Nitrogen Flow Model of the Chesapeake Bay watershed Food chain (NFCBF)

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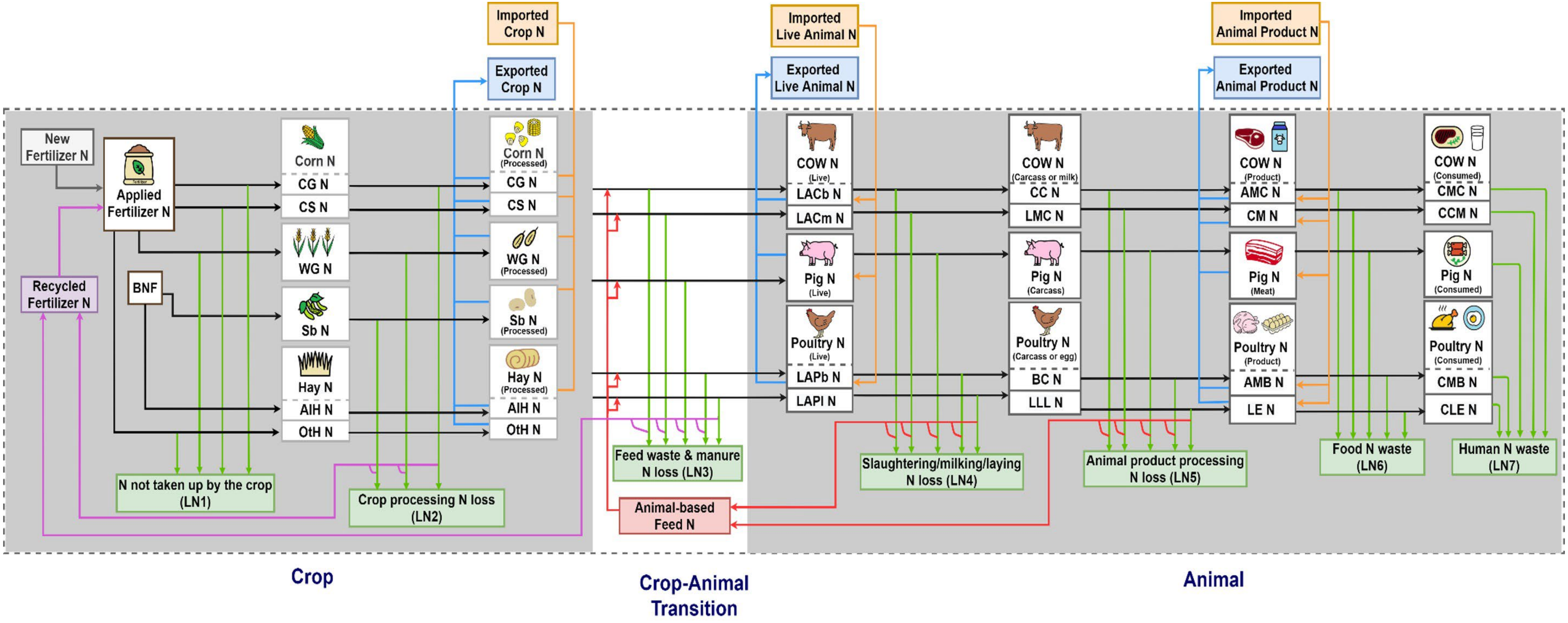
Conceptually this model is a systems model that incorporates nitrogen budget and nitrogen footprint modeling

We also track the import and export of three stages of the food-production supply chain



We have a couple of fully open access publications out on this model for anyone who would like to get into the nitty gritty details

Environmental Science & Technology
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Regional Analysis of Nitrogen Flow within the Chesapeake Ba Watershed Food Production Chain Inclusive of Trade

Paniz Mohammadpour and Caitlin Grady*

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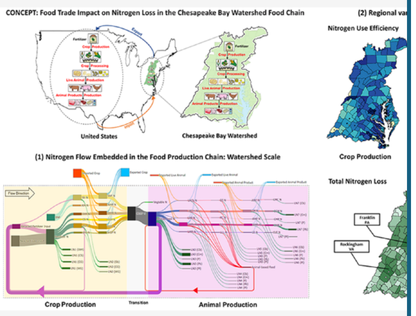

