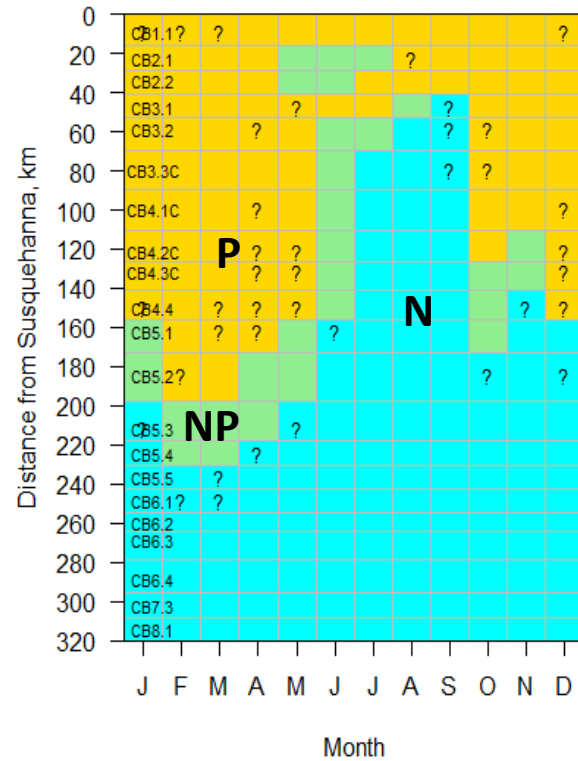
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2. WQSTM Scenarios

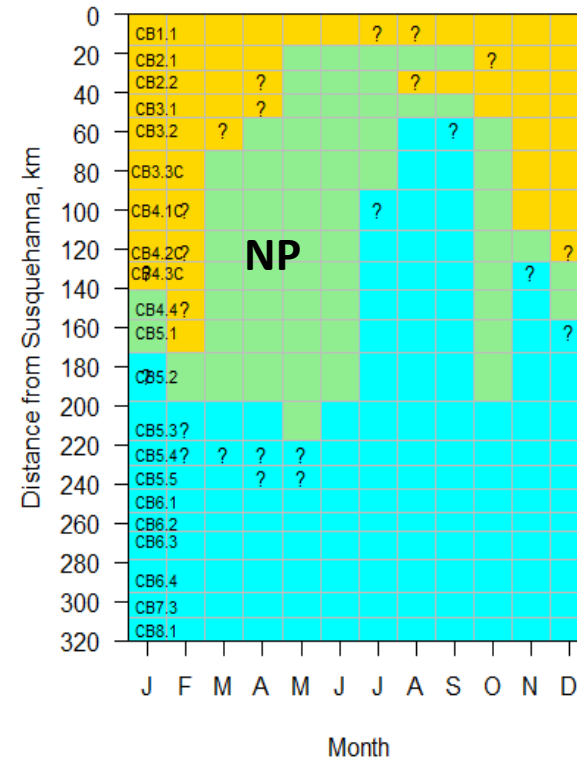
Mainstem Chesapeake Bay (1991-2000)
No Action (Full Data)



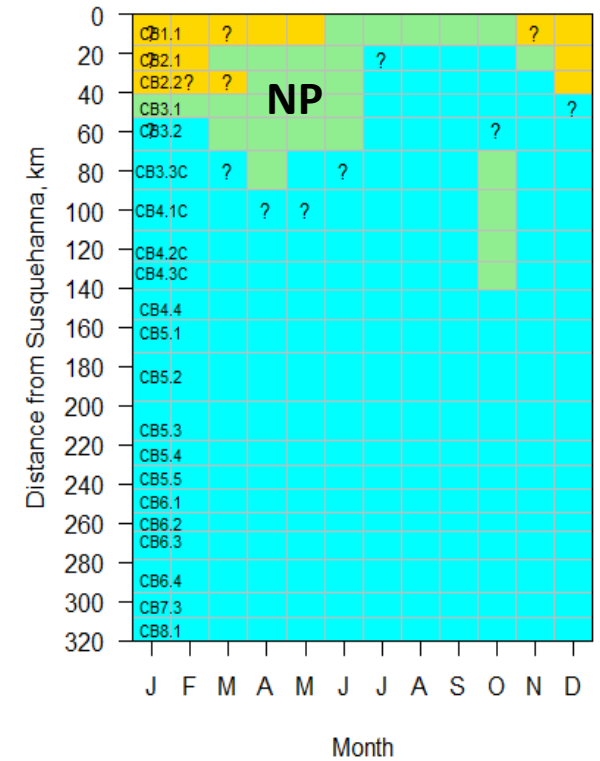
Mainstem Chesapeake Bay (1991-2000)
WIP3 (Full Data)



