Outcomes, obstacles and opportunities in reducing agricultural nutrient loads to the Chesapeake Bay

Chesapeake Bay Program Agriculture Work Group

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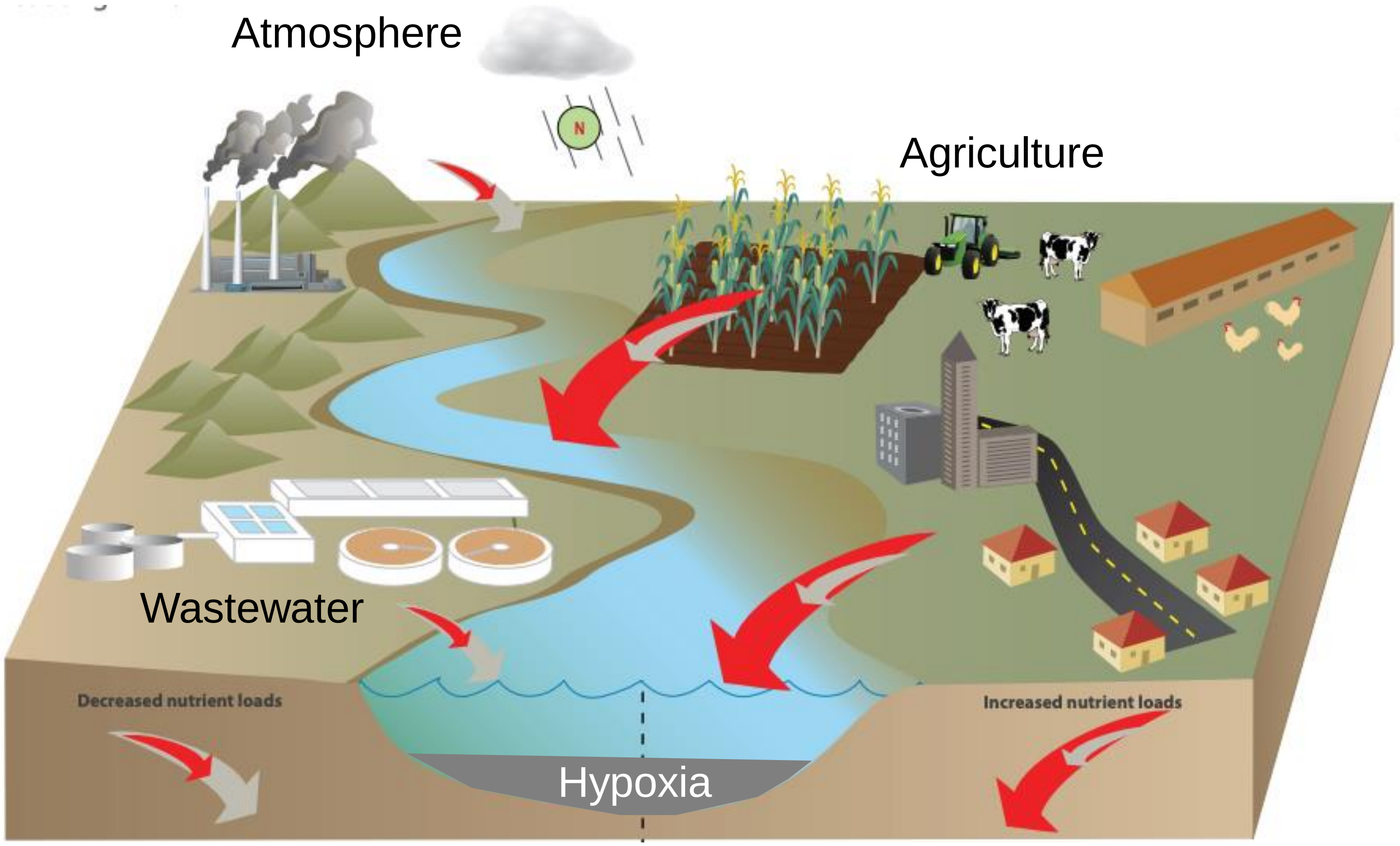
Controlling Nutrient Inputs



- Eutrophication results from excessive inputs of N & P
- Commitments to reduce nutrient inputs to Baltic Sea and Chesapeake Bay reached in 1980s
- Advanced wastewater treatment reduced P and N loads; atmospheric emission control reduced N-deposition
- Efforts to reduce agricultural sources produced limited and mixed results

