National Park Service
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Natural Resource Stewardship and Science

Forest Health Monitoring at Mississippi National River and Recreation Area

2022 Field Season

Natural Resource Data Series NPS/GLKN/NRDS—2023/1400

ON THE COVER
Clockwise from top left: Floodplain between the Mississippi and Vermillion Rivers (NPS); trunk of Kentucky coffeetree (*Gymnocladus dioicus*) (NPS); transect line through wood nettle (*Laportea canadensis*) (NPS); collecting diameter at breast height measurements (NPS).

Forest Health Monitoring at Mississippi National River and Recreation Area

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Natural Resource Stewardship and Science
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The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

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Executive Summary

The Mississippi National River and Recreation area (MISS), situated along a 116 km stretch of the Mississippi River through the Minneapolis and St. Paul urban corridor, encompasses ~21,800 ha of public and private land. In 2022, the Great Lakes Inventory and Monitoring Network (GLKN) resampled permanent forest monitoring sites in the park, marking the second assessment of these sites, which were established and initially sampled in 2011. The goal of this long-term monitoring project is to provides managers with routine updates on which to base management decisions; these data can also be used to tease apart impacts and elucidate causal agents when novel problems or situations arise.

We initiated a comprehensive forest monitoring program at MISS in 2011, establishing 33 sites at that time. High water levels during our sampling window that year precluded sampling on many of our planned sites while on others, water levels had only recently subsided. Here, the full complement of herbs had not yet emerged. In 2022, we resampled existing sites and established additional locations, bringing the total to 50. Sampled and derived metrics included trees (density and basal area of live trees, seedlings, and snags (i.e., standing dead trees)), understory (herb and shrub frequency), browse (bite marks on woody species and presence and height of herbaceous species), and taxa richness. We classified sites into four broad forest types using the newer (2022) dataset, resulting in two upland types (upland rich, upland disturbed) and two floodplain types (box elder-dominated and silver maple-dominated). Because of sampling difficulties in 2011, we are only comparing tree, sapling, and snag data between years.

At upland rich sites, overall tree (≥ 2.5 cm diameter at breast height [DBH]) density declined 22%, while that for just the small sapling component (≥ 2.5 cm, < 5 cm DBH) fell 41%. Species experiencing notable losses include basswood (*Tilia americana* L.), elm (*Ulmus* L.), bitternut hickory (*Carya cordiformis* (Wangenh.) K. Koch), and red oak (*Quercus rubra* L.). All three resampled sites are located in Spring Lake Park Reserve and subjected to high white-tailed deer (*Odocoileus virginianus* Zimm.) browse pressure.

We sampled seven sites in upland disturbed forests, where overall tree density fell 17% from 778 ± 215 trees/ha to 648 ± 72 trees/ha, largely due to declines in elm, ash (*Fraxinus* sp. L.), and hackberry (*Celtis occidentalis* L.). While changes in black cherry (*Prunus serotina* Ehrh.) mirrored this pattern in diameter classes above 5 cm, density of saplings increased 12-fold, largely due to a swamping effect from one site, possibly in response to buckthorn (*Rhamnus cathartica* L.) removal.

In the nine box elder-dominated sites, overall tree density declined from 635 ± 47 in 2011 to 500 ± 58 trees/ha in 2022, mainly reflecting changes in box elder (*Acer negundo* L.), elm, and silver maple (*Acer saccharinum* L.). In these sites, density of large (≥ 30 cm DBH) snags increased from 2.5 ± 1.6 to 11.1 ± 4.4 snags/ha. In silver maple-dominated floodplain forests, tree density in the 12 sites fell from 421 ± 63 to 291 ± 23 trees/ha, with declines observed in all five dominant species. Sapling density was low in these sites, falling from 62.6 ± 36 in 2011 to 23.6 ± 11 saplings/ha in 2022.

Our observations likely reflect both deer browse and alteration of the flow regime by river impoundment. At upland sites, deer browse is impeding regeneration of all major upland species: red oak, bitternut hickory, basswood, and elm. While browse is also occurring in floodplain sites, prolonged inundation may play a larger role in regeneration failure here. Saplings of silver maple, box elder, cottonwood, elm, and hackberry all have some degree of susceptibility to inundation, ranging from moderate tolerance to completely intolerant. The Mississippi River experienced flooding in 2014, 2017, and again in 2019 when flood stage was exceeded for a record number of days in St. Paul. Sapling decline at floodplain sites is likely a direct result of this.

Forest management within the park should focus both on invasive species control and floodplain reforestation. Several sites with heavy invasive weed species are in areas where leveraging local volunteers for removal projects may be possible. Floodplain reforestation requires a dual approach of research and active management. Research is needed to determine preferred propagule types and planting stock, as well as the most effective ways to control invasives, especially reed canarygrass (*Phalaris arundinacea* L.). Active floodplain reforestation can alleviate many of the issues we found here, although this is expensive, limited in scope, and carries with it a great deal of uncertainty. Nonetheless, projects undertaken at a small scale can provide lessons to managers, based on which aspects were successful and which were not.

Many of the park forests at MISS are nearing an inflection point and are at risk of becoming irreversibly altered if countermeasures are not undertaken in the near future. At this point, steps taken to promote ecosystem integrity are likely to be less costly and more effective than those which may be needed after further ecosystem decline. The river system through the Twin Cities metro area provides numerous services, both ecological and otherwise. As the need to act is becoming a pressing issue, it is incumbent on land managers to recognize this, and address it.

Acknowledgments

We wish to thank the vegetation monitoring field crew of E. Blow, J. Nelson, and N. Schalles. Their efforts through all sorts of working conditions, both good and bad, made this possible. We are also grateful to all the organizations and agencies on whose land we conducted this study. We appreciate the staff at Mississippi River National River and Recreation Area for helping us negotiate logistics and planning efforts. Finally, R. Key of the Great Lakes Inventory and Monitoring Network provided invaluable assistance with database development and data storage. We appreciate the reviews provided by N. Duncan and M. Windmuller-Campione.

Introduction

Riparian forest ecosystems are subject to stressors beyond climate change, invasive species, and ungulate browse, which are imposed on upland forests (Jandl et al. 2019, Miller et al. 2023). In riparian systems, dams and levees alter flow regimes, by prolonging inundation time (De Jager 2012) and attenuating large flow pulses (Rood et al. 2007). Ensuing overstory loss increases groundlayer light (Johnson and Waller 2013) and vulnerability to invasive species, among other effects, ultimately resulting in negative feedback loops (Jordan et al. 2010). In urban corridors, riparian forests are subjected to still more stressors, including greater pollution (Hobbie et al. 2017), flashy hydrographs (Walsh et al. 2005), and erosion and sedimentation (Jordan et al. 2010). Despite these stressors, these corridors remain areas of disproportionately high resource value.

Urban riparian zones are wildlife corridors, serving as songbird flyways (Liu et al. 2021), often surrounded by an expansive matrix of limited habitability (McClure et al. 2015). They promote terrestrial mammalian movement by connecting fragmented greenspaces (Jeong et al. 2018), and serve as denning habitat for aquatic mammals (England and Westbrook 2021). Additionally, these corridors provide cultural and social well-being for residents, including recreation opportunities (Phaneuf et al. 2008), and other physical and mental health advantages (Ignatieva et al. 2011, Astell-Burt et al. 2020). Collectively, these benefits highlight the importance of maintaining ecosystem function and ecosystem integrity within these corridors. This can be especially vital in river systems through large urban areas where, literally, millions of people have some degree of interaction with the river.

The Mississippi River winds through the Minneapolis-St. Paul metro area in southeastern Minnesota. Within this corridor, land holdings from dozens of public and private institutions have been designated as part of the Mississippi National River and Recreation Area (MISS), a unit of the National Park Service (NPS). While any land management activities within these tracts are developed and directed by local ownership, the compendium nature of this park promotes communication and partnerships. Management applications developed or applied to one unit will often be relevant elsewhere. Likewise, a unified monitoring network applied parkwide can inform us of problems and traits occurring across the broad area.

In 2022, the Great Lakes Inventory and Monitoring Network (GLKN) of the NPS resampled permanent forest monitoring sites at MISS. This marked the second assessment of these sites, which were established and initially sampled in 2011 (Sanders and Grochowski 2012). Here we report on the current (2022) status of MISS forests, as well as changes observed for a select number of metrics.

Methods

Sampling Design and Field Methods

Sampling Design

Sampling was conducted at MISS 23 June–23 August 2022. Site selection was made in 2011 prior to the initial sampling event using a generalized random-tessellation stratified design (Stevens and Olsen 2004). This design ensured that our sites were both randomly located and spatially balanced throughout the park. Our initial (2011) assessment included only 33 sites. While we had planned to sample 50, high water levels, coupled with logistical challenges, precluded this. In 2022, we resampled the initial locations, and installed additional sites, bringing the total for the program at MISS to 50.