ABSTRACT: In the Chesapeake Bay Watershed, excess nitrogen has contributed to poor water quality, leading to nitrogen mitigation efforts to restore and protect the watershed. The food production system is a top contributor to this nitrogen pollution. While the food trade plays a vital role in distancing the environmental impacts of nitrogen use from the consumer, previous work on nitrogen pollution and management in the Bay is yet to carefully consider the effect of embedded nitrogen found in products (nitrogen mass within the product) imported and exported throughout the Bay. Our work advances understanding across this area by creating a mass flow model of nitrogen embedded in the food production chain throughout the Chesapeake Bay Watershed that separates phases of the production and consumption processes for crops, live animals, and animal products and considers commodity trade at each phase by combining aspects of both nitrogen footprint and nitrogen budget models. Also, by tracking nitrogen em products imported and exported in these processes, we distinguished between direct nitrogen pollution and nitroger externalities (displaced N pollution from other regions) from outside of the Bay. We developed the model for the watersh its counties for major agricultural commodities and food products for 4 years 2002, 2007, 2012, and 2017 with a specifi

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Impacts of future scenarios on the nitrogen loss from agricultural supply chains in the Chesapeake Bay

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Supplementary material for this article is available online

Abstract

Excessive nitrogen (N) pollution in the Chesapeake Bay is threatening ecological health. This study presents a multilayer N flow network model where each network layer represents a stage in the production step from raw agricultural commodities such as corn to final products such as packaged meat. We use this model to assess the impacts of alternative future agricultural production and land use changes on multiple pathways of N pollution within the Chesapeake Bay Watershed (CBW)

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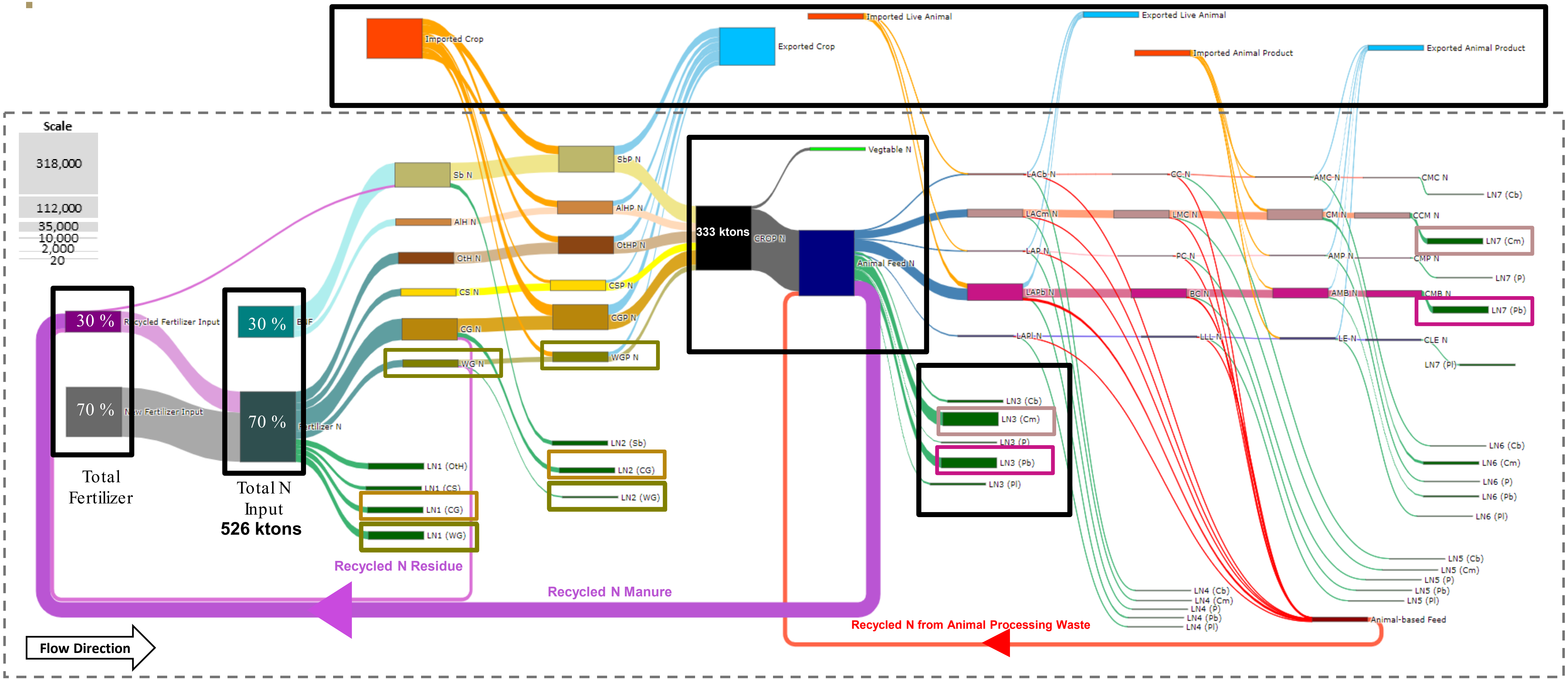
This is a quick overview of the results of the model



