CHARACTERIZING COMMUNITY COMPOSITION AND ESTIMATING ABOVEGROUND BIOMASS IN THE DEAD RIVER COMMUNITY FOREST

A report to the Upper Peninsula Land Conservancy

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INTRODUCTION

The Upper Peninsula Land Conservancy (hereafter "UPLC") is a 501(c)(3) non-profit organization based in Marquette, Michigan dedicated to the conservation and protection of the Upper Peninsula (UP) of Michigan. As of October 2022, UPLC fully acquired one (2) tract of land south of the Dead River and north of U.S. Highway 41 known as the Bayous Parcel and the Bridges Parcel. These tracts are now the core of the future Dead River Community Forest (hereafter "DRCF"). The DRCF will exist for natural conservation and recreation purposes, as well as serving to promote the local economy. The six (6) main objectives for development of this forest include: 1) permanently preserving the ecological value of the Bridges and Bayous Parcels; 2) provide recreational opportunities that meet the needs of the community; 3) actively engage the public in the land protection and management processes; 4) provide opportunities for the public to establish an emotional connection with the property and spur communal responsibility; 5) expand environmental education opportunities for students and landowners to experience hands-on learning about the sustainable management of various UP ecosystems/habitats; and 6) initiate a climate-change mitigation- and restoration-focused management plan. ("Protecting the Dead River Community Forest," 2021).

In July 2022, Dr. Adam Naito, an assistant professor of environmental science at Northern Michigan University (hereafter "NMU") contacted now Interim Director and Lands Program Manager Clare Fastiggi to request a continuation of a previous collaborative relationship first initiated between former UPLC Executive Director Andrea Denham, Dr. Susy Ziegler (head of the Department of Earth, Environmental, and Geographical Sciences at NMU), and Dr. Naito. As part of a service-learning project with Dr. Naito's Biogeography course in Fall 2021, he worked with UPLC and students to complete a field-based laboratory exercise that would serve to meet Objective #6 above. Specifically, undergraduate students in the biogeography course would characterize tree species composition, and through the application of basic forest mensuration techniques, estimate the biomass of trees greater than a diameter at breast height (DBH) measure of 20 cm. These biomass estimates can serve as a proxy for estimating the amount of carbon sequestered (stored) on the Earth's surface. As carbon sequestration potential of a plot of land increases, its ability to mitigate human-induced climate change also generally increases (Stephenson et a. 2014). As Dr. Naito was now taking on Sydney Chrome, an NMU Freshman Fellow during the 2022-2023 Academic Year, furthering this project from Fall 2021 would support UPLC's goal and provide another service-learning opportunity for a first-year student at NMU. With Ms. Fastiggi's approval, Dr. Naito and Sydney initiated an expansion of the project from Fall 2021 to provide a more spatially comprehensive assessment of community composition and aboveground biomass estimates across the DRCF. The following report details these findings.

STUDY SITE AND METHODS

The focus of this study was on the Bayous Parcel of the DRCF. After obtaining permission to enter DRCF from Ms. Fastiggi and the UPLC Board of Directors, Dr. Naito established four wandering transects extending through the lowland/riparian area of the northern section of the Bayous Parcel on Saturday 10 September 2022. Three transects were 200 m long, and one transect was 80 m long due to limitations created by poor weather and extent of marshes in the local area. Due to variability in topography in places, the wandering transect approach permitted forest stand characterization paralleling topographic contours so that transects would not cross into coves and thereby minimize/eliminate the potential for disturbance in those areas. At 20 m intervals along each transect, Dr. Naito planted 15" high-visibility flags and marked their locations as waypoints in a Garmin GPSMAP 64X handheld GPS receiver. These flags and the GPS waypoints would permit him and Sydney to locate the transects in the future and lay field tapes in the proper locations and orientation to establish the transect visually.