Basic Measurements: Trees, Groundlayer, and Coarse Woody Material

We sampled trees, seedlings, coarse woody material, herbs, and browse at each site using a plot composed of three 50-m parallel transects, with each in an east-west orientation and permanently monumented with below-ground rebar (Johnson et al. 2006, 2008) (Figure 1). We recorded the species, diameter at breast height (DBH), live/dead status, and damage or disease (see below) for all trees with a DBH ≥2.5 cm and standing within 3 meters of the central transect line (Sanders and Grochowski 2014a). The total area sampled for trees was 300 m^2 for each transect, or 900 m^2 for the entire plot.

We assessed the groundlayer in 1-m^2 quadrats placed every 5 m along each transect (n = 30 per plot). Within each quadrat, we recorded all herbaceous, vine, and shrub species present, allowing us to determine frequency for all species-plot combinations. We also counted seedlings, defined as tree species <2.5 cm DBH, but at least 15 cm in height and showing evidence of growth from the previous year (thus, we did not assess the current year's seedlings). For any species which reproduces vegetatively, we considered individual sprouts (i.e., both ramets and genets) as "seedlings" if no aboveground connections between them and a parent tree were visible.

We assessed coarse woody material (CWM) using the planar intercept method (Brown 1974, Woodall and Monleon 2008). For pieces with decay class 1–4 (Woodall and Monleon 2008), we tallied pieces with a diameter at transect intersect ≥7.5 cm and length ≥0.9 m; for decay class 5, minimum size of inclusion was 12.7 cm at transect and 1.5 m in length. For all pieces, we recorded the decay class, and measured the large end diameter, small end diameter, and length. The latter was recorded only along the piece where the minimum diameter criterion was met.

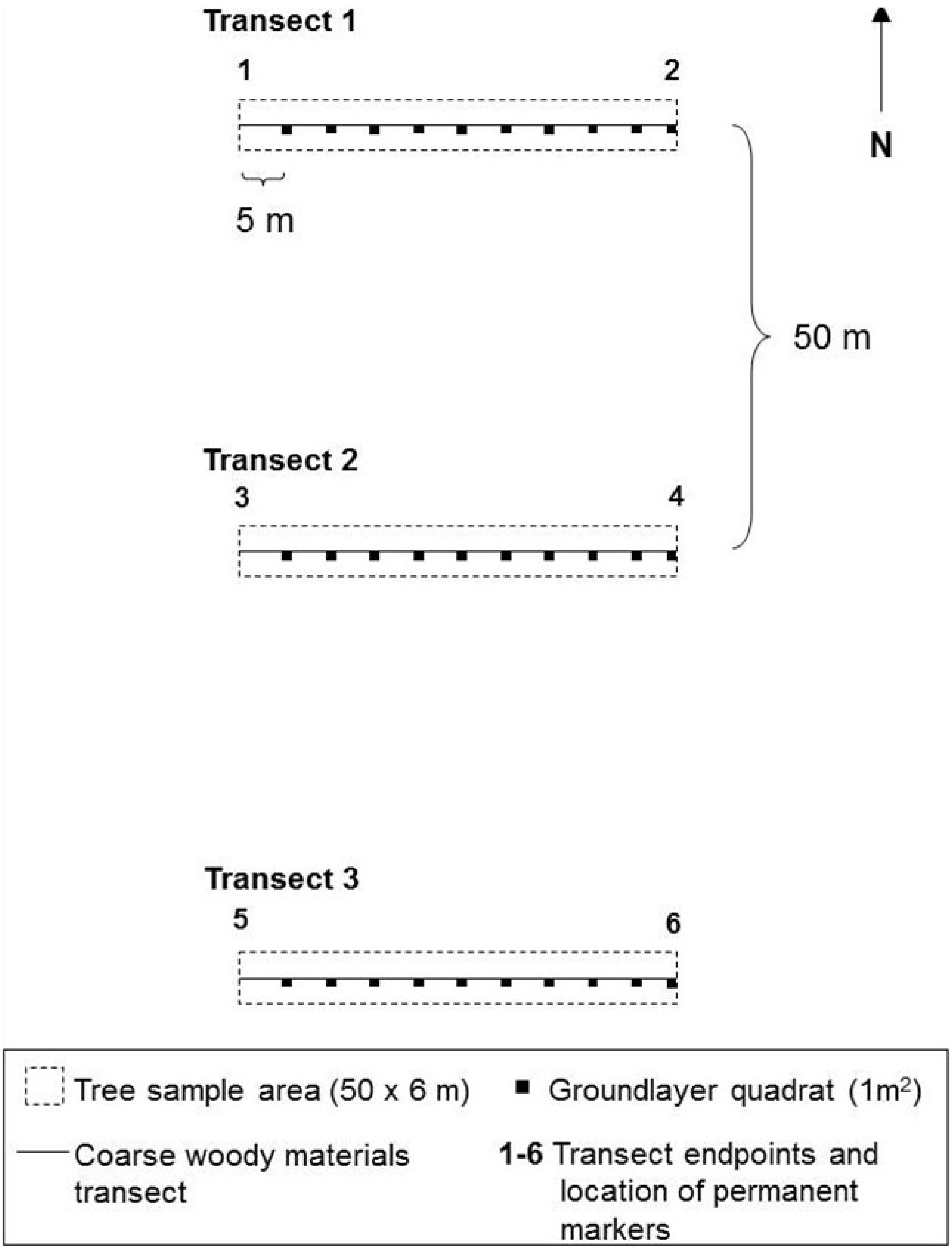

Figure 1. Great Lakes Network Hybrid plot showing three parallel transects (*solid lines*), tree sampling areas (*bounding dashed rectangles*), and quadrat locations (*solid squares*).

Browse

We examined browse pressure using two distinct measures. *Direct browse* is an assessment of white-tailed deer browse visible on *woody* species. This includes bite marks *directly evident and observable* on individual plants, appearing to occur on the current year's growth. Our sampling period extended over the course of the growing season. We acknowledge that this limitation introduces bias into our sampling, whereby those sites sampled later in the season would be expected to show more browse than sites sampled earlier. Nonetheless, we feel that our assessments of woody browse are valuable in that they provide insight on general levels of pressure and on species preferences but should be interpreted with these qualifiers in mind.

Indirect browse measures were used to assess the impacts of herbivory on *herbaceous* species. This type of assessment measures changes in herbaceous demography, which are often only *indirectly observed over time* (Webster et al. 2001, Kirschbaum and Anacker 2005). In the case of white-tailed deer (*Odocoileus virginianus* Zimmermann) browse, these changes are typically manifested as fewer and smaller individuals of preferred herbaceous browse species (Anderson 1994, Webster et al. 2001, Knight et al. 2009) and are well-documented in the literature (Williams et al. 2000, Knight 2003).

We assessed direct browse in 3.14-m^2 (1.0-m radius) circles centered every five meters along each of the three 50-m transects, for a total of 30 direct browse circles per plot, equal to a total sampling area of 94.2 m^2 per plot. Within each direct browse sampling circle, we recorded all woody species present within the browse zone—defined as the space between ground level and 1.8 m in height—and noted those circles where we observed any evidence of deer browse, and on which species this occurred.

We used direct browse data to calculate the *proportion of browse* (Frerker and Waller 2013) at two levels. At the site level, pooling across species, the numerator is the total of the 30 circles in which any browse was observed, regardless of species, while the denominator is the number of circles where any woody species were present. At the species level, for each species, we divided the total number of circles in which we observed browse by the total number of circles where it was present.

We assessed the *indirect impacts* (typically evidenced by fewer and smaller plants) of summer browse on herbs by several means. We used existing literature (Alverson et al. 1988, Rooney and Waller 2003) and our personal knowledge to identify preferred browse species as those that are both relatively common in the park and favored by deer (Table 1). We identified the *number of preferred herbaceous species* at each site, as well as the *abundance of preferred herbs*, determined by the total number of preferred species-quadrat combinations at each site. For example, a site where *Laportea canadensis* (L.) Wedd. (Canada woodnettle) was present in four quadrats and *Trillium grandiflorum* (Michx.) Salisb. in three quadrats, would have two preferred browse species present at an abundance of 7 preferred species. To examine browse impacts on herb demographics (Koh et al. 2010, Wilbur et al. 2017), we selected three target taxa on which to collect additional data: *Maianthemum racemosum* (L.) Link (false Solomon's seal), *Polygonatum biflorum* (Walter) Elliott (Solomon's seal), and *Uvularia grandiflora* Sm. (large-flower bellwort). For these taxa, in quadrats where they were present, we measured maximum height of the tallest individual and noted whether it was reproductive. For each target species, where present, at the site level, we calculated the *target herb* *frequency*, based on the frequency of presence in the 30 quadrats; we then determined *target herb maximum height*, by calculating the site-level mean of the tallest individual (if present) in each quadrat.

