Climate Change and Nontuberculous Mycobacteria

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Background

The intensifying effects of anthropogenic climate change are ongoing and impact life on earth at every level. Anticipated impacts of climate change in the eastern US include sea level rise, precipitation intensity increase, and temperature rise. Researchers have considered how climate change will likely impact the prevalence and persistence of various waterborne pathogens such as *Legionella*, *Salmonella*, and Nontuberculous *Mycobacteria* (NTM). NTM, a group of microbes which includes several opportunistic pathogens, is an emerging public health concern as instances of NTM lung infections have appeared in geospatial clusters at increasing rates in New Jersey and around the world. A comprehensive study on the expected behavior of NTM under climate stressors has yet to be completed.

NTM: What you need to know

1. NTM can be resistant to treatment by disinfectants and antibiotics
2. NTM can be opportunistic pathogens, infecting immunocompromised individuals
3. People encounter NTM through their environment, including drinking water
4. NTM can cause NTM Lung Disease (hard to treat, symptoms are similar to Covid-19)
5. Cases of NTM Lung Disease appear in geospatial clusters (some even in New Jersey!)

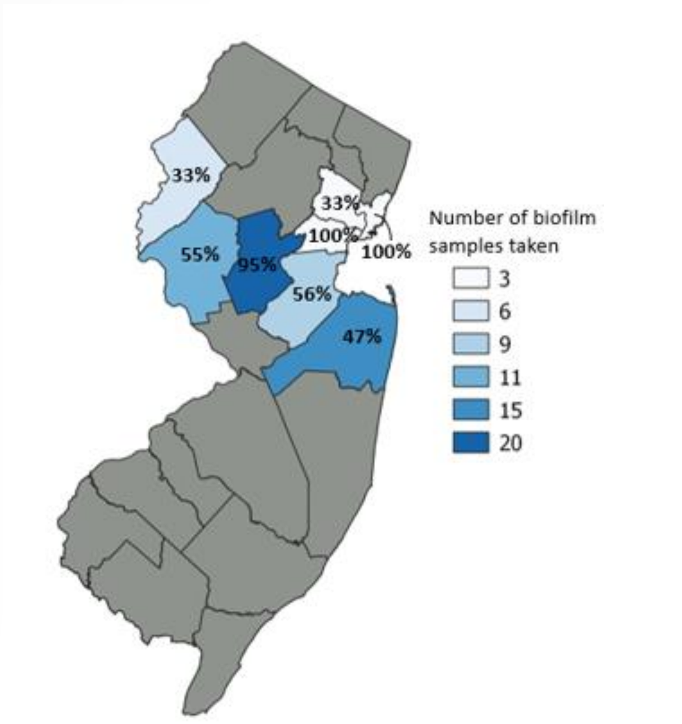

Figure 1. NTM prevalence in biofilms from private groundwater systems, measured via mycobacterium 16S rRNA marker gene, confirmed by 16S rRNA gene amplicon sequencing done in ongoing research.[20]

The objective of this work is to understand the potential effects of climate change on NTM concentrations in NJ's natural water ecosystems by synthesizing climate change and NTM literature, along with GIS mapping data. Climate change stressors explored here include temperature rise, sea level rise and increased precipitation intensity. This work builds upon current work being conducted by members of our group, which found NTM in biofilms from several drinking water systems served by private groundwater wells across the state (Figure1).

Methods

We reviewed the literature using the following search terms in Google Scholar: "Nontuberculous Mycobacteria" AND "climate change", NTM, "nutrient pollution", "sea level rise", "New Jersey land use", and "precipitation" AND NTM. Research published in peer reviewed journals, both new studies and reviews, were included.

Supplemental modeling included the use of SPARROW from USGS for thorough details on nutrient loading and ArcGIS for the most recent data on sea level rise and water pollution. **Figure 2.** above shows two of the models.

Discussion & Future Directions

The results of this review aim to direct future research by highlighting gaps in understanding of the relationship between climate change and NTM prevalence in natural water ecosystems. Topics not covered here but deserving attention include exploring the relationship between increasing humidity and the potential dispersion of NTM in aerosols.[11] Another lingering question given that rising surface temperature can change the selection for microbes such as NTM[3,4,5] is how many historically cooler natural and engineered systems will now be suitable environments for NTM proliferation? A better grasp of NTM transport and conditions that select for the bacteria given evidence that they are found in geographical clusters, could help scientists to predict future hotspots and public health officials to monitor them. A critical next step is understanding how environmental occurrence of NTM will affect its presence in treated drinking water. These findings would provide avenues for recommendations to public health officials seeking to prevent future outbreaks of NTM lung disease as our climate changes.