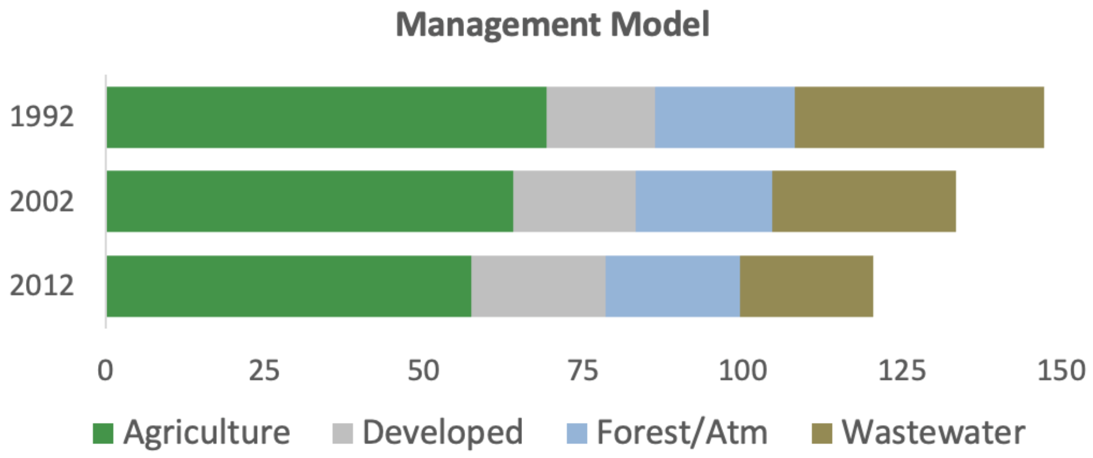
Chesapeake Bay: Reconciling Model Differences