Table 1. Preferred browse species at MISS, used for calculating *number of preferred herbs* and *abundance of preferred herbs*.

Species	Common name
Laportea canadensis (L.) Wedd.	Canada woodnettle
Maianthemum canadense Desf.	Canada mayflower
Maianthemum racemosum (L.) Link	false Solomon's seal
Maianthemum stellatum (L.) Link	starry false Solomon's seal
Polygonatum biflorum (Walter) Elliott	hairy Solomon's seal
Streptopus lanceolatus var. *roseus* (Michx.) Reveal	rosy twistedstalk
Trillium sp. L.	trilium
Uvularia grandiflora Sm.	largeflower bellwort
Uvularia sessilifolia L.	sessile bellwort

Tree Health

We used an evidence-based approach to assess tree health, whereby we examined each tree for the presence of broad classes of disease, damage, or injury (U.S. Department of Agriculture 2010). These classes included dieback, epicormic sprouting, wilted foliage, defoliation, discolored foliage, insect sign, and human induced stress. If a tree exhibited symptoms of one of these primary classes, a further classification of the damage or disease was made, based on predefined characteristics within each of the primary classes. For example, if a tree was classified as having discolored foliage, we would note whether this damage was in the form of (among other choices) marginal browning of the leaves, interveinal browning of the leaves, the leaves possessing a white coating, or a general yellowing of the leaves. This symptom-based assessment of damage and disease allows us to easily classify tree health issues, from which a diagnosis of the root cause can possibly be assigned upon further investigation. We feel that this symptom-based approach is more accurate than directly assigning a root cause to problems observed when at the field site. For some symptoms, there are dozens of possible causes and a pathologist or entomologist with specialization in the region would be needed to accurately assess the problem. Large-scale or persistent symptoms noted with this method can alert the park staff to potential disease or insect outbreaks, which would require further investigation by the park to identify the exact disease or pest.

Plant Identification

We attempted to identify all plants to the species level while in the field. When this was not possible, we typically collected specimens for later identification. In some instances, it was not possible to distinguish between multiple species present in a park unless they were flowering or fruiting, which often was not the case. In these instances, we identified only to the genus or family level. Examples include *Carex* sp. L. (sedge) and Asteraceae (daisy family). For *Amelanchier* sp. Medik. (serviceberry), all individuals were classified to the genus level. Finally, if a grass was not in flower or fruit, it was typically only possible to identify to the family (Poaceae) level. All nomenclature follows that of the Integrated Taxonomic Information System (Integrated Taxonomic Information System 2023).

Classifications and Summaries

Forest Type Classification

We classified all sites in the field using the National Vegetation Classification System (NVCS) (Hop 2015). The NVCS system was developed for the park based on field work in the early 2000s; as such, the forest has changed in the interim, in some places substantially, and numerous sites did not fit clearly into one of the preexisting categories. We wanted to explore and summarize data in an efficient and accurate manner, so after the field season, we grouped sites into similar broad forest types using cluster analysis.

We assigned sites to one of four broad forest types based on both overstory and understory composition. Because we did not sample the full complement of sites in 2011 (see Continuity of Sampling Effort, below), we performed this analysis on the 2022 dataset. We prepared our initial site × species matrix by including only those species present in at least 10% (n = 5) of sampling sites. For tree species, this community matrix consisted of importance values for each species at each site, defined as the mean of the relative frequency and relative basal area (Dyer 2006, Elliott and Swank 2008). For all other species, we calculated the species' relative frequency in quadrats at each site. To assign sites into groups, we used the R statistical environment (R Core Team 2022) followed by the hclust and cutree functions within the vegan package (Maechler et al. 2019). We performed a visual inspection to confirm group placement.

Coefficients of Conservatism and the Modified Floristic Quality Index

We identified the coefficient of conservatism (CoC) values for all species located during the sampling at MISS (Bernthal 2003). These values range from 0–10 and reflect a species' likelihood that it will be present in habitats with alterations from pre-settlement conditions (Swink and Wilhelm 1994), with 0 reflecting either non-native species or generalists with no faithfulness to any particular habitat and 10 denoting conservative species found only in high-quality, non-degraded habitats. We then used CoC values to calculate the modified floristic quality index (mFQI) (Rooney and Rogers 2002, Sanders and Grochowski 2014b), where mFQI is simply the mean of the CoC values for all species present within that site. We then summarized mFQI by year and forest type.

Quality Assurance/Quality Control

Training of Field Staff

We trained field staff in accordance with QA/QC guidelines established in our protocol (Sanders and Grochowski 2014a). The training period consisted of three weeks, during which time we focused on all aspects of plot establishment and data collection. For seasonal staff collecting data on trees (species, diameter, disease) and coarse woody material, the focus was on correct plant identification, as well as correct use of diameter tapes. Adherence to the rules of tape placement (such as on leaning, forking, downed, or otherwise non-standard trees) ensures accurate repeatability on those trees in future sampling events. For seasonal staff collecting data on the groundlayer and browse, the focus was on correct species identification, as well as completeness. Ensuring a thorough search within each quadrat to capture all herbaceous species present was essential to accurately assess frequency of presence for each species. For woody browse, the focus was on how to discern deer browse from other twig damage. This included discussions of how deer browse presents differently based on the timing in the season it occurred, as wells as how it presents differently from hare browse. All field staff underwent a final check by sampling a plot in tandem with GLKN permanent staff. This was a phased process with seasonal staff first sampling the unit (quadrat, browse circle, transect, etc.) alone, then with GLKN permanent staff sampling the same unit alone. This was followed by a reassessment of the sampling unit together, evaluating and discussing the data from the permanent and seasonal staff together.

Continuity of Sampling Effort between 2011 and 2022 and Presentation of Data

We sampled 33 sites in 2011, although we were unable to access two of sites in 2022 due to safety concerns. We eliminated these two sites permanently from the protocol. We then installed and sampled an additional 19 sites in 2022, bringing the total to 50 (Figure 2). These 50 sites are not anticipated to change and are expected to comprise our future effort in the park, indefinitely.

Here, we report on change between the two sampling periods, using the 31 sites sampled both years, excluding the 19 new sites from all summaries. When we test for change between years following future sampling events, we will likely eliminate data from the 2011 sampling event and use 2022 as the baseline year. This is for three reasons: 1) We only have data from 31 sites from the initial event, and not the entire suite. 2) We sampled early in the season in 2011 (31 May through 12 July) in a year when the river was high. Thus, at several of our sites, herbaceous floodplain species had not yet emerged. 3) We had identification problems with elm species in 2011, tallying most as *Ulmus rubra*. We now know that many of these were incorrectly identified. For the comparisons here, we are grouping elm species together as *Ulmus* sp.

For the present work, we have documented all methods for all field work that were carried out, although we are only reporting on metrics related to trees and coarse woody material, for reasons presented in the paragraph above. We feel it is important to include all methods both as documentation of the work that was done, and to inform other interested parties, who may be reading this report. All metrics will be reported on in full, following the next sampling event at MISS, tentatively planned for 2031.

We have decided to pool ash (*Fraxinus* spp. L.) species for all presentations and summaries here. While the overwhelming majority of individuals observed were green ash (*F. pennsylvanica* Marsh.), a small minority were either white ash (*F. americana* L.) or black ash (*F. nigra* Marsh.) and would likely not be clear when presented as unique species on graphs. Because of the imminent loss of all ash due to the emerald ash borer (*Agrilus planipennis* Fairmaire), we are more concerned about total abundance as this is what will be lost from the ecosystem. Thus, we feel that pooling species is the best way to include these individuals.

For the present work, we present density-diameter graphs to depict regeneration and successional projections then present box plots for several metrics to show differences between the sampling events and within forest types. We forgo statistical tests of change for this report, but we discuss differences between years in a general context.

Results

The taxa sampled included 45 trees species, 33 taxa of shrubs and woody vines, 162 forb and herbaceous vine taxa, 27 graminoids, and 10 fern species (Appendix A). The sites classified into four broad forest types (Figure 2).

