Ecological trends of *Ulmus americana* in the Upper Mississippi River Floodplain Forest

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Abstract

The Upper Mississippi River Floodplain Forest (UMR-FF) is located in the heart of the driftless region, an ecological system unique to the Midwest defined as an area unaffected by glacial drift from the last North American continental glacier. This diverse region is home to several characteristic plant species including the endangered American elm (*Ulmus americana*). Studies have determined significant ecological shifts as the UMR-FF's historically dominant tree species and understory species have changed, creating intermittent habitats and raising concerns for tree regeneration of the American elm. In analyzing a UMR-FF inventory dataset and considering a variety of parameters (pool location and American elm canopy class, health class and diameter at breast height), differences in parameter characteristics were determined to reflect changes between pool locations, revealing shifting ecological trends. There are multiple factors, including understory invasive species and deer herbivory, that may influence native tree regeneration, but we require additional data to understand the impacts on the American elm and the historically prominent tree species of the UMR-FF.

Introduction

- The fungal pathogen *Ophiostoma ulmi* is the causal agent of Dutch-elm disease (DED) that contributed to massive losses of American elms across North American forests (Dunn 1986; Newhouse et al. 2007).
- Wisconsin's hardwood forests have been impacted by the absence of the broad crown of the American elm, contributing to potential forest regime shifts as open canopy gaps from American elm absence were suitable for new species growth (Dunn 1986; Thomsen et al. 2017).
- Invasive species such as *Phalaris arundinacea* (reed canary grass) have been found to exploit canopy gaps, leading to concerns of native tree regeneration as invasive species outcompete native understory growth (Thomsen et al. 2017).
- Analysis of a recent forest inventory dataset of the UMR-FF may provide answers for conservation concerns by recognizing trends throughout pool locations.

Methodology

The UMR-FF forest inventory was conducted for the Mississippi River Project, St. Paul District where land was surveyed between Mississippi River mile 808.5 south of Hastings, MN (pool 3) and river mile 614 near Guttenberg, IA (pool 10) (Figure 1). The lands surveyed were located in the river floodplain and accessed mainly by boat. All data for this inventory analysis were collected as part of the US Army Corps of Engineers Phase Ⅱ forest inventory process.

Figure 1. The Upper Mississippi River pools 1 through 13. Photo was retrieved from: https://umesc.usgs.gov/rivers/upper_mississippi/reach_1/sel_a_pool_r1.html

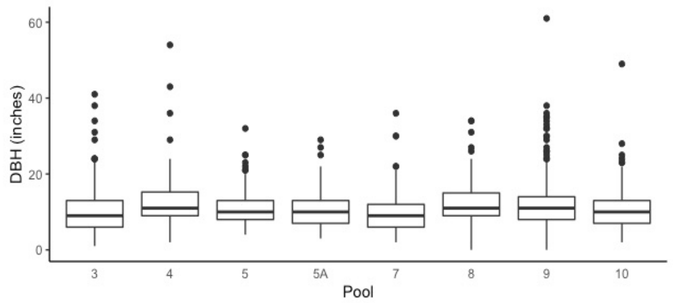

Figure 2. Diameter at breast height (DBH) of the American elm within each pool location (sample sizes in Table 1). Each box represents the 2nd and 3rd quartile (upper and lower, respectively) of the DBH with the respective pool. Whiskers represent the 1st and 4th quartile (upper and lower, respectively) of the DBH with the respective pool. Bolded horizontal bars within each box represents the median DBH per pool. Black points represent DBH outliers.

Table 1. American elm individual count per pool location.

Pool	Count
3	193
4	96
5	262
5A	200
7	217
8	106
9	587
10	517
Total	**2178**

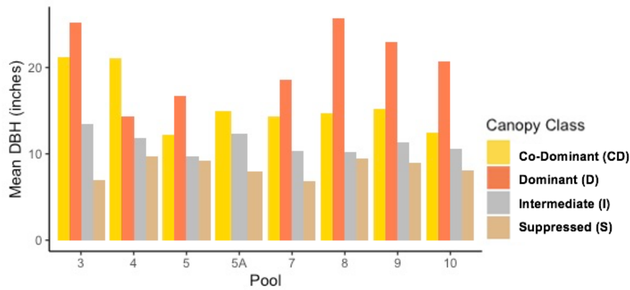

Figure 3. Mean diameter at breast height (DBH) of American elm classified by canopy class per pool location (sample sizes in Table 1).

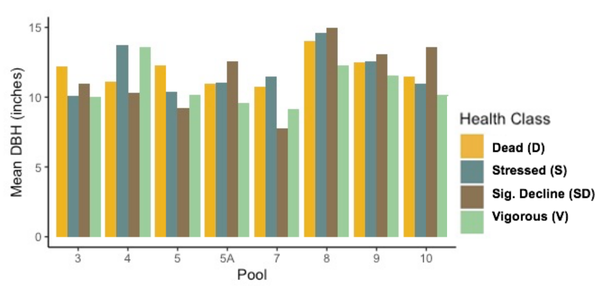

Figure 4. Mean diameter at breast height (DBH) of American elm classified by health class per pool location (sample sizes in Table 1).

