Prioritizing Vernal Pool Conservation In Central Massachusetts

Michael Jordan

Abstract

Massachusetts state law protects vernal pools from development. However, this protection is contingent on a pool being certified, which can only be requested at the discretion of private citizens. To help private citizens prioritize pool certification requests, this paper uses cluster analysis to identify hot spots of high conservation value pools in MassGIS potential pool data.

Introduction

Vernal pools are ephemeral bodies of water, often geographically separate from other wetlands, that typically fill in the spring and evaporate by summer (Burne & Griffin, 2005). Because vernal pools are not filled continuously, they do not support breeding fish populations, which makes them critical habitat for amphibian and invertebrate species that cannot reproduce in the presence of fish predation (Burne & Griffin, 2005). In the state of Massachusetts, such obligate habitators of vernal pools include the wood frog (*Lithobates sylvaticus*), several species of mole salamanders (*Ambystoma* spp.), and various fairy shrimp species (*Eubranchipus* spp.) (MA DFG, 2009). Without vernal pools, these species would be under high risk of local extinction and others that use the pools on a facultative basis would face additional pressure.

Because of their significance as critical wildlife habitat, vernal pools are protected under the Massachusetts Wetlands Protection Act (WPA), which establishes that development is not permitted within 100 feet of a vernal pool's boundary (i.e., water line) (MA DFW, 2009). However, a pool must meet two criteria to qualify for WPA protection. First, it must exist within 100 feet of a wetland under WPA jurisdiction (MA DFW, 2009). Second, it must be certified by the Natural Heritage and Endangered Species Program (NHESP) as functioning biologically as a vernal pool (MA DFW, 2009). Fortunately, WPA wetland jurisdiction is fairly broad. But, the requirement that vernal pools be certified does significantly constrain their protection.

The reason for this is that the Massachusetts government does not actively pursue vernal pool certification, but instead relies on private citizens to do so (MA DFW, 2009). If a citizen would like to request certification of a potential vernal pool, they must visit the pool, collect biological data demonstrating the presence of certain species, and submit them to the NHESP. The lack of an active certification process has left potentially tens of thousands of potential vernal pools unreviewed (per MassGIS data). This number of pools presents a prioritization problem. Which pools should interested citizens review first?

In this analysis, I aim to help focus vernal pool conservation in Massachusetts by identifying potential vernal pools that should be prioritized for review because they are more likely to receive WPA protection, face higher threat from development, or can be reviewed more efficiently based on their geographic clustering.

Methods

I completed this analysis using R version 4.3.2 (see Rmd for full code). I focused on three towns in Central Massachusetts: Berlin, Bolton, and Hudson. I downloaded vectors for municipal boundaries, potential vernal pools, certified vernal pools, wetland boundaries, and land cover/use from MassGIS on January 18, 2024. Pools were represented as geo points identifying the center of a pool and are dated to 1993-2000. Wetlands and land cover/use were represented as polygons and are dated to 2005 and 2016 respectively. Because the potential pool data set was not mutually exclusive from the certified pool data set, potential pools that are likely to represent certified pools were excluded based on proximity to certified pools. Vectors were plotted in the NAD83 / Massachusetts Mainland projection and visually inspected for errors.

To proxy for the threat each pool faces from human development, I measured the distance from each potential pool to the nearest land cover/use vector that could be expected to threaten the biological functioning of a pool (e.g., roads or industrial buildings). I defined this set of vectors based on NOAA C-CAP land cover/use codes (see Rmd for code mapping). I refer to this as the set of "impervious features."

To proxy for the likelihood that a potential pool contains certifiable species, I used hierarchical cluster analysis with a single linkage fusion strategy to identify networks of pools that were no farther from each other than the expected dispersal distance of one such species, the spotted salamander (*Ambystoma maculatum*). I set this distance at 150m based on the average dispersal distance of spotted salamanders in a radio telemetry study in Connecticut (McDonough & Paton, 2010). The idea behind this approach is that pools connected to each other within this distance could sustain a metapopulation that travels between pools.