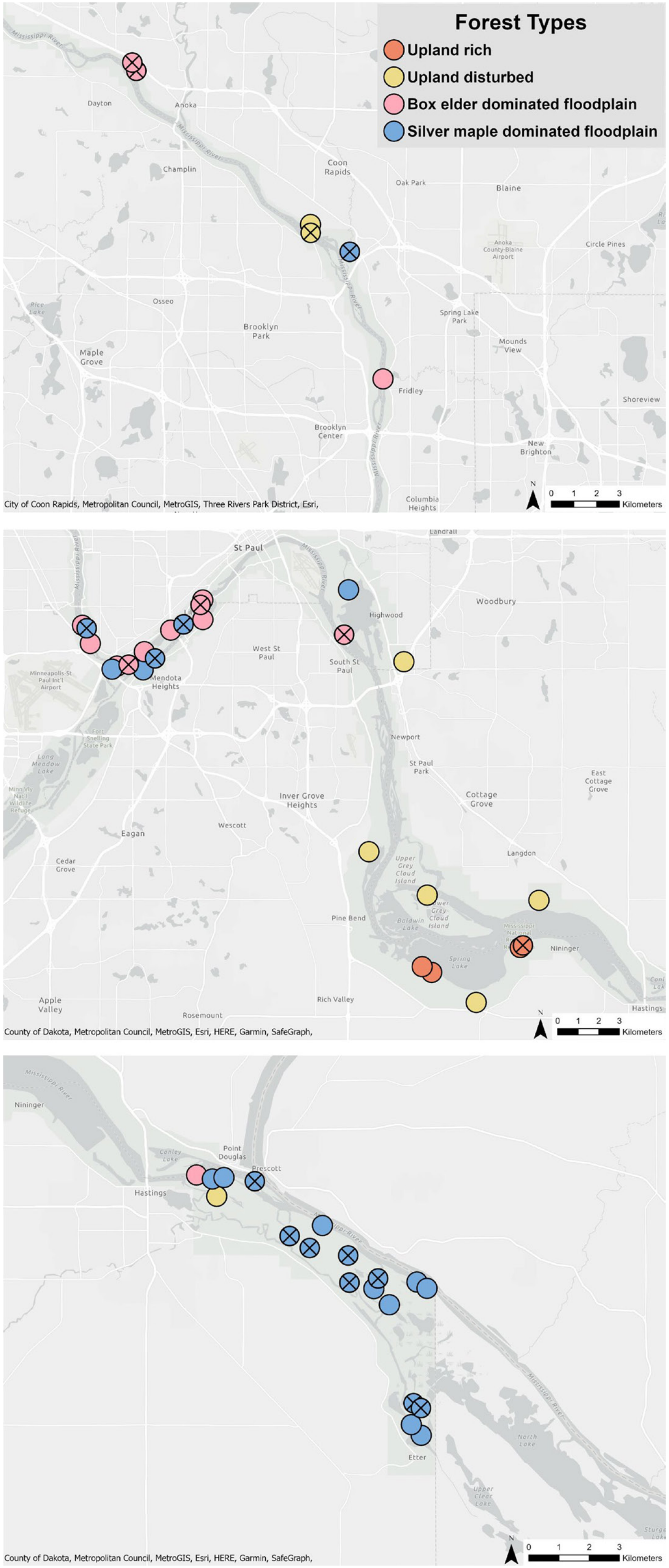

Figure 2. Resampled sites (*solid markers*) and new sites established in 2022 (*crossed markers*) in the upper (*top*), middle (*middle*), and lower (*bottom*) part of the park. Forest type key is in the top panel.

Regeneration and Successional Projections

In upland rich forests (three sites, all in Spring Lake Park Reserve (Figure 3A)), elm, basswood (*Tilia americana* L.), and hackberry (*Celtis occidentalis* L.) were common, though with some degree of impaired recruitment. We found lower density during the second sampling event for elm on size classes 15 cm DBH and below, and for basswood 10 cm DBH and below. Bitternut hickory (*Carya cordiformis* (Wangenh.) K. Koch) is also showing declines for individuals smaller than 15 cm DBH.

Seven sites were classified as upland disturbed forest (Figure 3B): one in Coon Rapids Dam Regional Park, one just east of Hastings, Minnesota, one in South St. Paul, and four in the Spring Lake basin (Figure 3B). With the exception of black cherry (*Prunus serotina* Ehrh.), common species in upland disturbed forests are also experiencing recruitment problems. In the two smallest size classes, densities of elm, ash, and bitternut hickory, have declined over the 11-year sampling interval. Bitternut hickory dominated the overstory at these sites.

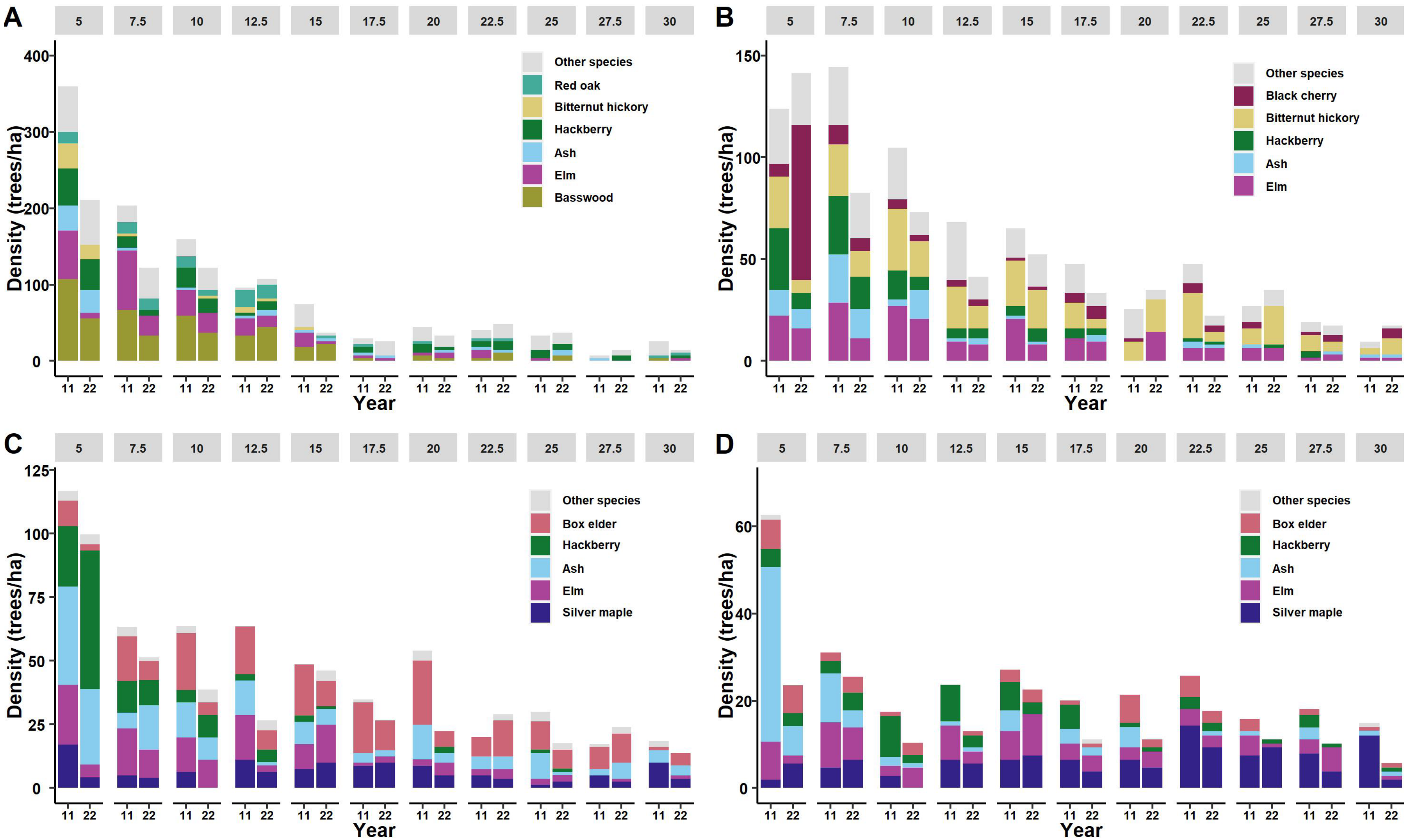

Figure 3. Diameter by size classes for sites in four forest types. Panel A: Upland rich forests; Panel B: Upland disturbed forests; Panel C: Box elder-dominated floodplain forests; Panel D: Silver maple-dominated floodplain forests. Note the difference in scales on the y-axes. Diameter at breast height classes across the top represent the maximum value in 2.5 cm classes.