LN1: N input not taken by crop, LN2: Crop processing N loss, LN3: Feed waste & manure Loss, LN4: Slaughtering/milking/laying N loss, LN5: Food processing N loss, LN6: Food N waste, LN7: Human N waste

Conceptual overview of how we calculate inorganic Nitrogen fertilizer application rates

Spatial Unit:
County

Variables:
Acres planted, by crop type

Crop need:
N need by crop type, based on yield, by State (based on Agronomy recommendations)

Apply organic fertilizer:
From animal stage, constrained within county, with maximum total constraint

Calculate remaining Inorganic need:
Remaining assumed to be fulfilled by inorganic fertilizer, independent of sales data

Here is a preview of our current work under review

Data Analysis

Sensitivity Analysis

Climate Analogs for future yields

Scenario Analysis

Future Scenarios: Climate, Crops, Animals

Management Scenarios: Crop & Animal efficiency

Combined Scenarios: Future & Management

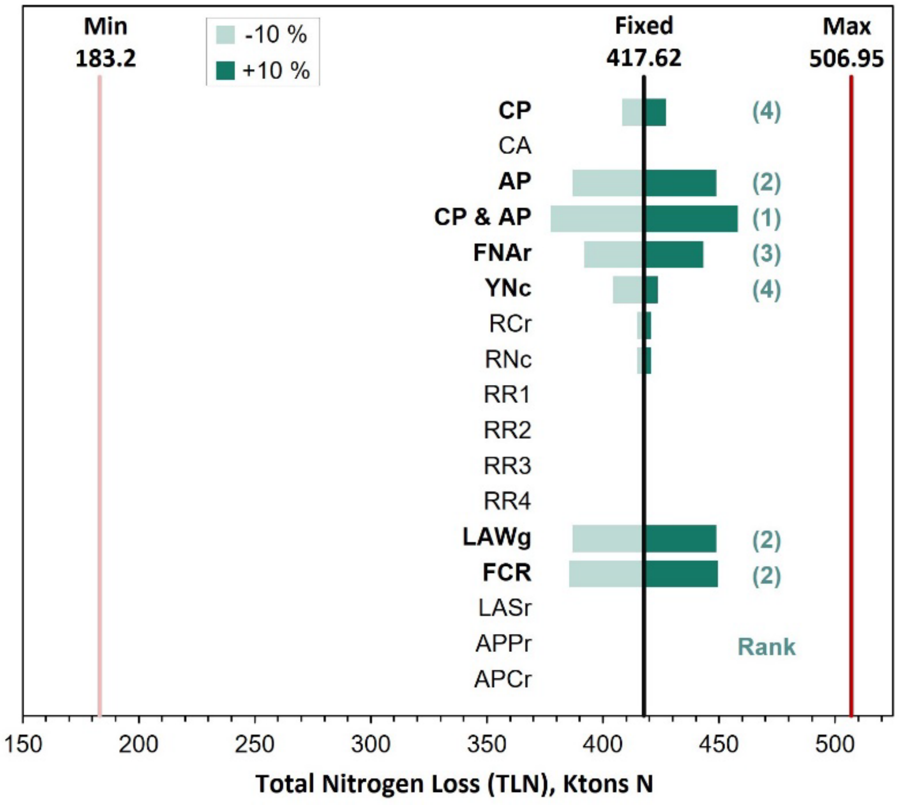
Sensitivity of nitrogen loss to different variables in the NFCBF Model

(a)