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Key Findings

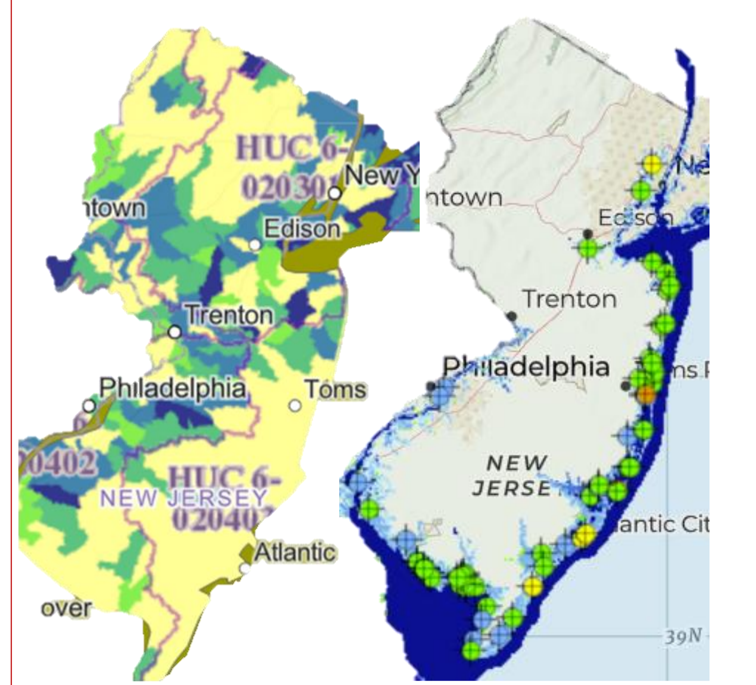

Figure 2. Nutrient pollution (Phosphorous and Nitrogen) distribution in NJ waterways (left) and inundation zones with 1-foot sea level rise (right). Most pollution currently exists in the metropolitan corridor between Philadelphia and New York City. With pressures for humans to migrate inland, pollution may extend as population density increases in currently less populated and less polluted areas. These data have implications for water quality, and NTM, as described in the table below.