Field sampling

On each Saturday from 10 September to 8 Oct 2022, Dr. Naito and Sydney (hereafter, "researchers") traveled to the Bayous Parcel to initiate data collection. They used 100m and 60m field tapes to re-establish line transects using the 15" high-visibility flags as guides. At every 20 m interval, the researchers collected data on eight overstory trees via the point-centered quarter method (Fig. 2). Each interval served as the center point for four quadrants along the transect. In each quadrant, the researchers identified an understory and overstory tree closest to the transect. The understory tree was defined as having morphometrics for diameter at breast height (DBH) and height of <=15 cm and >1.5 m, respectively. The overstory tree was defined as having morphometrics for DBH > 15 cm and > 1.5 m, respectively. For each tree, the researchers identified and recoded the tree's species, distance from the transect to the nearest tenth of a meter, and DBH to the nearest tenth of a centimeter using diameter tapes. This sampling approach ensured that both young trees (which can uptake carbon more rapidly) and overstory old-growth trees capable of greater carbon storage potential were more sufficiently represented in the sampling scheme.

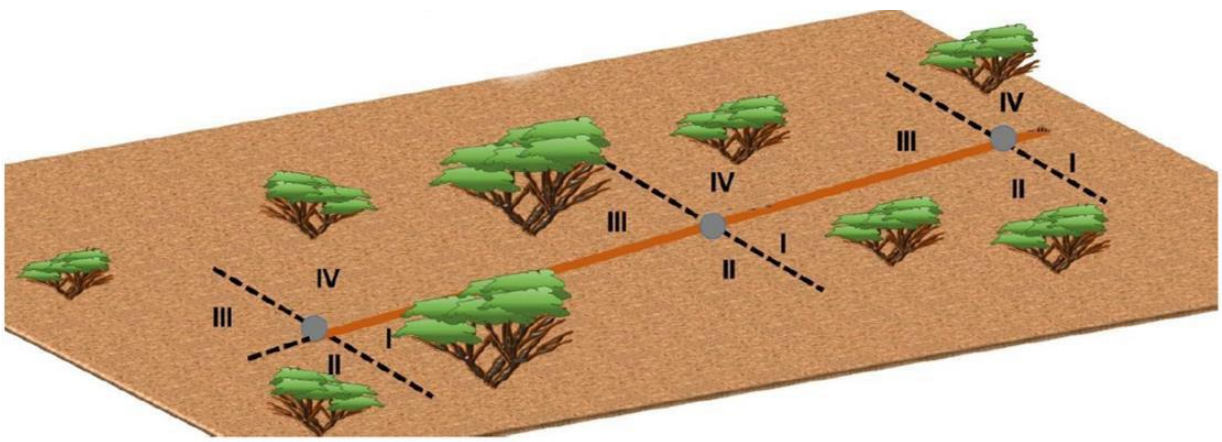

Figure 1*:* An example of the point-PCQ method along a transect.

Importance Values

The species, distance, and DBH data provide a basis for calculating importance values (IV) of a forest stand. IV is a measure of how dominant a species is in each forest area. It is commonly used by foresters to inventory a forest. Because of time and resource limitations, foresters cannot inventory a forest by counting all the trees. Instead, they sample an area to collect three kinds of data: 1) relative frequency, 2) relative density, and 3) relative dominance. Relative frequency refers to the percentage of inventory points occupied by a species expressed as a percentage of the occurrence of all species. Relative density refers to the number of individuals per area as a percentage of the number of individuals of all species. Relative dominance refers to the total basal area (BA) of the individuals of a species in an area as a percent of the total basal area of all species in that area. BA is the sum of the cross-sectional area of all the trees of a species, measured at 1.3-1.5 m above ground.

Biomass estimates

We obtained estimates of standing biomass (carbon on the ground minus the water) by collecting information on species and DBH and inputting these values into equations developed by other researchers. In this approach, other scientists have cut down trees, taken measurements of the foliage, the branches, the bole (main stem), and roots, dried them in massive ovens for at least 48 hours, and then mass them. Using these data, scientists can then generate a linear relationship between the natural log or base-10 log of the diameter or height and natural log or base-10 log of biomass, usually following one of three forms:

$$\ln(\text{biomass}) = \beta_0 + \beta_1 \ln(\text{diameter}) \quad (1)$$

$$\log_{10}(\text{biomass}) = \beta_0 + \beta_1 * \log_{10}(\text{diameter}) \quad (2)$$

$$\text{biomass} = \beta_0 * (\text{diameter}^\wedge \beta_1)) \quad (3)$$

where β_0 and β_1 are coefficients. This approach permits us to avoid cutting down, drying out, and massing all sampled trees. As peer-reviewed scientific papers provide the equations and the values for β_0 and β_1, we supplied diameter values to calculate biomass on a per-individual and per-species basis (per-species results presented in this report only).

