Climate Change Effects on Invasive Plant Cover in Mid-Atlantic Wetlands

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Abstract

Climate change can negatively impact ecosystems and the people dependent on the services ecosystems provide. Freshwater wetlands are one example of an ecologically sensitive landscape feature, which can be impacted by changes to the magnitude and timing of precipitation and flooding events. This research investigates how climate change driven alterations to wetland hydrology impacts invasive plant species in the Mid-Atlantic Region (MAR) by identifying correlations between previously collected ecological condition assessment data from surveys spanning multiple ecoregions across the MAR. Correlations extracted from the data highlight relationships between the invasive plant species cover and indicators of wetland hydrology. Results showed different patterns of invasive plant species coverage by State and the Riverine and Isolated Depression wetland sites with most observed indicators of wet conditions had the least invasive species cover. The information gained from this project will aid in understanding the future impacts of climate change on wetlands and be used to inform land managers and policymakers.

Introduction

Climate change is frequently described as an increase in annual global temperature, however smaller-scale changes to seasonal temperature and precipitation norms can have a significant impact on ecosystems. Human actions are driving climate change by emitting carbon dioxide (CO2) into the atmosphere, leading to many unwanted changes. These actions, including driving cars that run on gasoline, greenhouse gas emissions from factories, and use of electricity that is not generated from green energy sources lead to increasing levels of greenhouse gas (GHG) emissions, particularly CO2, leading to a warming of the Earth's atmosphere (Pennsylvania Department of Environmental Protection, 2015). These environmental changes can include an increase or decrease in precipitation, floods, drought, ice caps melting, wildfires, and stronger storms, these changes will continue to get worse over time (Pennsylvania Department of Environmental Protection, 2015). The aforementioned consequences have a tremendous effect on the environment which is a delicate system requiring balance (Abler, Blumsack, Shortle, 2015), climate change alters that balance forcing environments to adapt or be destroyed.

Seeing that climate change can have a major effect on the environments led us to investigate the question, how will climate change driven alterations to wetland hydrology impact invasive plant species in Mid- Atlantic wetlands? Wetlands are a unique and fragile landscape feature that requires a specific hydrology pattern which climate change is altering.

During my research I looked at ecological assessment data from wetlands adjacent to streams in agricultural landscapes in Pennsylvania (PA), Maryland (MD), Virginia (VA), and long-term study watersheds wetlands in Pennsylvania (PA), with the goal of identifying potential correlations between climate change driven hydrology patterns and wetland vegetation. By examining invasive species and hydrology in these wetlands, the hope is that it will give us more information on how wetlands will react to climate change. Invasive plant species are more prevalent in disturbed areas which are experiencing landscape or hydrology changes. The focus of my research is to determine if climate change alters wetland hydrology and how the change in that hydrology effects invasive species cover in the wetlands. This information is beneficial because it will provide insight into how potential climate change driven droughts could impact invasive vegetation species cover in wetlands. We hypothesized more invasive plants will be found at wetland sites where drier conditions are observed compared to wetland sites where wetter conditions are observed. The take away from this research is to find a correlation between hydrology conditions expected to arise from climate change and invasive plant species found in wetlands. In the future, we hope to be able to predict what might happen to other wetlands as climate change intensifies. These findings are important given the numerous ecosystem services, which include water quality improvement, flood control, and nursery areas for aquatic species. If wetland conditions continue to decline these ecosystem services will no longer be provided to our communities. That loss of function would cause us to find new, man-made ways to perform tasks which were previously done by properly functioning wetland ecosystems. In doing this research we hope to find broad or species-specific correlations, to better inform land managers and program administrators.

Methods

Our research approach was to focus on opposite ends of the observed hydrology spectrum, either extremely wet or extremely dry conditions. The first step was to construct a list of invasive plant species appearing in the ecological assessment data. This species list was then separated by state, ecological region, stream order, and wetland type. Invasive species profiles were created for invasive plants found in the assessed wetlands and included specific life cycle characteristics including bloom time, condition (e.g. hydrology, sunlight) needed to live, place of origin, seed life in soil, invasiveness, and how many seeds are produced. This data will aid in the understanding the invasiveness of the plants, what conditions are needed for them to out-compete native plant species, and if patterns or frequency of invasive plant species exists between groups of wetlands.

The next step was to assess wetland hydrology. This entailed looking at ecological assessment data from each site and quantifying indicators of wet conditions (Extreme, Moderate, Somewhat). This was done by tallying up the numbers of each indicator of hydrology individually and in severity-based groups. Tallying up these indicators helped to better understand the site hydrology. We then examined the data for the invasive species cover at each site, grouped them into categories of <5%, 5-20%, 20-50%, and >50%, and assigned number categories (<5% is Category 1, 5-20% is Category 2, 20-50% is Category 3, and >50% is Category 4).