We classified nine sites as box elder-dominated floodplain forest (Figure 3C): two in the Mississippi River Community Park in Anoka County, one in Manomin County Park in Fridley, one near the Gores Pool Wildlife Management Area, one on Pig's Eye Lake and the remainder (nine) near the confluence with the Minnesota River. While these sites support green ash (*Fraxinus pennsylvanica* Marsh.), box elder (*Acer negundo* L.), and silver maple across all size classes, recent recruitment (i.e., those individuals in smallest size class) for the latter two is notably less.

The twelve silver maple-dominated floodplain sites (Figure 3D) were located mainly around the confluence with the Minnesota River and downstream of the confluence with the St. Croix in the Gores Pool Wildlife Management Area, below dam in Hastings. Here, we found very little silver maple in small size classes and very little recruitment, in general, of other species.

Short-Term Change

Live tree density (Figure 4, *left*) was generally higher in upland sites compared with box elder and silver maple-dominated floodplain sites. We also found generally lower density in all four forest types in 2022, including upland rich (22% decline), box elder-dominated (21% drop), and silver maple-dominated (31% decline). Basal area (Figure 4, *right*) was higher in silver maple-dominated forests but in general, did not appear to differ between years for any of the forest types.

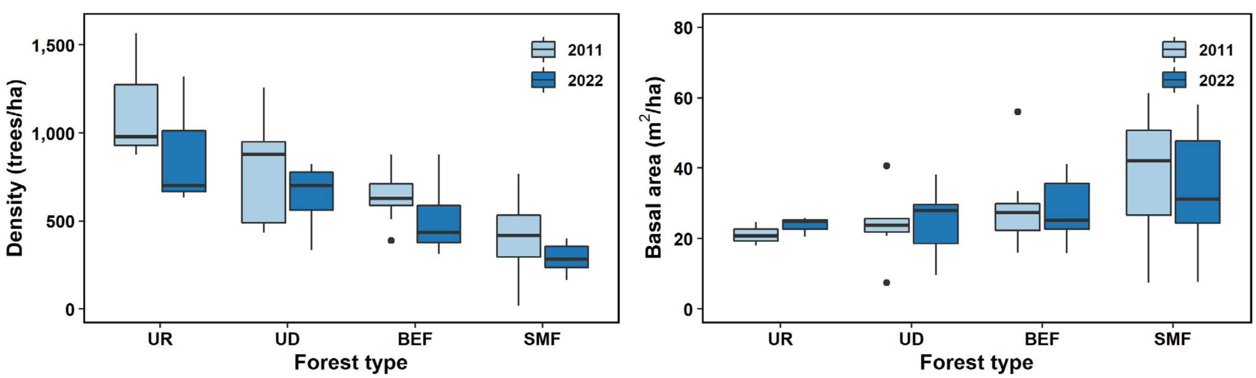

Figure 4. Live tree density (*left*) and basal area (*right*) by forest type for individuals ≥2.5 cm DBH of all tree species. Forest type abbreviations are: UR: Upland Rich forests; UD: Upland disturbed forests; BEF: Box elder-dominated floodplain forest; SMF: Silver maple-dominated floodplain forest.

Sapling (≥2.5 cm, <5 cm DBH) density was highest in upland rich sites and lowest in silver maple sites (Figure 5, *left*). Sapling density fell in three of the four forests: upland rich (41% drop), box elder-dominated floodplain (15%), and silver maple-dominated floodplain (62% decline). Seedling density (Figure 5, *right*) was generally higher in the two upland forests but lower in the two floodplain forests.

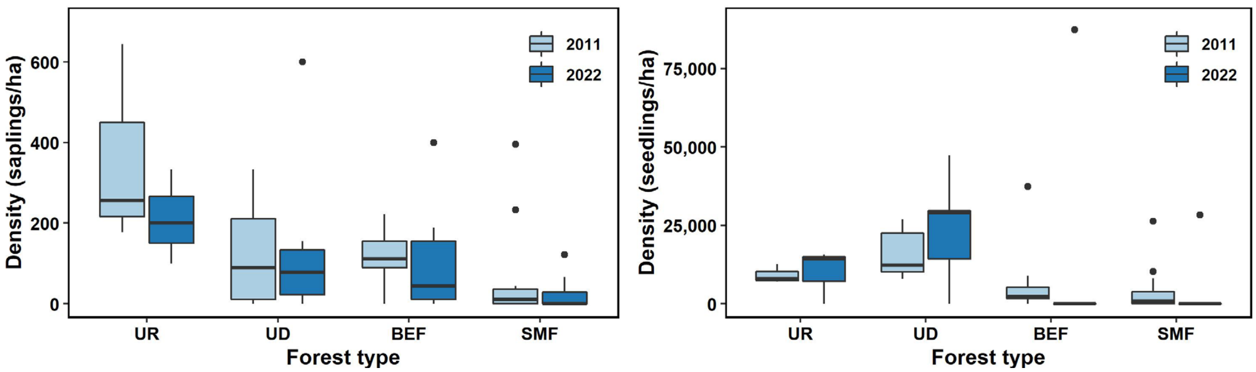

Figure 5. Small sapling (≥2.5 cm DBH, <5.0 cm DBH) density by forest type (*left*); seedling (≥15.0 cm in height, <2.5 cm DBH) density by forest type (*right*). For forest type names, see Figure 4.

Coarse Woody Material and Standing Dead Trees

In general, measures of coarse woody material varied somewhat between forest types but changed little between sampling periods (Figure 6). One exception is in box elder-dominated floodplain sites. Here, density increased 76% from 266 ± 61.8 to 447 ± 59.7 pieces/ha. Additionally, both the volume and biomass of pieces in silver maple-dominated floodplain sites increased, as did density of large, advanced decay pieces. (Figure 6B, C, D).

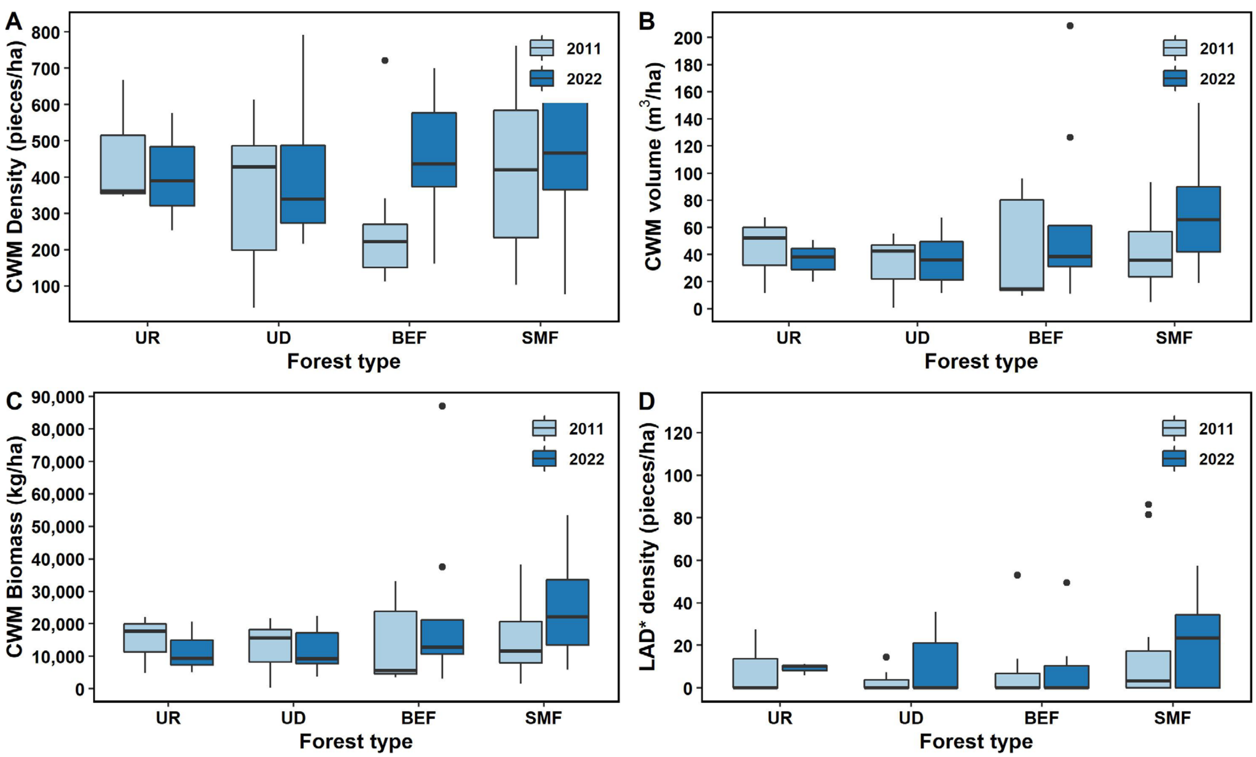

Figure 6. Coarse woody material by forest type and year: density (*top left*), volume (*top right*), biomass (*lower left*), and large, advanced decay (*) piece density (*lower right*). For forest type names, see Figure 4.

c Density of large snags (standing dead trees) ≥30 cm DBH varied greatly between years and forest types (Figure 7, *left*). This declined in upland rich forests, increased in upland disturbed and box elder forests, and was similar between sampling events at silver maple floodplain sites. Basal area of snags followed the same general pattern (Figure 7, *right*).