***Figure 2**:* A photo of DRCF along the Dead River near Transect 2.

***Figure 3**:* A photo of DRCF along Transect 2.

Figure 4: Researcher Sydney Chrome measuring the diameter of a tree.

RESULTS AND DISCUSSION

A total of n=297 trees were sampled. *Acer saccharum*, *Acer rubrum*, and *Ostrya virginiana* were the most dominant species in terms of number of individuals and importance values (Fig. 5 and Table 1), with IV values of 103, 45, and 36, respectively. *Pinus strobus*, *Acer platanoides, and Acer pennsylvanicum.* followed as the next most dominant species in terms of individuals and IV values, with IV values of 30, 18, and 7, respectively. Other species observed included *Abies balsamea*, *Betula alleghaniensis*, *Betula papyrifera*, *Pinus banksiana*, *Picea glauca*, *Populus grandidentata*, *Populus tremuloides*, and *Quercus rubra.*

Of the species identified and measured, *Acer saccharum* and *Pinus strobus* had the highest estimated values of standing aboveground biomass, at 119 and 37 metric tons, respectively (Fig. 6, Table 2). These estimated values include the stem, bark, branches, and live or senescing foliage. *A. rubrum*, *O. virginiana*, and *Populus grandidentata* followed, with 32, 15, and 14 metric tons respectively. All other species had standing aboveground biomass estimates of less than 10 metric tons.

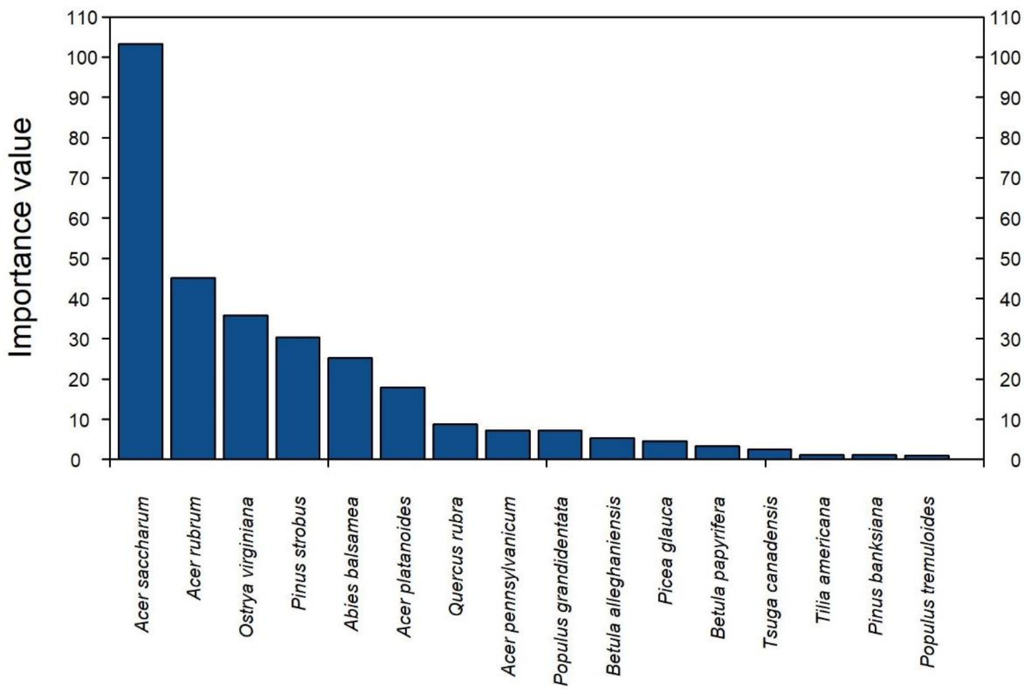

Figure 5. Importance values (IV) of all species sampled in DRCF. *A. saccharum* and *A. rubrum* were the most dominant in terms of individuals and IV values.