Then, each sites' total invasive species cover was assessed and assigned a category. This process then was also applied to individual invasive species cover of each site.

We then compared and quantified the indicators of hydrology conditions at the sites to the invasive species profile and cover categories, to determine if there is a relationship between locations considered extremely wet sites and invasive species abundance. The ecoregions we considered in our study were the Appalachian Plateau, Piedmont, Ridge and Valley, and Coastal Plain. The wetland types included in our study are Riverine, Headwater Floodplain, Mineral Flat, Fringe, Depression, and Slope. This was used to determine if there are more invasive species in certain ecoregions or wetland types.

Results

We first looked at the frequency of the invasive species for each state and landscape focus area and saw all four groups have the invasive plant species multiflora rose in common. Figure 1 also indicated that streamside wetlands in PA agricultural landscapes had a higher frequency of invasive species than the PA sites from a long-term study watershed. The third finding in the profile showed that all four projects had different invasive species frequency and different invasive species.

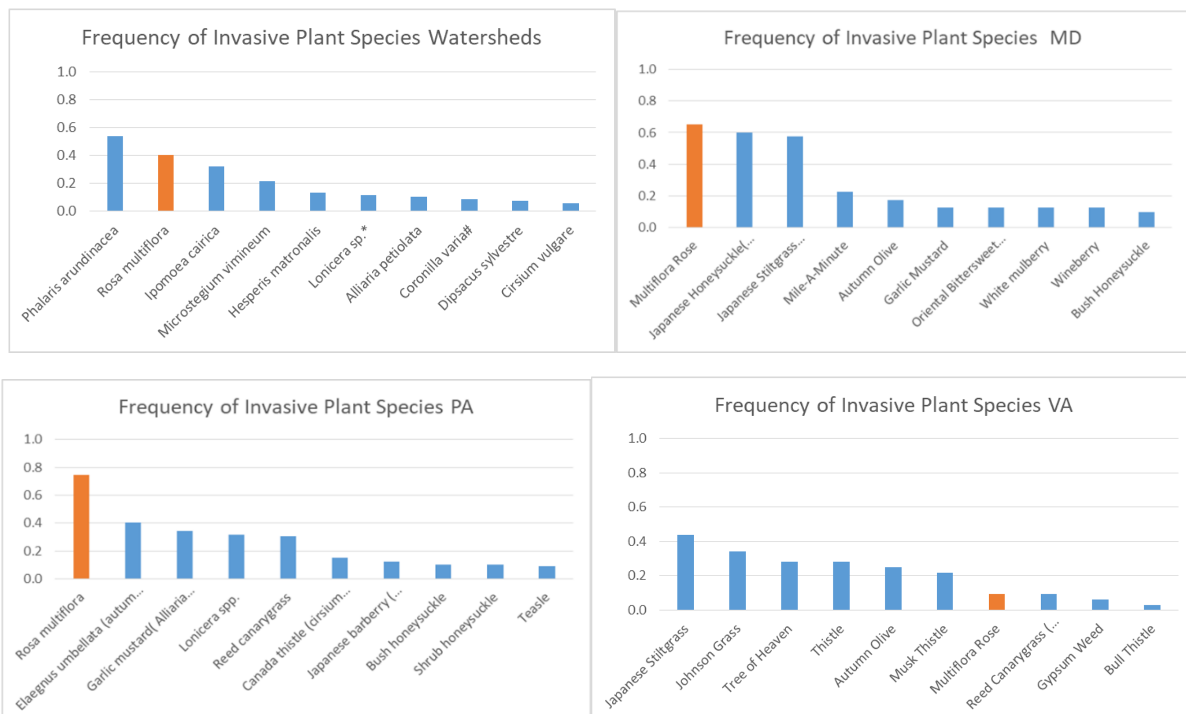
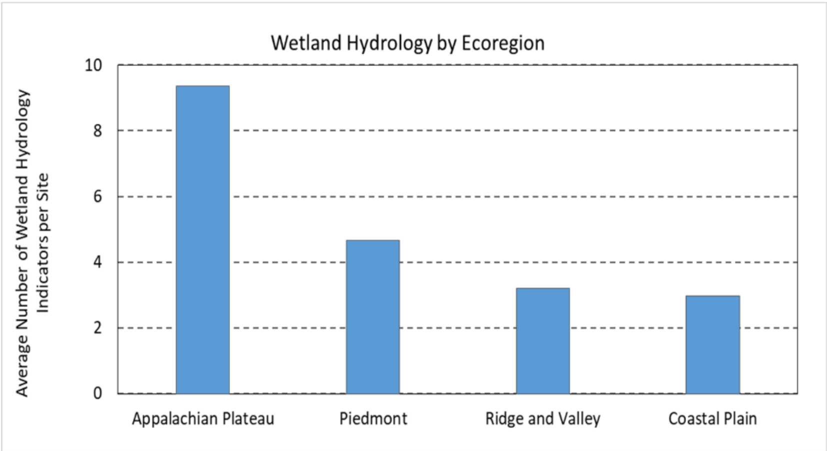