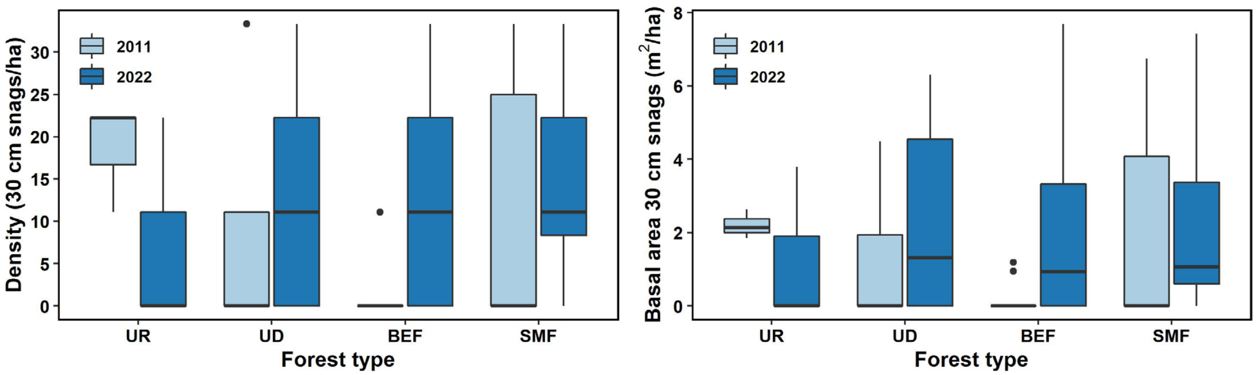

Figure 7. Density (*left*) and basal area (*right*) of snags ≥30 cm DBH for all forest types, both years. For forest type names, see Figure 4.

No consistent damage or disease was noted in any one forest type or tree species.

Discussion

Our work largely aligns with that of others, showing impaired regeneration on large river floodplains. We show here that none of the dominant tree species in the monitoring sites are successfully regenerating.

Within monitoring sites, we found no cottonwood trees smaller than 17.5 cm DBH in 2011, and 22.5 cm DBH in 2022. In places within upper Mississippi River floodplains, American elm is reported to be the second or third most abundant species (Knutson and Klaas 1998, De Jager et al. 2012), which is consistent with our findings. Along with box elder, hackberry, and green ash, American elm was one of the most common species, though we see a notable drop in abundance above DBH values of 15 cm (see Figure 3C and 3D).

At upland sites, we found impaired regeneration of overstory species. Within the three upland rich sites, all in Spring Lake Park Reserve, basswood, elm, bitternut hickory, and red oak all showed impaired regeneration.

At the upland disturbed sites we surveyed, invasive plant species were generally present, though not necessarily abundant; common buckthorn (*Rhamnus cathartica* L.) was the most serious issue. Within these seven sites, several native taxa were common, including *Rubus occidentalis* L. (black raspberry), *Prunus serotina* Ehrh. (black cherry), and *Geum* sp. L. (avens).

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Appendix A. All species located during 2022 sampling.

Table A-1. Ferns and fern allies located in 2022 GLKN sampling sites.

Family	Species	Common name
Dryopteridaceae	*Dryopteris carthusiana*	spinulose woodfern
Equisetaceae	*Equisetum arvense*	western horsetail
Equisetaceae	*Equisetum hyemale*	western scouring-rush
Onocleaceae	*Matteuccia struthiopteris*	ostrich fern
Onocleaceae	*Onoclea sensibilis*	sensitive fern
Ophioglossaceae	*Botrychium* sp.	moonwort
Osmundaceae	*Osmunda claytoniana*	interrupted fern
Pteridaceae	*Adiantum pedatum*	northern maidenhair
Woodsiaceae	*Athyrium filix-femina* var. *angustum*	subarctic ladyfern
Woodsiaceae	*Cystopteris fragilis*	fragile fern

Table A-2. Herbaceous (forb) species located in 2022 GLKN sampling.

Family	Species	Common name
Alismataceae	*Alisma* sp.	waterplantain
Alismataceae	*Sagittaria latifolia*	wapato
Amaranthaceae	*Amaranthus retroflexus*	rough pigweed
Amaranthaceae	*Amaranthus tuberculatus*	tall waterhemp
Amaranthaceae	*Chenopodium album*	white goosefoot
Amaranthaceae	*Chenopodium* sp.	goosefoot
Apiaceae	*Cryptotaenia canadensis*	honewort
Apiaceae	*Daucus carota*	Queen Anne's lace
Apiaceae	*Osmorhiza longistylis*	longstyle sweetroot
Apiaceae	*Osmorhiza* sp.	sweetroot
Apiaceae	*Sanicula marilandica*	Maryland sanicle
Apiaceae	*Sanicula odorata*	clustered blacksnakeroot
Apiaceae	*Sium suave*	hemlock water-parsnip
Apiaceae	*Torilis japonica*	erect hedgeparsley

Table A-2 (continued). Herbaceous (forb) species located in 2022 GLKN sampling.

Family	Species	Common name
Apocynaceae	*Apocynum cannabinum*	Indianhemp
Apocynaceae	*Asclepias incarnata*	swamp milkweed
Apocynaceae	*Asclepias* sp.	milkweed
Apocynaceae	*Asclepias syriaca*	common milkweed
Araceae	*Arisaema dracontium*	greendragon
Araceae	*Arisaema triphyllum*	Jack-in-the-pulpit
Araceae	*Lemna minor*	lesser duckweed
Araceae	*Lemna* sp.	duckweed
Aristolochiaceae	*Asarum canadense*	Canadian wild ginger
Asparagaceae	*Convallaria majalis*	European lily of the valley
Asparagaceae	*Maianthemum canadense*	Canada mayflower
Asparagaceae	*Maianthemum racemosum*	feathery false Solomon's-seal
Asparagaceae	*Maianthemum stellatum*	starry Solomon's-seal
Asparagaceae	*Polygonatum biflorum*	Solomon's seal
Asteraceae	*Ageratina altissima*	white snakeroot
Asteraceae	*Ambrosia artemisiifolia*	small ragweed
Asteraceae	*Ambrosia trifida*	tall ragweed
Asteraceae	*Arctium minus*	common burdock
Asteraceae	*Bidens connata*	purple-stem beggarticks
Asteraceae	*Bidens frondosa*	tickseed sunflower
Asteraceae	*Boltonia asteroides* var. *latisquama*	white doll's-daisy
Asteraceae	*Cirsium arvense*	Canada thistle
Asteraceae	*Cirsium discolor*	field thistle
Asteraceae	*Cirsium vulgare*	bull thistle
Asteraceae	*Conyza canadensis*	Canadian horseweed
Asteraceae	*Erechtites hieraciifolius*	American burnweed
Asteraceae	*Erigeron annuus*	eastern daisy fleabane
Asteraceae	*Erigeron philadelphicus*	Philadelphia fleabane
Asteraceae	*Eutrochium maculatum*	spotted joepyeweed

Table A-2 (continued). Herbaceous (forb) species located in 2022 GLKN sampling.

Family	Species	Common name
Asteraceae	*Eutrochium purpureum*	sweetscented joe pye weed
Asteraceae	*Eutrochium* sp.	joe pye weed
Asteraceae	*Helenium autumnale*	false sunflower
Asteraceae	*Lactuca canadensis*	wild lettuce
Asteraceae	*Lactuca* sp.	lettuce
Asteraceae	*Rudbeckia laciniata*	green-head coneflower
Asteraceae	*Solidago flexicaulis*	zigzag goldenrod
Asteraceae	*Solidago* sp.	goldenrod
Asteraceae	*Sonchus oleraceus*	common sow-thistle
Asteraceae	*Symphyotrichum lanceolatum*	white panicle aster
Asteraceae	*Symphyotrichum lateriflorum*	calico aster
Asteraceae	*Symphyotrichum* sp.	aster
Asteraceae	*Taraxacum officinale*	common dandelion
Asteraceae	*Vernonia fasciculata*	western ironweed
Asteraceae	*Xanthium strumarium*	rough cockleburr
Balsaminaceae	*Impatiens capensis*	spotted touch-me-not
Balsaminaceae	*Impatiens pallida*	pale touch-me-not
Balsaminaceae	*Impatiens* sp.	touch-me-not
Berberidaceae	*Caulophyllum thalictroides*	blue cohosh
Boraginaceae	*Hackelia virginiana*	virginia stickseed
Brassicaceae	*Alliaria petiolata*	garlic mustard
Brassicaceae	*Berteroa incana*	hoary alyssum
Brassicaceae	*Cardamine impatiens*	narrowleaf bittercress
Brassicaceae	*Hesperis matronalis*	dames rocket
Campanulaceae	*Campanula americana*	American bellflower
Cannabaceae	*Cannabis sativa*	marijuana
Caprifoliaceae	*Triosteum perfoliatum*	feverwort
Caryophyllaceae	*Dianthus armeria*	Deptford's pink
Caryophyllaceae	*Myosoton aquaticum*	giantchickweed

Table A-2 (continued). Herbaceous (forb) species located in 2022 GLKN sampling.