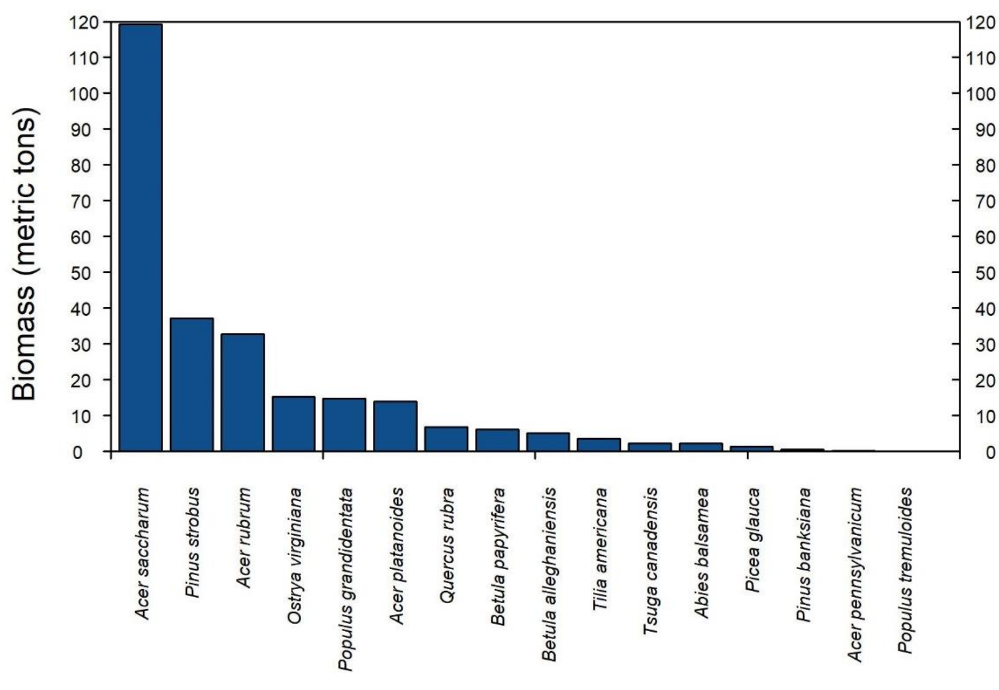

Figure 6. Estimates of standing aboveground biomass of all species sampled in DRCF. *A. saccharum* and *A. rubrum* were the most dominant in terms of total aboveground biomass.

Table 1. Number of individuals, range of DBH values, and importance values of all n=297 tree individuals sampled in DRCF.

Species	Count	DBH range (cm)	Relative density	Relative frequency	Relative dominance	Importance Value
Abies balsamea	33	5.5 - 41.6	11.1	12.8	1.5	25.3
Acer pennsylvanicum	9	6.0 - 16.7	3.0	4.3	0.0	7.3
Acer platanoides	32	8.3 - 76.1	10.8	7.1	0.0	17.9
Acer rubrum	37	5.3 - 107.2	12.5	13.5	19.2	45.2
Acer saccharum	72	8.5 - 82.5	24.2	18.4	60.5	103.2
Betula alleghaniensis	5	22.1 - 46.3	1.7	3.5	0.1	5.4
Betula papyrifera	3	35.5 - 68.2	1.0	2.1	0.1	3.3
Ostrya virginiana	51	5.1 - 57.3	17.2	12.8	5.8	35.8
Pinus banksiana	1	36.4	0.3	0.7	0.0	1.1
Picea glauca	5	10.5 - 36.4	1.7	2.8	0.1	4.6
Pinus strobus	26	9.4-78.5	8.8	10.6	11.0	30.4
Populus grandidentata	8	9.3 - 72.8	2.7	3.5	1.0	7.2
Populus tremuloides	1	11.7	0.3	0.7	0.0	1.0
Quercus rubra	10	7.7 - 63.3	3.4	5.0	0.4	8.8
Tilia americana	1	80.6	0.3	0.7	0.0	1.1
Tsuga canadensis	3	8.0 - 61.5	1.0	1.4	0.1	2.5

Table 2. Total and per-species estimates of aboveground biomass (metric tons) of individuals sampled in DRCF.