Nitrogen

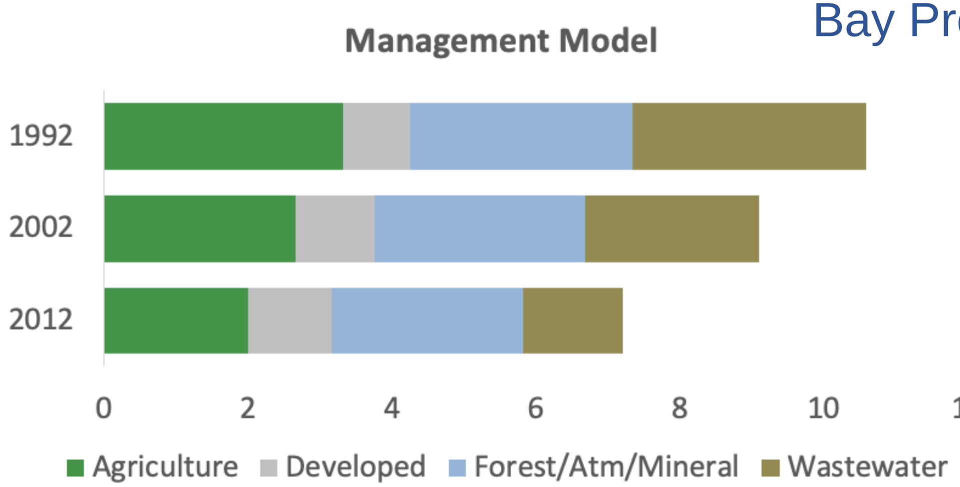
Thousand metric tons per year

Phosphorus

Chesapeake Bay Program

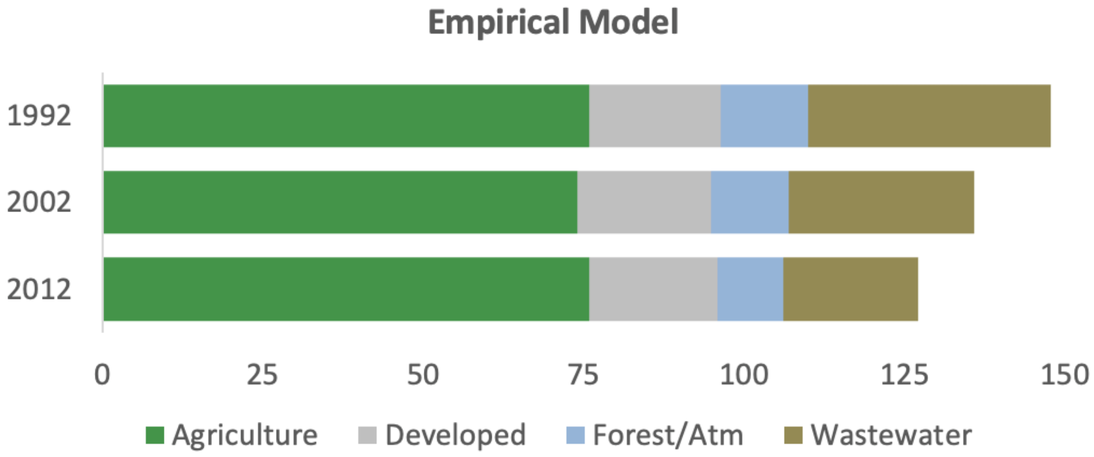


Agr.
-17%



Agr.
-40%

Ator et al. 2020
J. Env. Qual. 49:812



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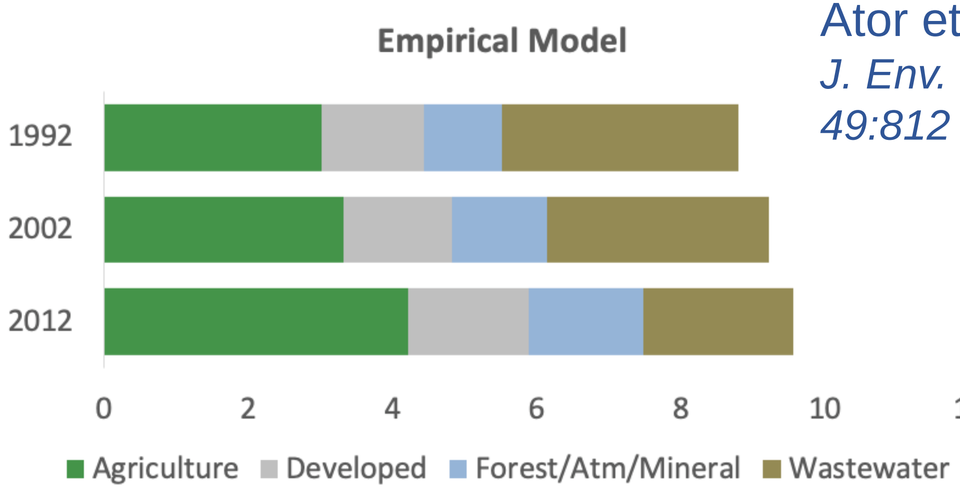
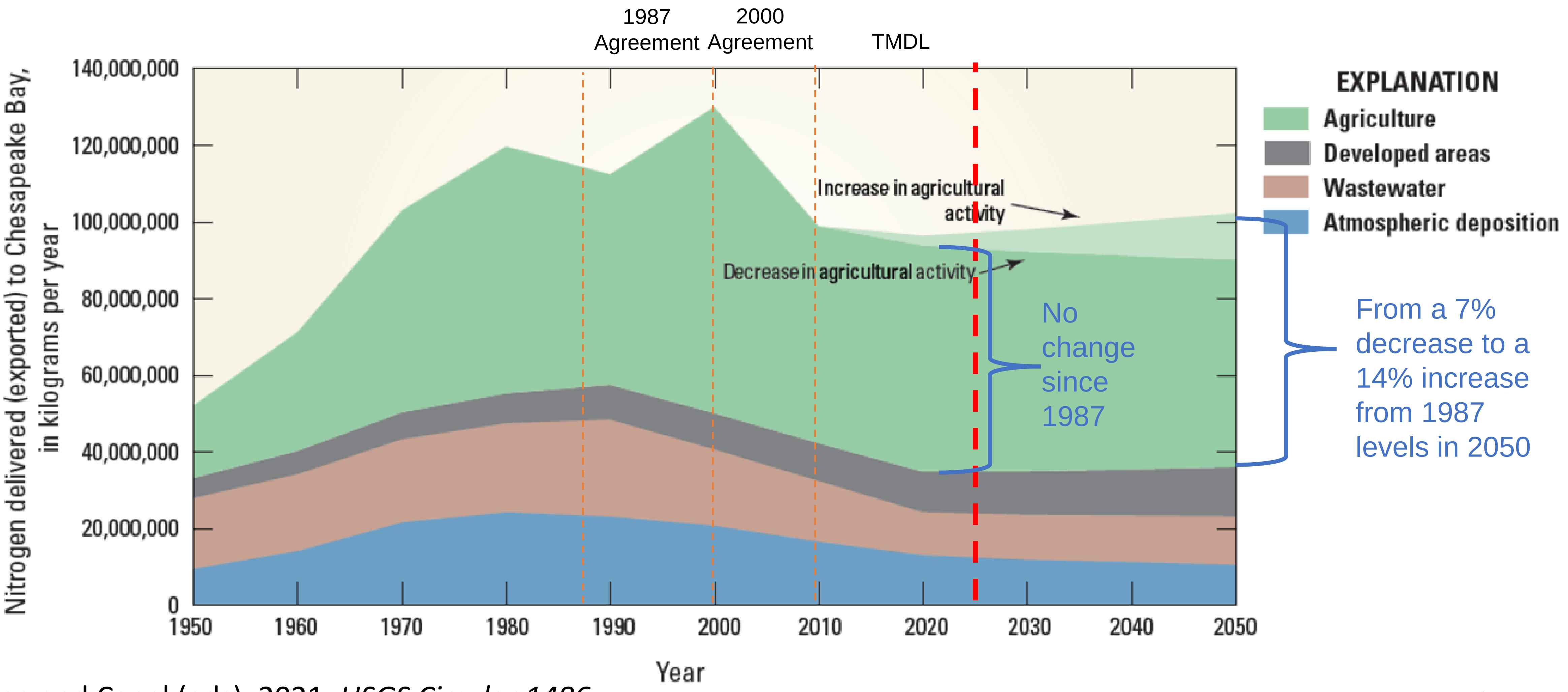