Because the boundary of a pool must exist within 100 feet of a wetland for the pool to receive WPA protection, I evaluated each pool's proximity to a wetland. Potential pools that were within 115 feet of the nearest wetland were deemed to be candidates for certification. The rest were excluded. This cut off was based on the 100 foot WPA jurisdiction threshold, plus 15 feet of imprecision in potential pool vectors (Burne, 2001).

To flag potential pools that are geographically close together and so could be reviewed efficiently, I grouped potential pools by running a hierarchical cluster analysis using a single linkage fusion strategy. I segregated clusters based on a threshold of 1/4 of a mile, ensuring that no two pools in a cluster will be more than 1/4 of a mile apart. This threshold was arbitrary, but seemed reasonable to keep pool clusters feeling contiguous.

Finally, I computed a prioritization index for each potential pool cluster based on an equal weighting between whether the cluster contained a pool within the dispersal network of a certified pool, the average distance to the nearest impervious feature among pools in the cluster, and the number of pools in the cluster.

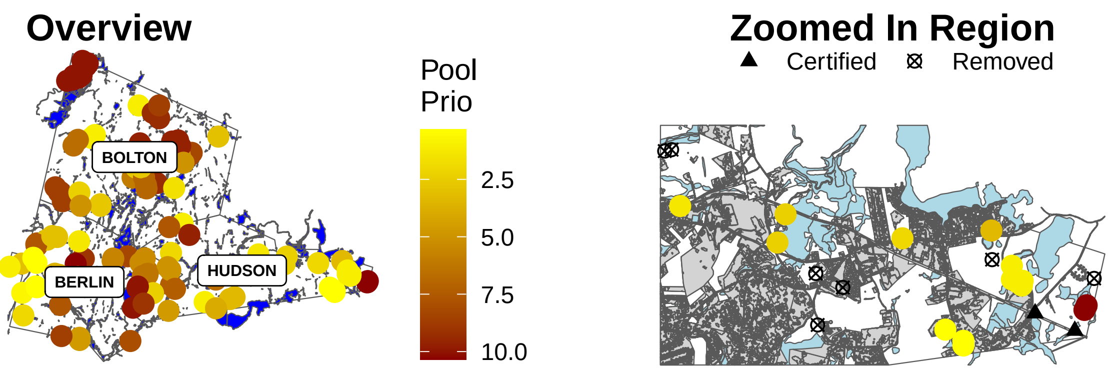
Discussion

The most obvious caveat to the above analysis is the old adage "garbage in, garbage out." Because it combines data from different time periods, some several decades in the past, results may not reflect current conditions. Wetlands and vernal pools may have shifted boundaries, disappeared, or been developed over since the data were derived. There may also be bias in the potential pool data itself, since it was based on visual inspection of aerial photography, which is open to human error. The NHESP was able to validate that the false positive rate was low in trials (less than 3%), but it was unable to validate the false negative rate (Burne, 2001). It could be high because pools below ~50-60 feet in diameter could not be reliably identified (Burne, 2001).

The more critical caveat is that this analysis is very back-of-the-envelope. Proxy metrics, thresholds, and index design were informed by the literature where possible, but were fundamentally arbitrary and unvalidated.

Results

54 potential pools (31%) were excluded because they were not in close enough proximity to a wetland to fall under WPA jurisdiction. Using the remaining 125 pools, I produced a map that identifies hot spots of high value potential pools (coded in a heat map with more yellow colors indicating higher value). To validate that outcomes seemed reasonable, I also produced a zoomed in map and confirmed that removed pools were far from wetlands and high value pools tended to be clustered and close to certified pools.



Conclusion

This analysis could be expanded in several ways. Covering the entire state would be valuable and would simply require more computational power. I'd also like to move beyond the MassGIS data based on aerial photography, which, as mentioned, likely has high false negative rates. Lidar mapping has been shown to accurately identify vernal pools and could be used to expand my data set (Qiusheng, Lane, & Hongxing, 2014).

But, most critically, I'd like to move beyond unvalidated back-of-the-envelope indexing and create a statistical model to predict which potential pools are likely to be strong certification candidates. To do this, I would require data on pools that were submitted for review and the certification and WPA jurisdiction outcomes of that review. Perhaps in the future such data could be compiled in partnership with citizen groups.

Reference List

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Working Style Assessment