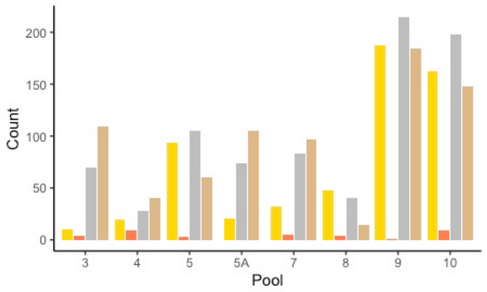

Figure 5. Count of American elm observations classified by canopy class in respective pool locations (sample sizes in Table 1; see Figure 3 for legend).

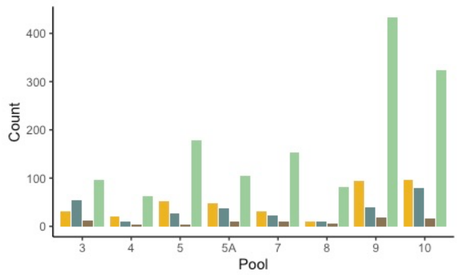

Figure 6. Count of American elm observations classified by health class in respective pool locations (sample sizes in Table 1; see Figure 4 for legend).

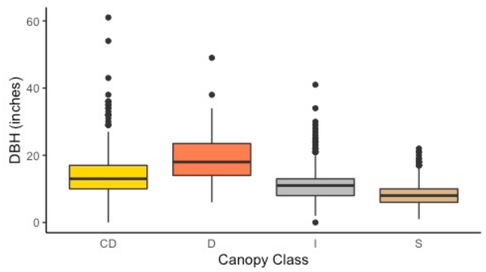

Figure 7. Diameter at breast height (DBH) of American elm per canopy class (sample sizes in Table 1; see Figure 3 for legend). Each box represents the 2nd and 3rd quartile of the DBH with the respective canopy class. Whiskers represent the 1st and 4th of the DBH with the respective canopy class. Bolded horizontal bars within each box represents the median DBH per canopy class. Black points represent DBH outliers.

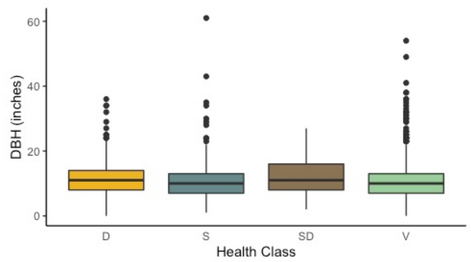

Figure 8. Diameter at breast height (DBH) of American elm per health class (sample sizes in Table 1; see Figure 4 for legend). Each box represents the 2nd and 3rd quartile of the DBH with the respective health class. Whiskers represent the 1st and 4th quartile of the DBH with the respective health class. Bolded horizontal bars within each box represents the median DBH per health class. Black points represent DBH outliers.

Data Analysis

Because of the number of missing factorial combinations for the main factors of pool, canopy class, and health, two-way ANOVAs of all pairwise combinations of the effects of the main factors and their interactions on American elm DBH were performed. Associations between all pairwise combinations of pool, canopy class, and health were examined using chi-square analyses. All statistical analyses were performed in RStudio (RStudio Team 2020).

Results

- **Canopy Class and Interactions**

Canopy class is contingent upon pool location (χ^2 = 237.68, df = 21, p < 0.001) with a larger aggregation of healthy canopies associated with the southern pools 9 and 10 (Figure 5). Mean DBH differs significantly by canopy class in all classes ($F_{(3,\ 2174)}$ = 203.8, p < 0.001, ANOVA) (Figure 7). The interaction between canopy and pool has a significant effect on elm DBH ($F_{(20,2147)}$ = 7.180, p < .001, ANOVA) (Figure 3).

- **Health Class and Interactions**

Health class is contingent upon pool location (χ^2 = 108.32, df = 21, p < 0.001) with a larger aggregation of healthy individuals associated with the southern pools 9 and 10 (Figure 6). Mean DBH differs significantly between Vigorous and Dead health classes ($F_{(3,\ 2174)}$ = 5.225, p = 0.00136, ANOVA) (Tukey) (Figure 8). The interaction between health and pool did not have a significant effect on DBH (Figure 4).

- **Pool and DBH**

Pool location had a significant effect on DBH ($F_{(7,\ 2170)}$ = 8.8354, p < 0.001, ANOVA) where southern pools 8, 9, and 10 had the highest DBH (Figure 2) and highest American elm tree count (Table 1).

Conclusion

- Overall trends show a decline in healthy elm populations in northern pools 3 to 8 of the UMR-FF when compared to southern pools 9 to 10.
- Possibly explanations for the north to south trends could be attributed to temporal changes, DED infection rates or invasive species competition rates of spread.
- With the absence of the American elm's spanning crown, the UMR-FF is facing a change in understory species leading to subsequent shifts in all tiers of forest vegetation.

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