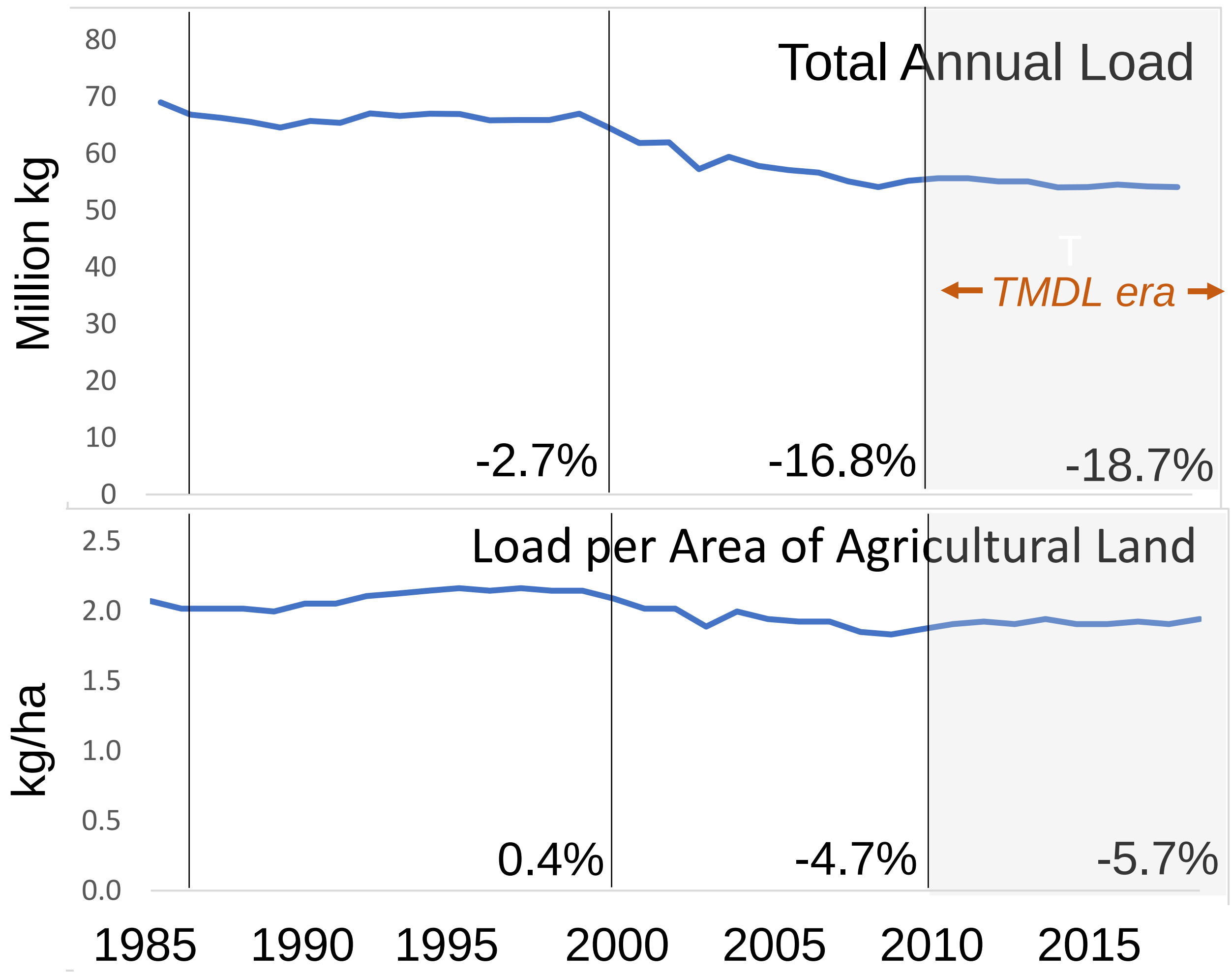
Agr.
+40%

USGS *A Century of Change* Report



Clune and Capel (eds). 2021. *USGS Circular 1486*

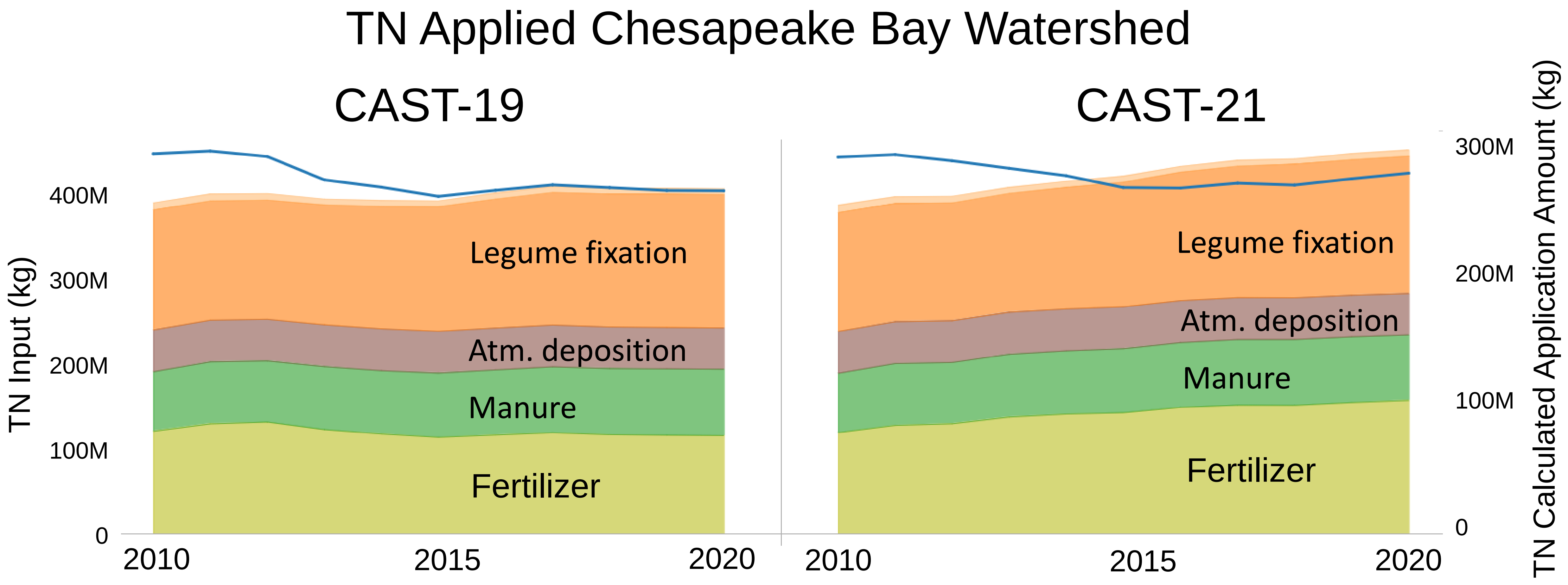
CBP Model Estimates of Agricultural N Load



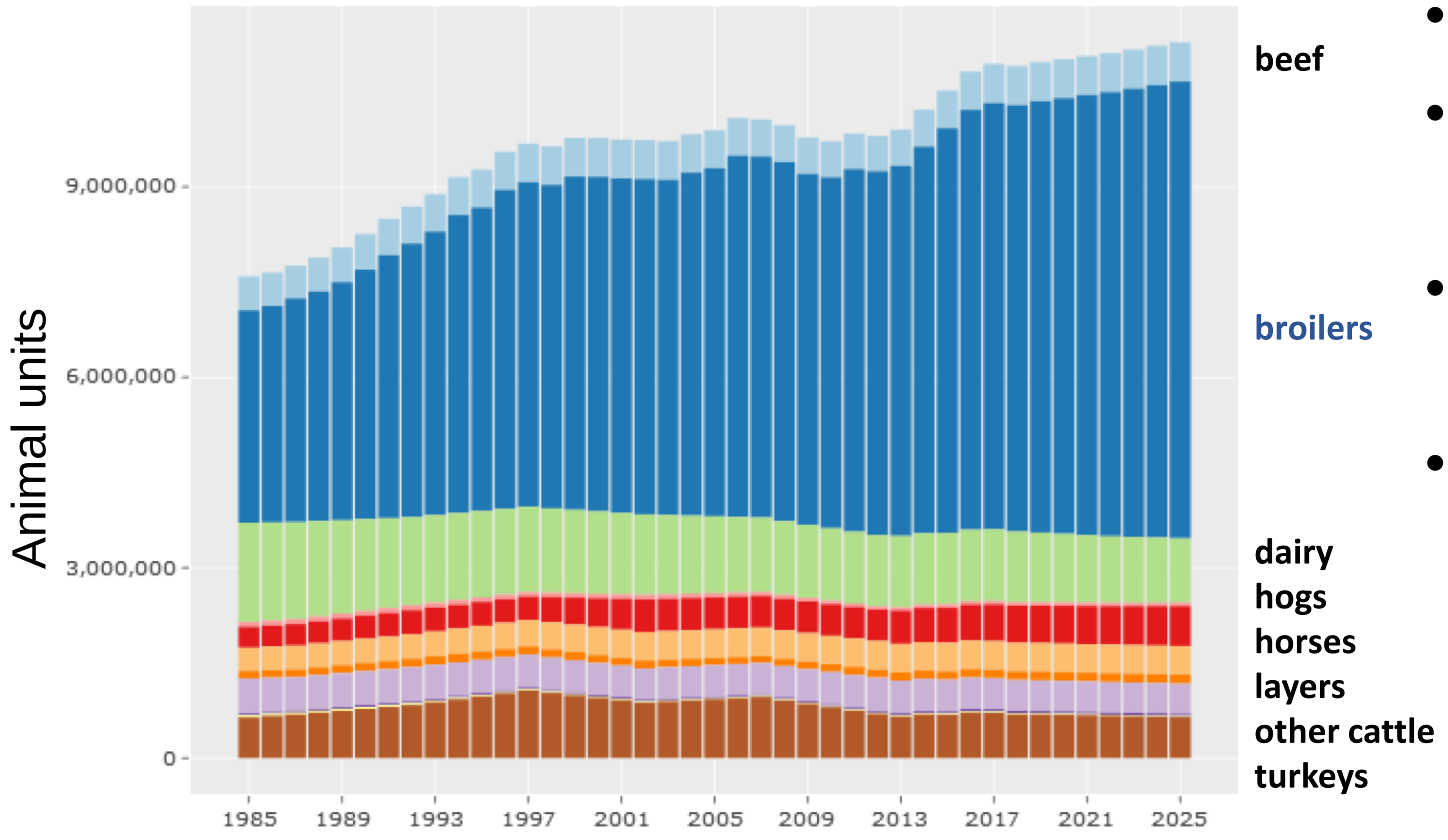
- Watershed Model-Chesapeake Assessment Scenario Tool (CAST-19)
- Loads **delivered to edge of tide** (no lag time)
- ~17% reduction by 2010, then slowed
- Modest reduction in load per area of agricultural land suggests ~2/3 of load reductions due to land conversion
- Revisions in CAST-21 data for fertilizer & yield eliminates TMDL-era achievements for agriculture