	LN1	LN2	LN3	LN4	LN5	LN6	LN7	TLN
Crop Production **(CP)**	0.07	0.20	0.00	0.00	0.00	0.00	0.00	0.05
Crop planting Area **(CA)**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Animal Production **(AP)**	0.13	0.00	0.20	0.19	0.18	0.18	0.18	0.15
Crop & Animal Production **(CP & AP)**	0.20	0.20	0.20	0.19	0.18	0.18	0.18	0.19
Fertilizer Nitrogen Application rate **(FNAr)**	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.12
Crop Yield Nitrogen content **(Ync)**	-0.16	0.01	0.26	0.00	0.00	0.00	0.00	0.05
Residue: Crop ratio **(RCr)**	-0.04	0.19	0.00	0.00	0.00	0.00	0.00	0.01
Crop Residue Nitrogen content **(RNc)**	-0.04	0.19	0.00	0.00	0.00	0.00	0.00	0.01
Crop Residue Recycling Rate **(RR1)**	0.05	-0.11	0.00	0.00	0.00	0.00	0.00	0.00
Animal Manure Recycling Rate **(RR2)**	0.13	0.00	-0.11	0.00	0.00	0.00	0.00	0.00
Live Animal Processing waste Recycling Rate **(RR3)**	0.01	0.00	0.01	-1.80	0.00	0.00	0.00	0.00
Animal Product Processing waste Recycling Rate **(RR4)**	0.00	0.00	0.01	0.00	-1.79	0.00	0.00	0.00
Live Animal Weight Gained from Birth to Slaughter/Milk/Lay **(LAWg)**	0.13	0.00	0.20	0.19	0.18	0.18	0.18	0.15
Feed Conversion Ratio/ Feed Efficiency Ratio **(FCR)**	0.19	0.00	0.28	0.00	0.00	0.00	0.00	0.15
Live Animal Slaughtering/milking/laying rate **(LASr)**	-0.05	0.00	-0.07	-1.06	0.21	0.18	0.18	0.00
Animal Product Processing rate **(APPr)**	-0.05	0.00	-0.07	0.00	-2.57	0.18	0.18	0.00
Animal Product Consumption rate **(APCr)**	0.00	0.00	0.00	0.00	0.00	-0.70	0.19	0.00

− 0 +

(b)