Mainstem Chesapeake Bay (1991-2000)
E3 (Full Data)



Mainstem Chesapeake Bay (1991-2000)
Forest (Full Data)



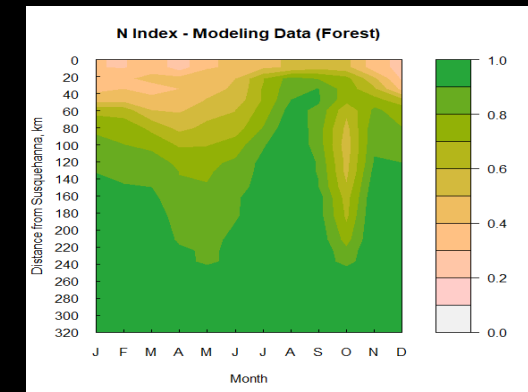
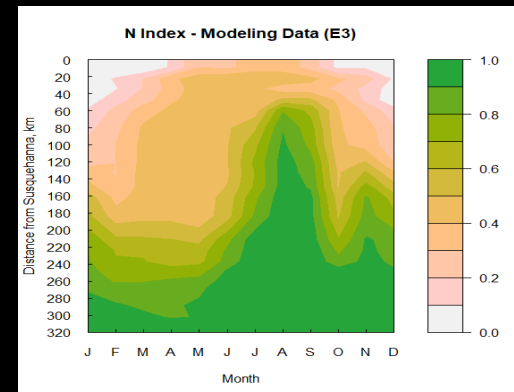
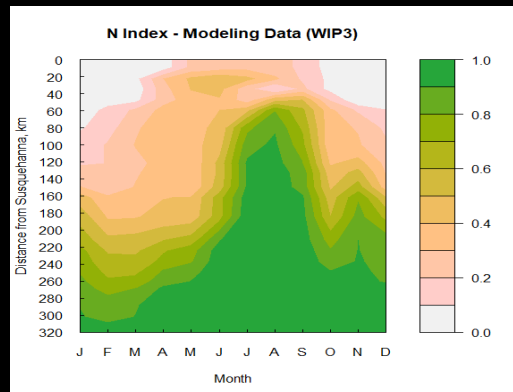
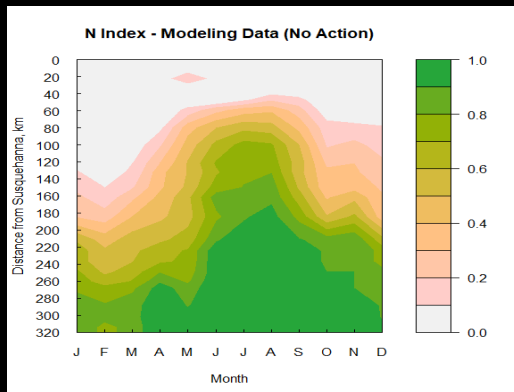
No Action

WIP3

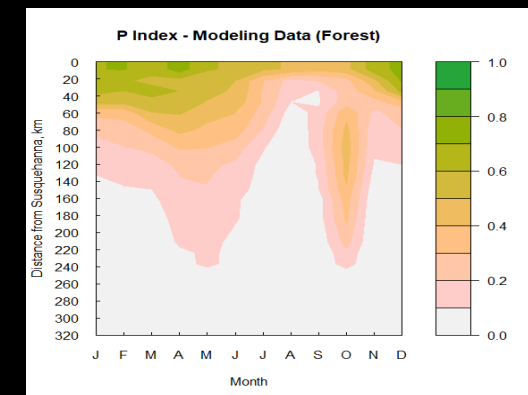
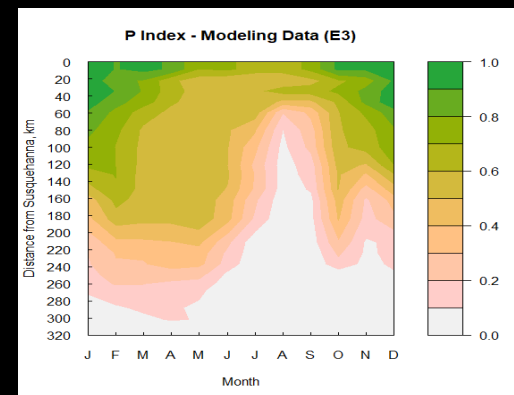
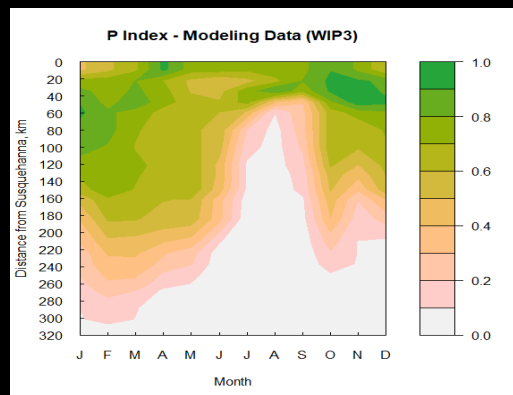
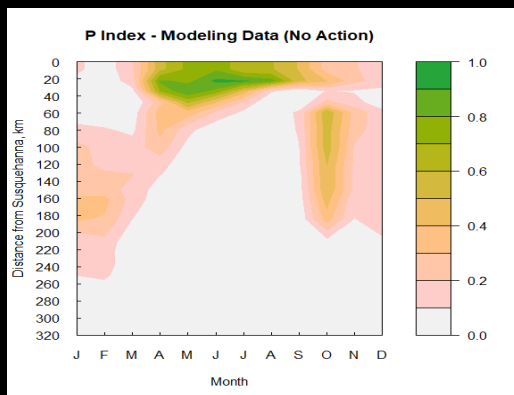
E3