https://cast.chesapeakebay.net/TrendsOverTime/Loads

Model Revisions of Agricultural N Application

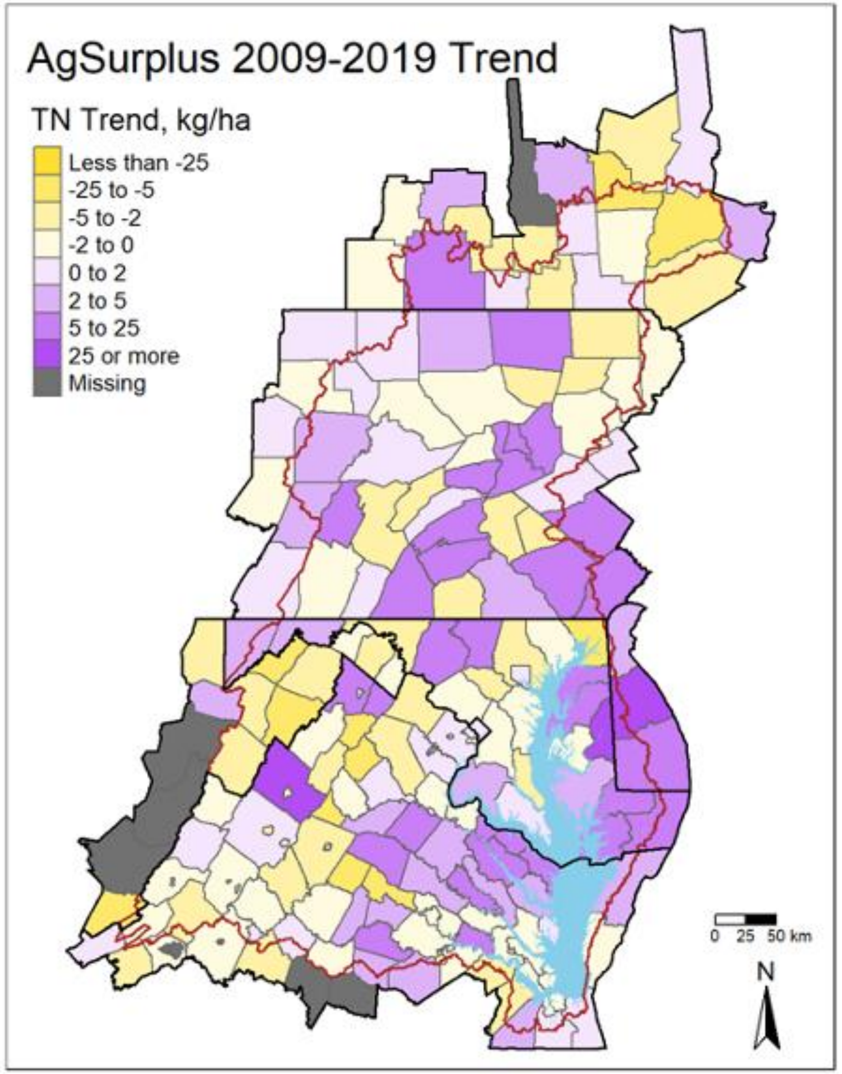


Growth of Poultry Production Drives Agriculture



- Animal units increased by 60%
- Chicken production more than doubled since 1987 commitment
- Drives grain production and requires more grain imports
- Future of coastal ecosystem depends on management of agroecosystems