Species	Source	β_0	β_1	Biomass (metric tons)
Abies balsamea	Chojnacky et al. 2013	-2.3123	2.3482	2.28
Acer pennsylvanicum	Fatemi et al. 2011	-2.047	2.3852	0.31
Acer platanoides	Chojnacky et al. 2013	-2.047	2.3852	14.06
Acer rubrum	Fatemi et al. 2011	2.13	2.237	32.82
Acer saccharum	Chojnacky et al. 2013	2.18	2.416	119.20
Betula alleghaniensis	Schmitt and Grigal 2011	2.26	2.513	5.11
Betula papyrifera	Chojnacky et al. 2013	1.99	2.538	6.15
Ostrya virginia	Chojnacky et al. 2013	-2.2652	2.56349	15.38
Picea glauca	Chojnacky et al. 2013	-2.1364	2.3233	1.41
Pinus banksiana	Chojnacky et al. 2013	-2.6177	2.4638	0.55
Pinus strobus	Fatemi et al. 2011	-2.6177	2.4638	37.18
Populus grandidentata	Chojnacky et al. 2013	-1.8096	2.348	14.91
Populus tremuloides	Chojnacky et al. 2013	-2.441	2.4561	0.04
Quercus rubra	Fatemi et al. 2011	-2.5095	2.6175	6.86
Tilia americana	Chojnacky et al. 2013	-2.4108	2.4177	3.65
Tsuga canadensis	Chojnacky et al. 2013	-3.0506	2.6465	2.33
			Total	**262.24**

Species richness and evenness were assessed using a rank abundance curve (Fig. 7). Richness (the number of species) is arranged in order on the x-axis from highest (on the left) to lowest (on the right). Evenness is a measure of relative abundance of a species in comparison to all other species present in a community and is represented by the shape of the curve. Several metrics for relative abundance can be used, including canopy cover and biomass. In this case, the metric for relative abundance was aboveground biomass. While high species richness in an ecological community is often desirable and is an indicator of ecological resilience, evenness is also important to assess, with higher evenness often more desirable and conferring higher resilience. In a highly even community, the rank abundance curve will either be flat or gently sloping upwards to the left. In a highly uneven community, the rank abundance curve will be steep, indicating that only one or several species are abundant.

The rank abundance curve in Fig. 7 indicates a somewhat uneven ecological community present in the forest. The most abundant species in terms of both richness and aboveground biomass is *Acer saccharum*. This is followed closely by old-growth, large-diameter *Pinus strobus*. Other species with relatively high abundance as a function of biomass included *A. rubrum*, *O. virginiana*, and *Populus grandidentata*. All other species ranked low in terms of abundance as a function of biomass.