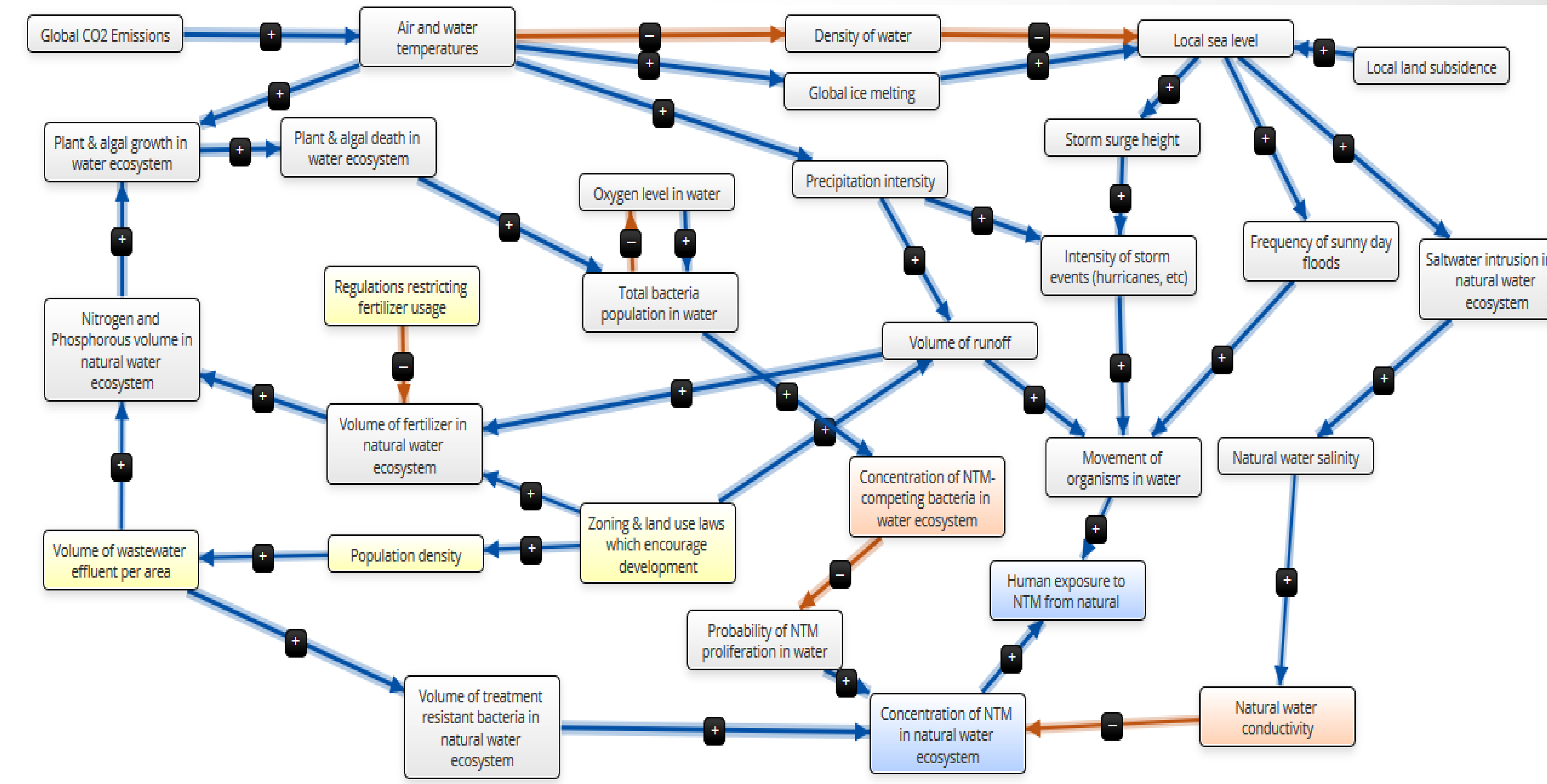

Figure 3. Mental Model of interactions between climate change, NTM, and humans. This model describes the interrelationships uncovered throughout this literature review. Anticipated causal increases are represented by a "+" whereas a negative relationship is represented by a "-".**Table 1** below expands upon these ideas. This model can be used to identify opportunities within the system to make changes, which could, for example reduce NTM exposure.

Table 1. Detailed interactions between indicators of climate change and NTM (connects to the interactions visualized in Figure 3, above)

Climate Change Indicator	Direct or Indirect Environmental Impact	Impact to Water Quality	Relevant NTM behavior	Expected changes to NTM Prevalence	Confidence level	Studied in...
Temperature rise[19]	Biological change in surface and groundwater, direct[1]	Increased plant & algal growth & decay leading to eutrophication and hypoxia[2]	Form pellicles in eutrophic environments, enabling survival in hypoxic conditions, field & bench studies[3, 4, 5]	increase	moderate	Natural and Engineered systems[21,22]
Temperature rise[19]	Biological change in surface and groundwater, direct[1]	Death of some microbes, and preferred selection of others.[12]	Grow rarely, if at all, in cold natural waters (T <15.5 C), bench study[6, 11]	increase	moderate	Natural systems
Sea level rise[15, 19, 23, 24]	Saltwater intrusion inland & into the water table, direct[13, 23]	Increased salinity & conductivity[13]	Found in lower amounts in high salinity waters, field study and bench study[5, 11]	decrease	moderately high	Natural systems
Sea level rise[15, 19, 23, 24]	Increase in sunny day floods & storm surge make the coastal zone inhospitable, forcing human inland migration, increasing population density, indirect[14, 15, 16, 24]	Increased nutrient loads from increased volume of wastewater discharge and leakage, leading to eutrophication and hypoxia[8, 9]	Form pellicles in eutrophic environments, enabling survival in hypoxic conditions, field & bench studies[3, 4, 5, 10]	increase	moderately high	Natural and Engineered Systems[8]
Precipitation intensity increase[18, 19]	Increased runoff volume to streams and lakes, direct[17]	Increased turbidity & nutrient load, leading to eutrophication and hypoxia[9, 17]	Attach to suspended particles to survive, & survive well in hypoxic waters, field and bench studies[3, 4, 5, 10]	increase	moderate	Natural systems

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