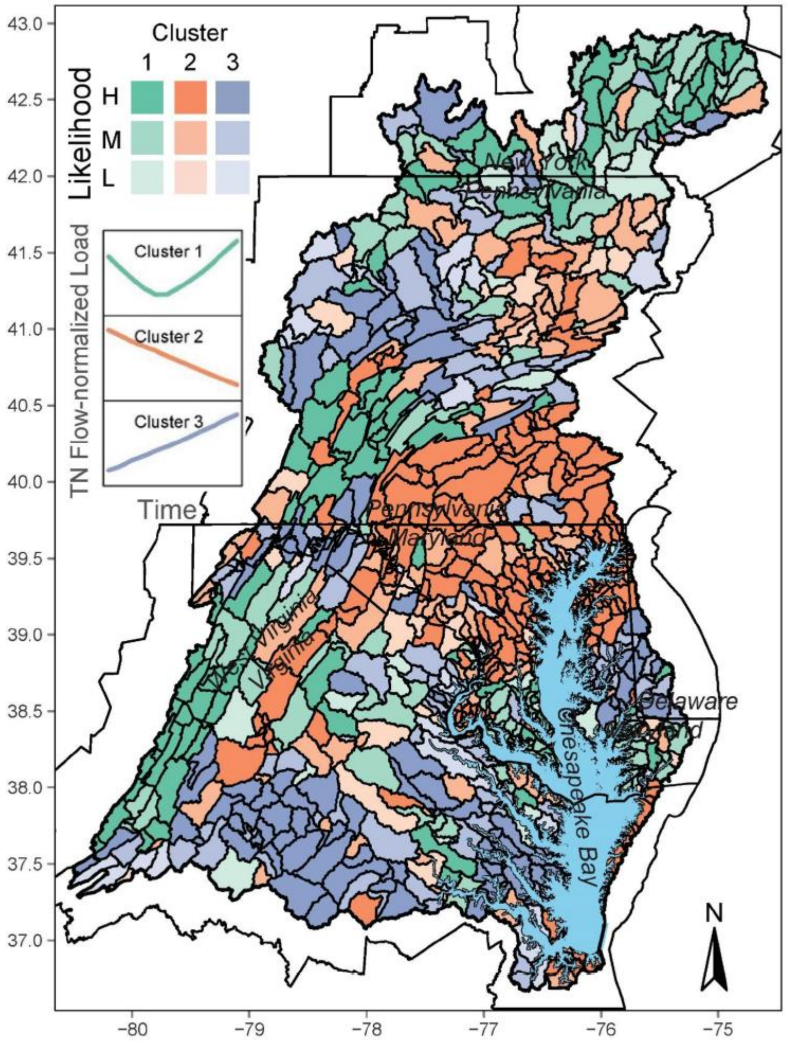
Trends in Agricultural N-Surplus



- Nutrient surplus is difference between agricultural N inputs (including atmospheric deposition) and crop removal
- Decline in atmospheric N deposition about 2X decline in agricultural N surplus
- Agricultural nitrogen surplus declined significantly in most counties from 1985 to 2019
- Reversal of the trend over 2009 to 2019 in many key agricultural counties
- New data in CAST-21 revision would exacerbate trend toward increased N-surplus in some places