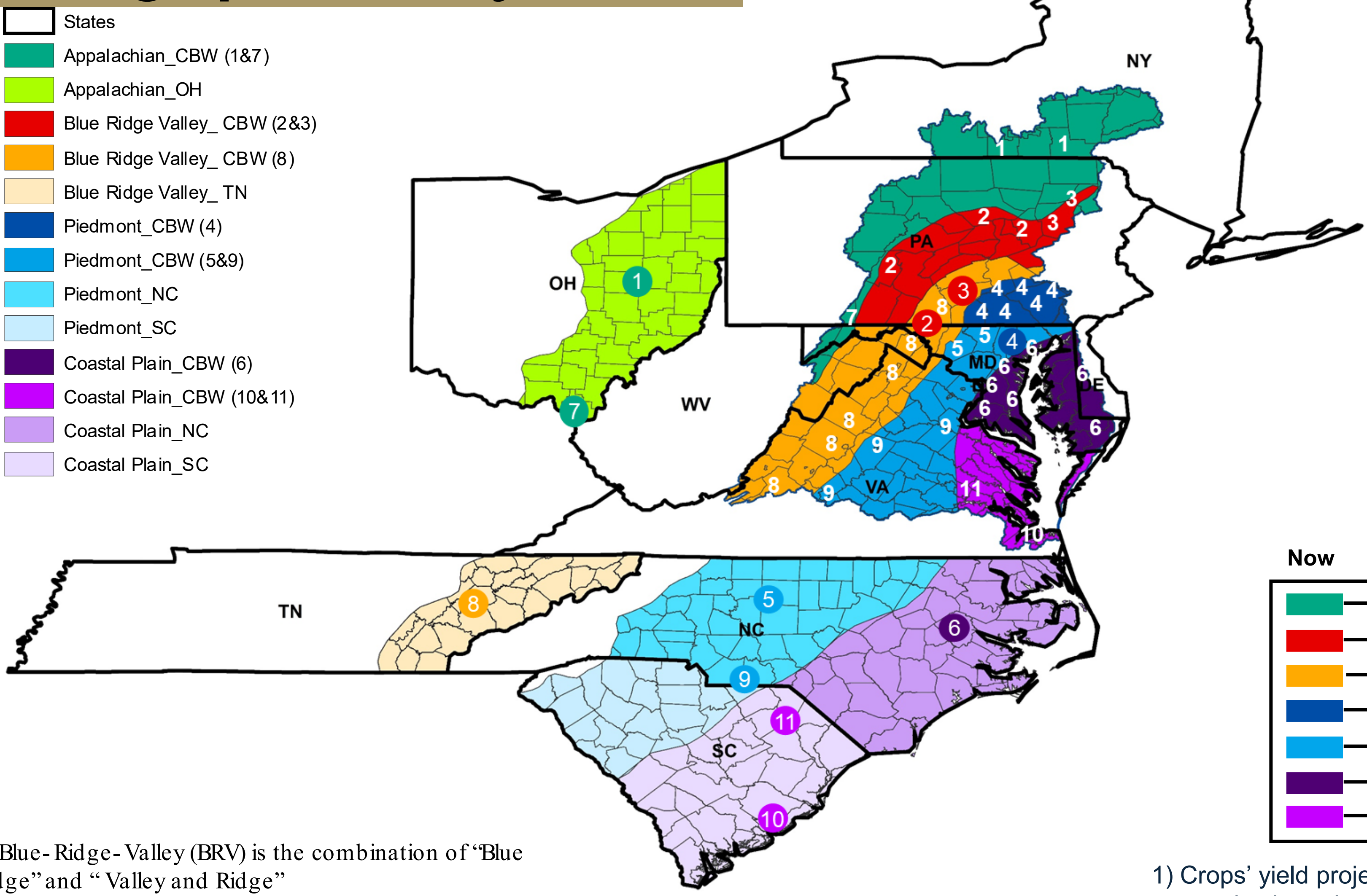


We developed a number of scenarios to test management

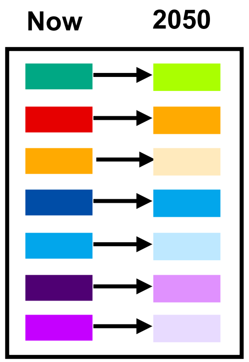
Table 1. Developed Future and Management Scenarios for the Chesapeake Bay Watershed (CBW)

	Scenario Name	Climate	Crop Production Amounts (Weight)	Animal Production Amounts (Head)	Crop Efficiency	Animal Efficiency
Baseline (BS)	**BS**: Baseline	Same as current	Crops' total planting area and production amounts by county from the 2017 Ag Census (USDA-NASS, 2017b).	Animals number by county from the 2017 Ag Census (USDA-NASS, 2017b).	Fertilizer Nitrogen Application rates (FNAr) same as current; Crops' Yield Nitrogen content (YNc) same as current; from literature (Table S2)	Live Animals' Weight gains (LAWg) same as current; Live animals' Feed Conversion Ratio (FCR) same as current; from literature (Table S2)
Future (FS)	**FS-2050 A**: Climate + Crops	Climate analog (Fitzpatrick & Dunn, 2019)	1. Crops' yield projection (2050) for CBW counties based on the climate analog 2. Crops planting area for counties remain the same as the **BS** 3. Crops production amounts for counties = (1) x (2)	Same as **BS**	Same as **BS**	Same as **BS**
	FS-2050 B: Animals	Same as **BS**	Same as **BS**	County total animals' number in 2050 using % per yr growth from Ag Census (Table S3)	Same as **BS**	Same as **BS**
	FS-2050 C: Climate, Crops + Animals	Same as **FS-2050 A**	Same as **FS-2050 A**	Same as **FS-2050 B**	Same as **BS**	Same as **BS**
Management (MS)	**MS-2030 A:** Crop Efficiency	Same as **BS**	Same as **BS**	Same as **BS**	- FNAr to the crops is equal to the **BS** min (Table S2) - crops' YNc crops are equal to the **BS** min (Table S2)	Same as **BS**
	MS-2030 B: Animal Efficiency	Same as **BS**	Same as **BS**	Same as **BS**	Same as **BS**	Animals' LAWg crops are equal to the **BS** min (Table S2) Animals' FCR crops are equal to the **BS** min (Table S2)
	MS-2030 C: Crop + Animal Efficiency	Same as **BS**	Same as **BS**	Same as **BS**	Same as **MS-2030 A**	Same as **MS-2030 B**
Combined (CS)	**CS-2050 D**: Future + Management	Same as **FS-2050 C**	Same as **FS-2050 C**	Same as **FS-2050 C**	Same as **MS-2030 C**	Same as **MS-2030 C**

Some of our scenarios also had climate analog mapping applied to change predicted yeilds