Forest

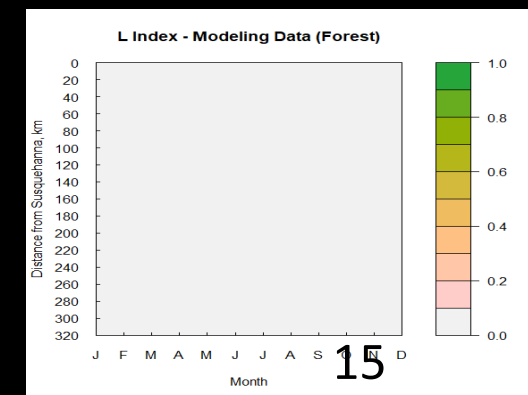
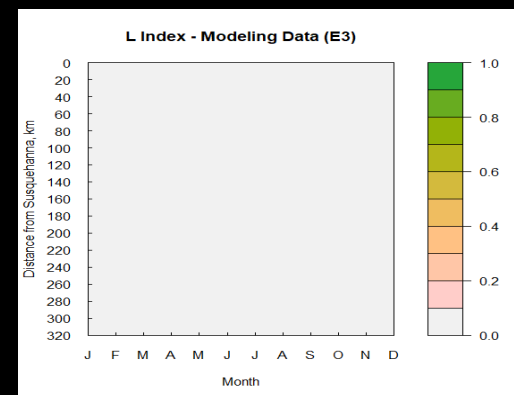
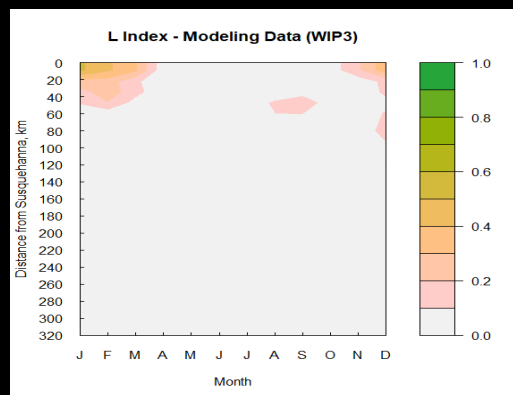
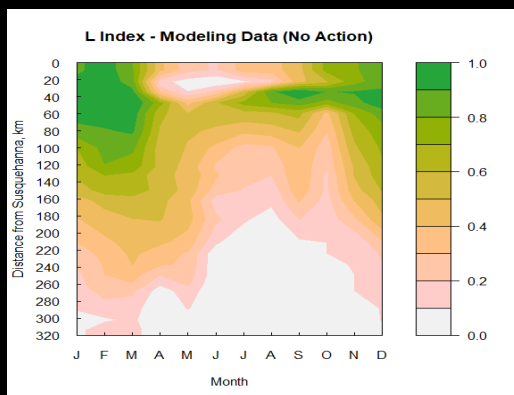
N Index



P Index



L Index



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Next Steps

- How would limitation patterns from the WQSTM data vary if a shorter period is considered?
- How would limitation patterns from the WQSTM data compare between 1990s and 2010s?
- How would limitation patterns from the WQSTM data compare between different hydrologic conditions?