Family	Species	Common name
Caryophyllaceae	*Silene latifolia*	white campion
Caryophyllaceae	*Silene* sp.	silene
Caryophyllaceae	*Stellaria media*	nodding chickweed
Colchicaceae	*Uvularia grandiflora*	large-flower bellwort
Colchicaceae	*Uvularia sessilifolia*	sessile-leaf bellwort
Convolvulaceae	*Calystegia sepium*	wild morning glory
Convolvulaceae	*Calystegia* sp.	false bindweed
Convolvulaceae	Cuscuta gronovii	scaldweed
Convolvulaceae	Cuscuta sp.	dodder
Cucurbitaceae	*Echinocystis lobata*	wild mockcucumber
Cucurbitaceae	*Sicyos angulatus*	wall bur cucumber
Dioscoreaceae	*Dioscorea villosa*	wild yam
Ericaceae	*Pyrola* sp.	shinleaf
Euphorbiaceae	*Acalypha rhomboidea*	Virginia threeseed mercury
Fabaceae	*Amphicarpaea bracteata*	American hogpeanut
Fabaceae	*Desmodium glutinosum*	trefoil tickclover
Fabaceae	*Medicago lupulina*	yellow trefoil
Fabaceae	*Melilotus* sp.	sweetclover
Fabaceae	*Securigera varia*	crownvetch
Fabaceae	*Trifolium repens*	white clover
Geraniaceae	*Geranium maculatum*	wild crane's-bill
Hydrophyllaceae	*Hydrophyllum virginianum*	Shawnee-salad
Hypericaceae	*Hypericum perforatum*	St. Johnswort
Iridaceae	*Iris* sp.	iris
Lamiaceae	*Glechoma hederacea*	creeping charlie
Lamiaceae	*Leonurus cardiaca*	motherwort
Lamiaceae	*Lycopus americanus*	waterhorehound
Lamiaceae	*Lycopus uniflorus*	oneflower bugleweed
Lamiaceae	*Lycopus virginicus*	Virginia water horehound

Table A-2 (continued). Herbaceous (forb) species located in 2022 GLKN sampling.

Family	Species	Common name
Lamiaceae	*Mentha arvensis*	wild mint
Lamiaceae	*Monarda fistulosa*	wildbergamot horsemint
Lamiaceae	*Nepeta cataria*	catnip
Lamiaceae	*Physostegia virginiana*	obedient-plant
Lamiaceae	*Prunella vulgaris*	selfheal
Lamiaceae	*Scutellaria galericulata*	marsh skullcap
Lamiaceae	*Scutellaria lateriflora*	mad dog skullcap
Lamiaceae	*Scutellaria ovata*	heartleaf skullcap
Lamiaceae	*Scutellaria* sp.	skullcap
Lamiaceae	*Stachys palustris*	marsh hedgenettle
Lamiaceae	*Stachys* sp.	hedgenettle
Lamiaceae	*Stachys tenuifolia*	smooth hedge-nettle
Lamiaceae	*Teucrium canadense*	wood sage
Liliaceae	*Lilium* sp.	lily
Liliaceae	*Streptopus lanceolatus* var. *roseus*	twistedstalk
Linderniaceae	*Lindernia dubia*	yellow-seed false pimpernel
Lythraceae	*Lythrum salicaria*	purple loosestrife
Melanthiaceae	*Trillium cernuum*	whip-poor-will-flower
Melanthiaceae	*Trillium flexipes*	nodding wakerobin
Melanthiaceae	*Trillium* sp.	trillium
Onagraceae	*Circaea canadensis* ssp. *canadensis*	broadleaf enchanter's nightshade
Oxalidaceae	*Oxalis stricta*	yellow woodsorrel
Papaveraceae	*Chelidonium majus*	celandine
Papaveraceae	*Sanguinaria canadensis*	bloodroot
Phrymaceae	*Mimulus ringens*	ringen monkeyflower
Phrymaceae	*Phryma leptostachya*	lopseed
Plantaginaceae	*Plantago rugelii*	Rugel's plantain
Plantaginaceae	*Plantago* sp.	plantain
Plantaginaceae	*Veronica* sp.	speedwell

Table A-2 (continued). Herbaceous (forb) species located in 2022 GLKN sampling.

Family	Species	Common name
Polemoniaceae	*Phlox divaricata*	wild blue phlox
Polygonaceae	*Fallopia scandens*	climbing false buckwheat
Polygonaceae	*Fallopia* sp.	false-buckwheat
Polygonaceae	*Persicaria* sp.	smartweed
Polygonaceae	*Persicaria virginiana*	jumpseed
Polygonaceae	*Rumex altissimus*	smooth dock
Polygonaceae	*Rumex crispus*	curly dock
Primulaceae	*Lysimachia ciliata*	fringed yellow-loosestrife
Primulaceae	*Lysimachia nummularia*	moneywort
Primulaceae	*Lysimachia thyrsiflora*	water loosestrife
Ranunculaceae	*Actaea rubra*	red baneberry
Ranunculaceae	*Actaea* sp.	baneberry
Ranunculaceae	*Anemone canadensis*	Canadian anemone
Ranunculaceae	*Anemone quinquefolia*	wood anemone
Ranunculaceae	*Anemone virginiana*	Virginia anemone
Ranunculaceae	*Caltha palustris*	yellow marsh-marigold
Ranunculaceae	*Clematis virginiana*	virgin's bower
Ranunculaceae	*Ranunculus abortivus*	smallflower crowfoot
Ranunculaceae	*Ranunculus recurvatus*	littleleaf buttercup
Ranunculaceae	*Thalictrum dasycarpum*	purple meadow-rue
Ranunculaceae	*Thalictrum dioicum*	early meadow-rue
Ranunculaceae	*Thalictrum thalictroides*	rue anemone
Rosaceae	*Agrimonia gryposepala*	tall hairy agrimony
Rosaceae	*Agrimonia* sp.	agrimony
Rosaceae	*Agrimonia striata*	roadside agrimony
Rosaceae	*Fragaria vesca*	woodland strawberry
Rosaceae	*Fragaria virginiana*	wild strawberry
Rosaceae	*Geum canadense*	white avens
Rosaceae	*Geum laciniatum*	rough avens

Table A-2 (continued). Herbaceous (forb) species located in 2022 GLKN sampling.

Family	Species	Common name
Rosaceae	*Geum* sp.	avens
Rosaceae	*Potentilla norvegica*	Norwegian cinquefoil
Rubiaceae	*Galium aparine*	white hedge
Rubiaceae	*Galium asprellum*	rough bedstraw
Rubiaceae	*Galium tinctorium*	stiff marsh bedstraw
Rubiaceae	*Galium triflorum*	sweetscented bedstraw
Scrophulariaceae	*Scrophularia lanceolata*	lance-leaf figwort
Scrophulariaceae	*Scrophularia marilandica*	maryland figwort
Scrophulariaceae	*Verbascum thapsus*	common mullein
Smilacaceae	*Smilax ecirrhata*	upright carrionflower
Solanaceae	*Physalis heterophylla*	clammy ground-cherry
Solanaceae	*Physalis* sp.	groundcherry
Solanaceae	*Physalis virginiana*	Virginia ground-cherry
Solanaceae	*Solanum ptychanthum*	West Indian nightshade
Urticaceae	*Boehmeria cylindrica*	smallspike false nettle
Urticaceae	*Laportea canadensis*	Canadian wood-nettle
Urticaceae	*Parietaria pensylvanica*	Pennsylvania pellitory
Urticaceae	*Pilea pumila*	Canadian clearweed
Urticaceae	*Pilea* sp.	clearweed
Urticaceae	*Urtica dioica* ssp. *gracilis*	stinging nettle
Verbenaceae	*Verbena hastata*	swamp verbena
Verbenaceae	*Verbena urticifolia*	white vervain
Violaceae	*Viola* sp.	violet

Table A-3. Graminoid species located in 2022 GLKN sampling.