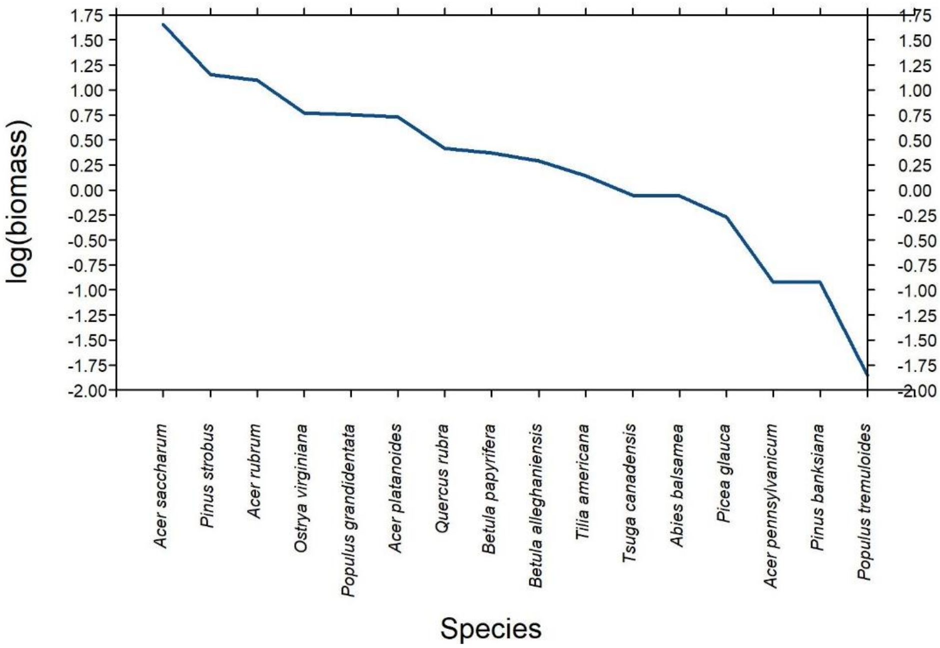

Figure 7. Rank abundance curve of species present along the four sampling transects as a function of aboveground biomass.

While data collection occurred at peak biomass just before the onset of autumn senescence, per-species estimates of biomass would have been improved if: 1) height measurements from our rangefinders could have been more effectively acquired, and 2) data collection was not limited to a single day per week for a month, and 3) more region-specific biomass equations could have been obtained. Efforts were made to find sources providing estimates of biomass from areas in the Upper Midwest, but this was not always possible, particularly for *Abies, Acer, Quercus, and Tsuga.* In these instances, the equations are suitable for estimating biomass at the genera level for all of North America. As these are suitable at the continental scale, they likely contain higher amounts of variability in their predictive capacity, reducing the accuracy of the estimates presented herein.

More extensive field work will be needed to better characterize the community composition and total estimates of biomass in the Bayous Parcel of DRCF, particularly at peak standing biomass in August. However, given these very preliminary results, appropriate conservation practices at DRCF will ensure that the forest can continue to sequester carbon and promote economic opportunities. Both natural and human disturbances impact carbon storage potential at regional scales (Coomes et al. 2011). With broadly regional losses of fire-dependent *Q. rubra* as a consequence of fire suppression during the 20th century, as well as projected losses of the economically- important *Acer* species due to a variety of factors such as soil acidification, climate-mediated stress, insect infestations, and nutrient depletion (*cf*. Bishop et al. 2014). DRCF could potentially serve to mitigate both regional concerns.

CONCLUSION

This was a very preliminary study to characterize tree community composition, the relative dominance of species, and standing aboveground biomass estimates in the northern lowland area of the Bayous Parcel of the Dead River Community Forest near Marquette, Michigan. The work presented here may serve as a foundation for future longer-term studies that involve UPLC staff, community members, and students at Northern Michigan University that involve community composition and standing biomass characterization. Trends in these ecosystem components may help support and guide UPLC practices as the DRCF becomes open to the community for research, education, and recreation.

Researcher Sydney Chrome presented a portion of this work at the NMU Celebration of Student Scholarship in April, 2022. You can find her 10-minute talk at about the 1 hour mark at the following YouTube link: https://youtu.be/8VLESe-lzF0?t=3614.

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APPENDIX

Examples descriptions of the components of Importance Values (IV):

Relative frequency: Suppose the species under consideration is *Pinus resinosa* (red pine). If *P. resinosa* is found in 4 out of 10 sample points, its relative frequency is 40%. Note that this calculation involves counting whether or not an individual species is found in each sampling point at 20 m intervals. It does not account for the actual number of individuals found at each sampling point. Rather, it is just accounting for "is it present or not at each sampling, regardless of how many there actually are?"

Relative dominance: Diameter measurements of each tree were converted to an areal measurement in square meters. So, imagine, that we cut the tree at 1.3-1.5m off the ground and measure the exposed area of wood inside. This would be the BA of this individual. We calculated the total BA of each species within the entire transect and across all three transects (Table 3).