** Blue-Ridge-Valley (BRV) is the combination of "Blue Ridge" and " Valley and Ridge"



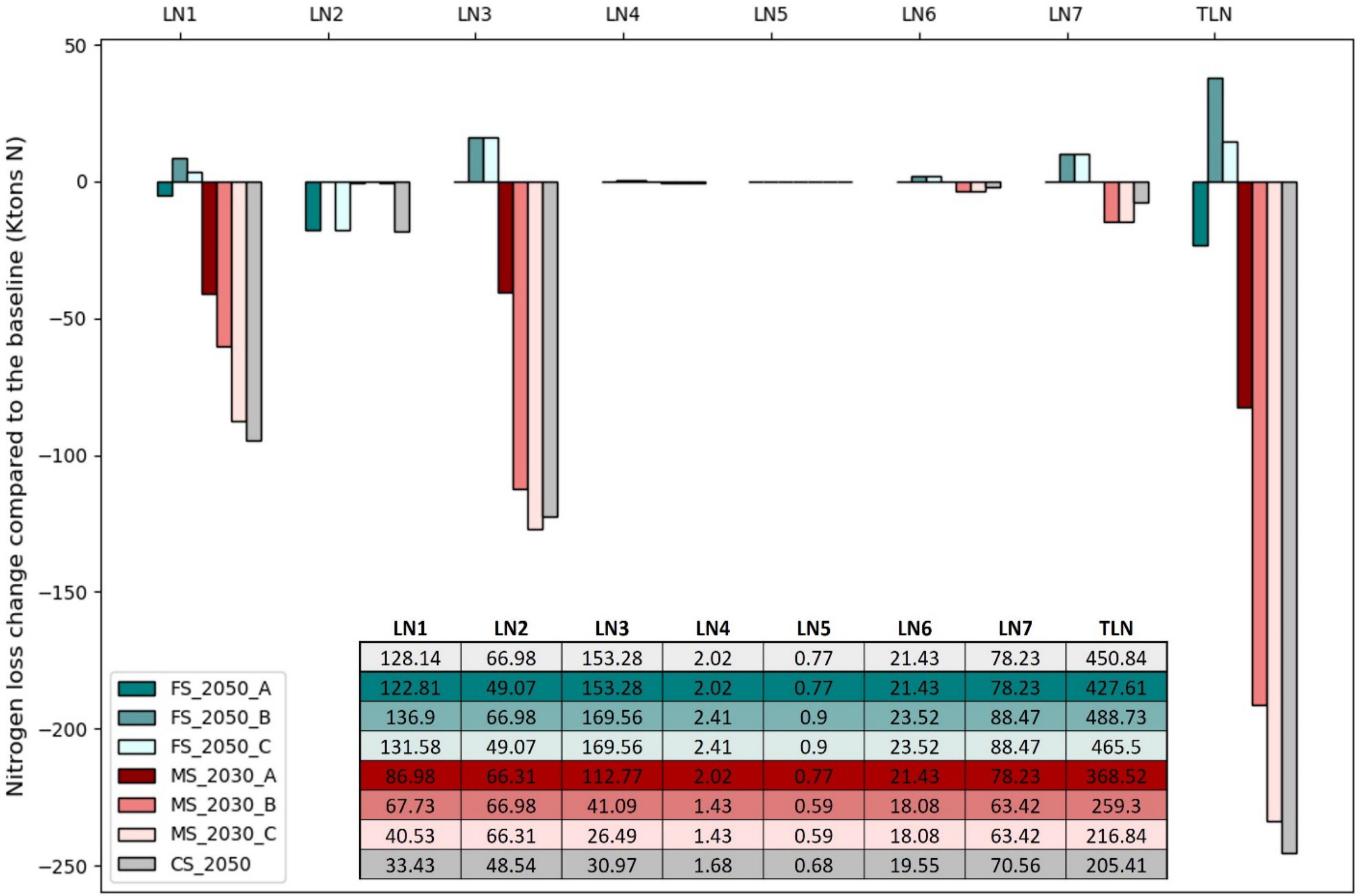
1) Crops' yield projection (2050) for CBW counties based on the climate analog

(2) Crops planting area for counties remain the same as the BS-2030

(1) x (2)

Crop Production (2050)
Projected using climate analog

Our results indicate that the nitrogen loss will continue to be difficult to manage without rethinking the approach



LN1	LN2	LN3	LN4	LN5	LN6	LN7	TLN
128.14	66.98	153.28	2.02	0.77	21.43	78.23	450.84
122.81	49.07	153.28	2.02	0.77	21.43	78.23	427.61
136.9	66.98	169.56	2.41	0.9	23.52	88.47	488.73
131.58	49.07	169.56	2.41	0.9	23.52	88.47	465.5
86.98	66.31	112.77	2.02	0.77	21.43	78.23	368.52
67.73	66.98	41.09	1.43	0.59	18.08	63.42	259.3
40.53	66.31	26.49	1.43	0.59	18.08	63.42	216.84
33.43	48.54	30.97	1.68	0.68	19.55	70.56	205.41