Family	Species	Common name
Cyperaceae	*Carex blanda*	woodland sedge
Cyperaceae	*Carex cephalophora*	oval-leaved sedge
Cyperaceae	*Carex deweyana*	round-fruit short-scale sedge

Table A-3 (continued). Graminoid species located in 2022 GLKN sampling.

Family	Species	Common name
Cyperaceae	*Carex grisea*	inflated narrow-leaf sedge
Cyperaceae	*Carex intumescens*	greater bladder sedge
Cyperaceae	*Carex lupulina*	hop sedge
Cyperaceae	*Carex pedunculata*	long-stalk sedge
Cyperaceae	*Carex projecta*	necklace sedge
Cyperaceae	*Carex radiata*	eastern star sedge
Cyperaceae	*Carex retrorsa*	retrorse sedge
Cyperaceae	*Carex rosea*	rosy sedge
Cyperaceae	*Carex* sp.	sedge
Cyperaceae	*Carex sprengelii*	Sprengel's sedge
Cyperaceae	*Carex stipata*	stalk-grain sedge
Cyperaceae	*Carex vesicaria*	inflated sedge
Juncaceae	*Juncus* sp.	rush
Poaceae	*Bromus inermis*	smooth brome
Poaceae	*Cinna latifolia*	slender wood-reed
Poaceae	*Elymus* sp.	wildrye
Poaceae	*Elymus villosus*	slender wild-rye
Poaceae	*Elymus virginicus*	Virginia wildrye
Poaceae	*Leersia oryzoides*	rice cutgrass
Poaceae	*Leersia virginica*	whitegrass
Poaceae	*Milium effusum*	American milletgrass
Poaceae	*Phalaris arundinacea*	reed canarygrass
Poaceae	*Poa compressa*	flat-stem blue grass
Poaceae	*Poa* sp.	bluegrass
Poaceae	*Poaceae* fam.	grass family
Poaceae	*Schizachne purpurascens*	false melic grass
Typhaceae	*Sparganium* sp.	bur-reed

Table A-4. Shrub and woody vine species located in 2022 GLKN sampling.

Family	Species	Common name
Adoxaceae	*Sambucus nigra* ssp. *canadensis*	elderberry
Adoxaceae	*Sambucus racemosa* var. *racemosa*	red elderberry
Adoxaceae	*Viburnum lantana*	wayfaringtree
Adoxaceae	*Viburnum lentago*	nannyberry
Adoxaceae	*Viburnum opulus* var. *americanum*	American cranberrybush
Adoxaceae	*Viburnum rafinesqueanum*	downy arrowwood
Berberidaceae	*Berberis* sp.	barberry
Anacardiaceae	*Toxicodendron rydbergii*	western poison ivy
Anacardiaceae	*Toxicodendron* sp.	poison ivy
Betulaceae	*Corylus americana*	American hazelnut
Caprifoliaceae	*Lonicera* sp. (exotic)	exotic honeysuckle
Celastraceae	*Celastrus scandens*	American bittersweet
Celastraceae	*Euonymus atropurpureus*	burning bush
Cornaceae	*Cornus alternifolia*	alternate-leaf dogwood
Cornaceae	*Cornus amomum*	silky dogwood
Cornaceae	*Cornus racemose*	gray dogwood
Cornaceae	*Cornus rugosa*	round-leaf dogwood
Cornaceae	*Cornus sericea*	red-osier dogwood
Grossulariaceae	*Ribes americanum*	wild black currant
Grossulariaceae	*Ribes cynosbati*	pasture currant
Grossulariaceae	*Ribes hirtellum*	hairy stem gooseberry
Grossulariaceae	*Ribes missouriense*	Missouri gooseberry
Menispermaceae	*Menispermum canadense*	common moonseed
Rhamnaceae	*Rhamnus cathartica*	common buckthorn
Rosaceae	*Amelanchier* sp.	serviceberry
Rosaceae	*Malus* sp.	apple
Rosaceae	*Rubus flagellaris*	whiplash dewberry
Rosaceae	*Rubus occidentalis*	black raspberry
Rosaceae	*Rubus pensilvanicus*	Pennsylvania blackberry

Table A-4 (continued). Shrub and woody vine species located in 2022 GLKN sampling.

Family	Species	Common name
Rosaceae	*Rubus sachalinensis* var. *sachalinensis*	red raspberry
Rutaceae	*Zanthoxylum americanum*	common prickly ash
Smilacaceae	*Smilax* sp.	greenbrier
Smilacaceae	*Smilax tamnoides*	bristly greenbrier
Solanaceae	*Solanum dulcamara*	woody nightshade
Vitaceae	*Parthenocissus quinquefolia*	Virginia creeper
Vitaceae	*Parthenocissus* sp.	Virginia creeper
Vitaceae	*Parthenocissus vitacea*	Virginia creeper
Vitaceae	*Vitis riparia*	riverbank grape
Vitaceae	*Vitis* sp.	grape

Table A-5. Tree species located in 2022 GLKN sampling.

Family	Species	Common name
Betulaceae	*Betula alleghaniensis*	yellow birch
Betulaceae	*Betula nigra*	river birch
Betulaceae	*Betula papyrifera*	paper birch
Betulaceae	*Ostrya virginiana*	ironwood
Cannabaceae	*Celtis occidentalis*	northern hackberry
Cupressaceae	*Juniperus virginiana*	red cedar juniper
Fabaceae	*Gleditsia triacanthos*	honey locust
Fabaceae	*Gymnocladus dioicus*	Kentucy coffeetree
Fagaceae	*Quercus alba*	white oak
Fagaceae	*Quercus bicolor*	swamp white oak
Fagaceae	*Quercus ellipsoidalis*	northern pin oak
Fagaceae	*Quercus macrocarpa*	bur oak
Fagaceae	*Quercus rubra*	northern red oak
Juglandaceae	*Carya cordiformis*	bitternut hickory
Juglandaceae	*Juglans cinerea*	butternut
Juglandaceae	*Juglans nigra*	black walnut

Table A-5 (continued). Tree species located in 2022 GLKN sampling.

Family	Species	Common name
Malvaceae	*Tilia americana*	American basswood
Moraceae	*Morus alba*	white mulberry
Moraceae	*Morus rubra*	red mulberry
Moraceae	*Morus* sp.	mulberry
Oleaceae	*Fraxinus americana*	white ash
Oleaceae	*Fraxinus nigra*	black ash
Oleaceae	*Fraxinus pennsylvanica*	green ash
Oleaceae	*Fraxinus* sp.	ash
Pinaceae	*Abies balsamea*	balsam fir
Rosaceae	*Amelanchier arborea*	downy serviceberry
Rosaceae	*Prunus pensylvanica*	pin cherry
Rosaceae	*Prunus serotina*	black cherry
Rosaceae	*Prunus tomentosa*	Nanking cherry
Rosaceae	*Prunus virginiana*	chokecherry
Rosaceae	*Sorbus* sp.	mountain ash
Salicaceae	*Populus deltoides* ssp. *monilifera*	plains cottonwood
Salicaceae	*Populus tremuloides*	quaking aspen
Salicaceae	*Salix amygdaloides*	peach-leaf willow
Salicaceae	*Salix nigra*	black willow
Salicaceae	*Salix* sp.	willow
Sapindaceae	*Acer negundo*	western boxelder
Sapindaceae	*Acer nigrum*	black maple
Sapindaceae	*Acer rubrum*	red maple
Sapindaceae	*Acer saccharinum*	silver maple
Sapindaceae	*Acer saccharum*	sugar maple
Sapindaceae	*Acer spicatum*	mountain maple
Sapindaceae	*Aesculus glabra*	Ohio buckeye
Salicaceae	*Salix* sp.	willow
Salicaceae	*Salix* sp.	willow

Table A-5 (continued). Tree species located in 2022 GLKN sampling.

Family	Species	Common name
Sapindaceae	*Acer negundo*	western boxelder
Sapindaceae	*Acer nigrum*	black maple
Sapindaceae	*Acer rubrum*	red maple
Sapindaceae	*Acer saccharinum*	silver maple
Sapindaceae	*Acer saccharum*	sugar maple
Sapindaceae	*Acer spicatum*	mountain maple
Sapindaceae	*Aesculus glabra*	Ohio buckeye
Ulmaceae	*Ulmus americana*	American elm
Ulmaceae	*Ulmus pumila*	Siberian elm
Ulmaceae	*Ulmus rubra*	slippery elm

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