Figure 1: Frequency of invasive species for the four projects. Multiflora Rose is indicated using orange.

Key for figure 1:

Top Left Graph	Frequency of invasive plant species for long-term study Watersheds Wetlands in Pennsylvania
Top Right Graph	Frequency of invasive plant species for Wetland adjacent to streams in agricultural landscape in Maryland
Bottom Left Graph	Frequency of invasive plant species for Wetland adjacent to streams in agricultural landscape in Pennsylvania
Bottom Right Graph	Frequency of invasive plant species for Wetland adjacent to streams in agricultural landscape in Virginia

When comparing hydrology indicators across ecoregions, the Appalachian Plateau had the highest frequency of wet indicators and the Coastal Plain had the lowest frequency of wet indicators. When comparing average invasive plant species cover across ecoregions, we found that Appalachian Plateau had the lowest invasive species cover. This shows an inverse correlation between the number of observed wet indicators and average invasive plant species cover across the ecoregions in our study.



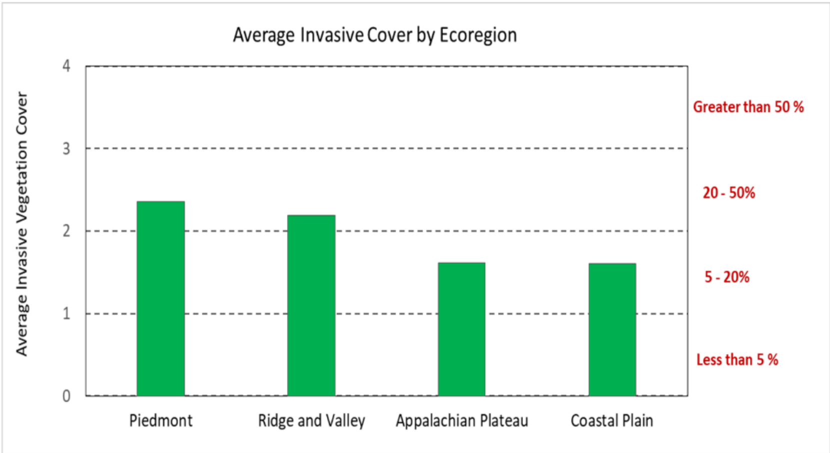
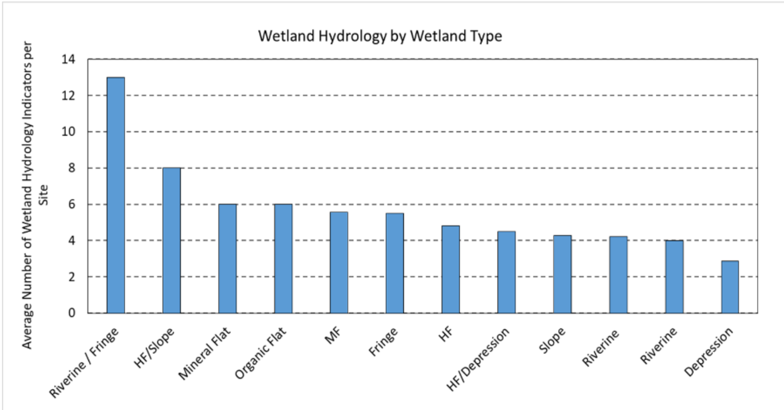


FIGURE 2: The graph on top shows the amount of wet indicators for each ecoregion. The graph on the bottom shows the invasive species cover in the category for each ecoregion.

The results from comparing wet indicators and wetland type revealed Riverine/ Fringe wetlands have the highest amount of wet indicators and Headwater Floodplain / Depression wetlands has one of the lowest frequencies of wet indicators. When average invasive plant species cover was compared with wetland type, we found Headwater Floodplain / Depression has the highest amount of invasive species cover and Riverine/ Fringe has one of the lowest average invasive plant species cover. This shows an inverse correlation between wet indicators and average invasive plant species cover for this wetland type.