Sabo et al. 2022. *Environ. Res. Com.* 4: 045012

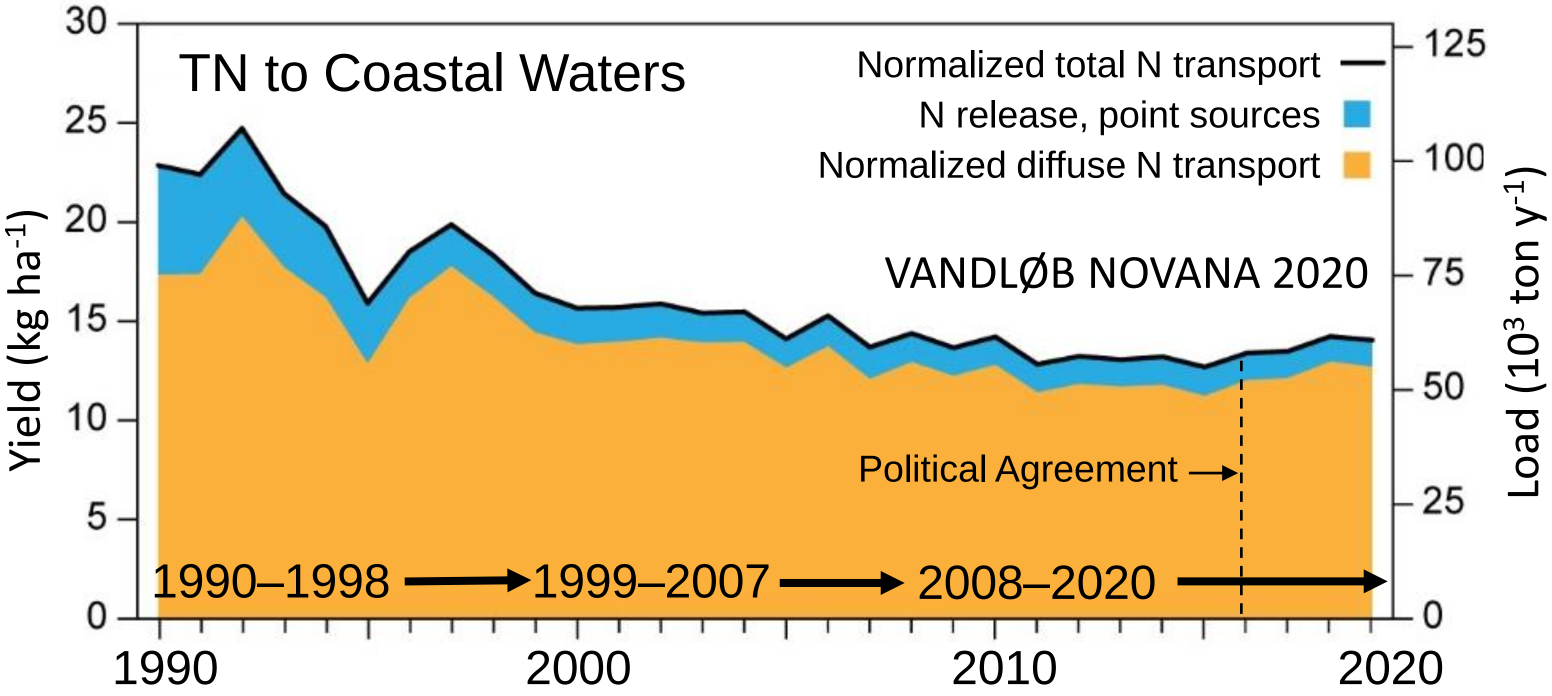
Other Analyses Based on Measured Loads

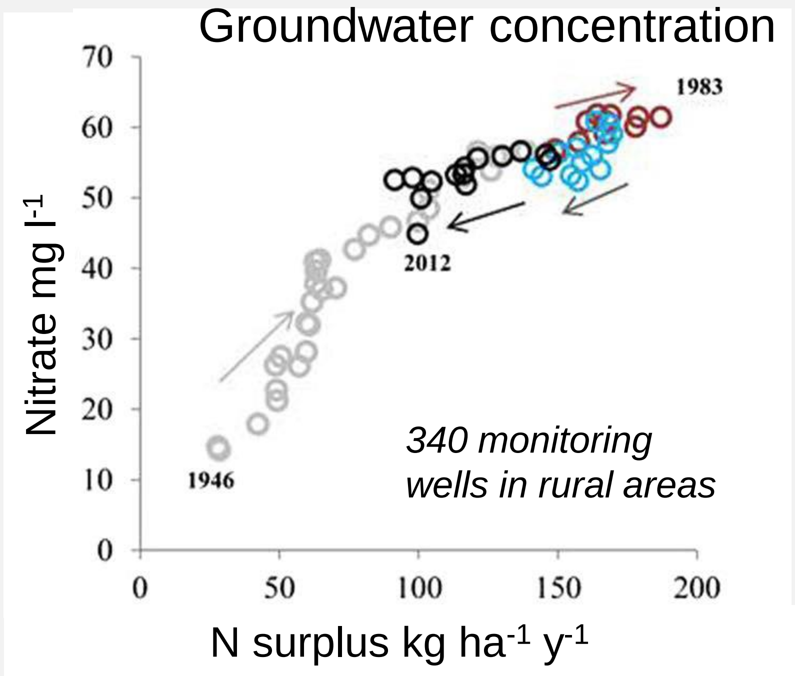


☜ Zhang et al. (2022 *Wat. Res.* 218:118443) — machine-learning analysis of N-trends (2007–2018) in watersheds showed some declines (over carbonate rocks), increases (Coastal Plain), and reversals (forested)

- ✓ Fisher et al. (2021 *Estuar. Coast.*) — decline in N in Choptank estuary (1983–2017) due to -20% in atmospheric deposition & -80% wastewater treatment
- ✓ Fox et al. (2021 *J. Environ. Mgt.* 299:113478) — small declines in N-loads (2003–2014) in half of Choptank watersheds under BMPs
- ✓ Zhang et al. (2021 *Sci. Total Environ.*) — declines in South Fork Shenandoah (1985–2018) mainly due to wastewater loads
- ✓ Chang et al (2021 *Environ. Res. Lett*. 16:085002) — 13% of estimated load reduction due to atm. deposition; ~50% of N leaving catchment is >5 years old.

Denmark: A Story of Mandates and Monitoring





Hansen et al. 2017. *Sci. Rep.* 7:8566

- Intense agriculture (63% of land use)
- Mandatory: N quota (90% economic optimum), store & spread manure, later tillage, catch crop
- Extensive, sustained monitoring, in-depth assessments

- Groundwater & stream nitrate declined w/ surplus
- 43% reduction in N delivery, little in past 10 yr.
- Targeted and collective N regulations to achieve additional 10,800 t N from 2021-2027

Pathways Forward

- Audit
- Subsidies conditional on performance
- Manage by field-level surplus
- Circular economy
- Target mitigation, investments, retirement
- Drainage, riparian buffers, wetlands, bioreactors
- Limit animal intensity
- Plant-based food systems

Break barriers,
build bridges.

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