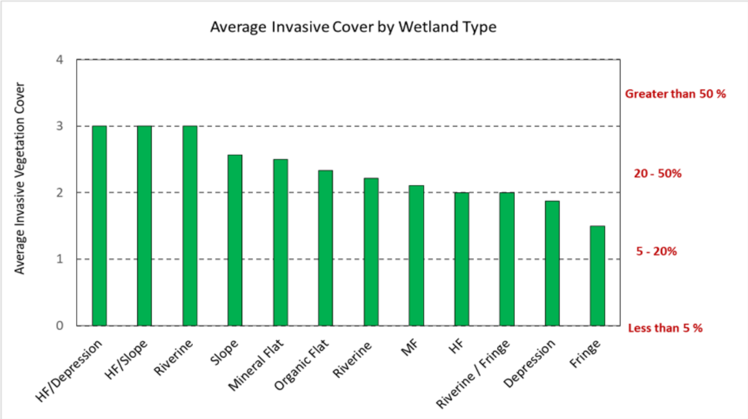


FIGURE 3: The graph on top shows the amount of wet indicators for each wetland type. The graph on the bottom shows the invasive species cover in the category for each wetland type.

The most significant finding in this research project is the link between hydrology indicators and invasive plant species cover. The results from grouping sites by state showed the differences between PA, VA, and MD were not significant. Even with the small differences, the data showed that sites with less wet indicators had 20% invasive vegetation cover and sites with more wet indicators had 10% invasive vegetation cover. When we compared wetland type by ecoregion we found that sites with the wettest conditions had 5% or less invasive cover. While sites with less wet indicators had 20% or more invasive species cover. This correlation was observed in Riverine and Isolated Depression wetlands in the Appalachian Plateau, Coastal Plain, Piedmont, and Ridge and Valley ecoregions.

Discussion

The results from the invasive plant profile indicated there is a difference in the type of invasive vegetation found in each state and landscape type. This means there will likely be a difference in how these locations respond to hydrology changes caused by climate change or new management practices in these areas. Figure 1 shows multiflora rose is a common invasive species across all study areas in the MAR and indicates region-wide attention is required. Figure 1 also indicates that constructed wetlands adjunct to agricultural streams in PA have a higher invasive species frequency then sites from more diverse locations in these long-term study watersheds. These results are significant because wetlands adjunct to agricultural streams in PA in this study were all man-made wetlands, which are normally more vulnerable to invasive plants due to the recent landscape disturbance. The analysis of hydrology indicators and average invasive plant species cover by ecoregion showed that wet indicators and average invasive plant species cover have an inverse relationship. This was also true for wetland type in comparison with wet indicators and average invasive species cover. This is most likely due to the ecoregions like Appalachian Plateau being in a less disturbed area making it less vulnerable to invasive vegetation.

Analysis comparing site hydrology to invasive cover by state did not show a strong correlation, which we can interpret as there is probably not much effect on the wetland condition caused by state management practices. For ecoregion and wetland type, the research showed a strong correlation between wet indicators and invasive plant cover, which was 5 % for sites with the most wet indicators and 20% for sites which had the least wet indicators. We can infer for the wetland types that showed this correlation (riverine and isolated depression) that if climate change results in lower groundwater levels, invasive species cover will increase.

The results of this research could have many implications going forward. It can be used to aid in future design and construction of wetlands. Additionally, knowing which areas have been more affected by invasive species, can aid in selecting more sustainable sites for constructed wetlands. These results will also influence the management of the wetlands, by letting groups which manage wetlands know which sites require frequent attention, money, and time to maintain. This will also help environmentalist in understanding how wildlife habitats will be affected by changes in wetland vegetation. If wetland function degrades dues to climate change, quality of nearby bodies of water could also be negatively affected. This could help better inform groups focused on measures to improve water quality. Lastly, the results of this research can be used to help policymakers make informed decisions for the environment and the communities surrounding these ecosystems.

Conclusion

At a broad scale, our hypothesis was not proven, however the results of this project will be beneficial as we continue to further understand how climate change is impacting specific wetland types and ecoregions. This research project has highlighted some important effects of climate change on wetland hydrology it also brought to light other factors and questions which need answers as we move forward in protecting our environment. Some additional questions which need to be considered include: How stressors impact the MAR wetland vegetation? How will wetland vegetation not in the MAR be impacted by climate change? How can management be improved in constructed wetlands? and How will extreme wet conditions impact invasive vegetation cover? Overall this project has aided in the progression of understanding how climate change will affect wetlands.

Acknowledgements

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