Comparing Dual Restorations in an Urban Park: Twice as Nice?

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Introduction:

New York City (NYC) originally contained a multitude of ecological zones ranging from coastline to forest[1]. Remnants of its unique diversity continue to inhabit many green spaces in NYC, such as **Van Cortlandt Park** (VCP) in the Bronx (see **fig.1**), which is now the city's 3rd largest park[2]. During its **300 year-history**, the Van Cortlands operated it as a slave plantation for much of its colonial history for grain farming and logging[3]. The remnants of the estate were sold to NYC as a 464-hectare woodland at the end of the 1800s. Robert Moses fragmented VCP by running multiple highways through it in the middle of the 1900s, after which the park become neglected during the 1970s financial crisis that plagued the city[4]. The park is now maintained under the auspices of the **New York City Department of Parks and Recreation** (NYCDPR) and a private organization, the **Van Cortlandt Park Conservancy**, both of which undertake selective removal of non-natives followed by **restoration with native replantings**.

City parks contain a complex admixture of native and non-native vegetation due to years of anthropogenic perturbations, which may increase biodiversity[5]. This stands in contrast to the historical paradigm that considered most cities biotically depauperate[6]. Floral interactions in VCP conducted in 2015 found the park species-rich with much of diversity residing at the **herbaceous layer**[7], a hypothesis originally proposed by Gilliam[8] for the forests of all Eastern seaboard states. Using the park as a proxy, we explored Gilliam's findings by comparing the **floral biodiversity** of two sites at the north end of VCP, both **pre- and post-renovation**, with each site employing a different methodology.

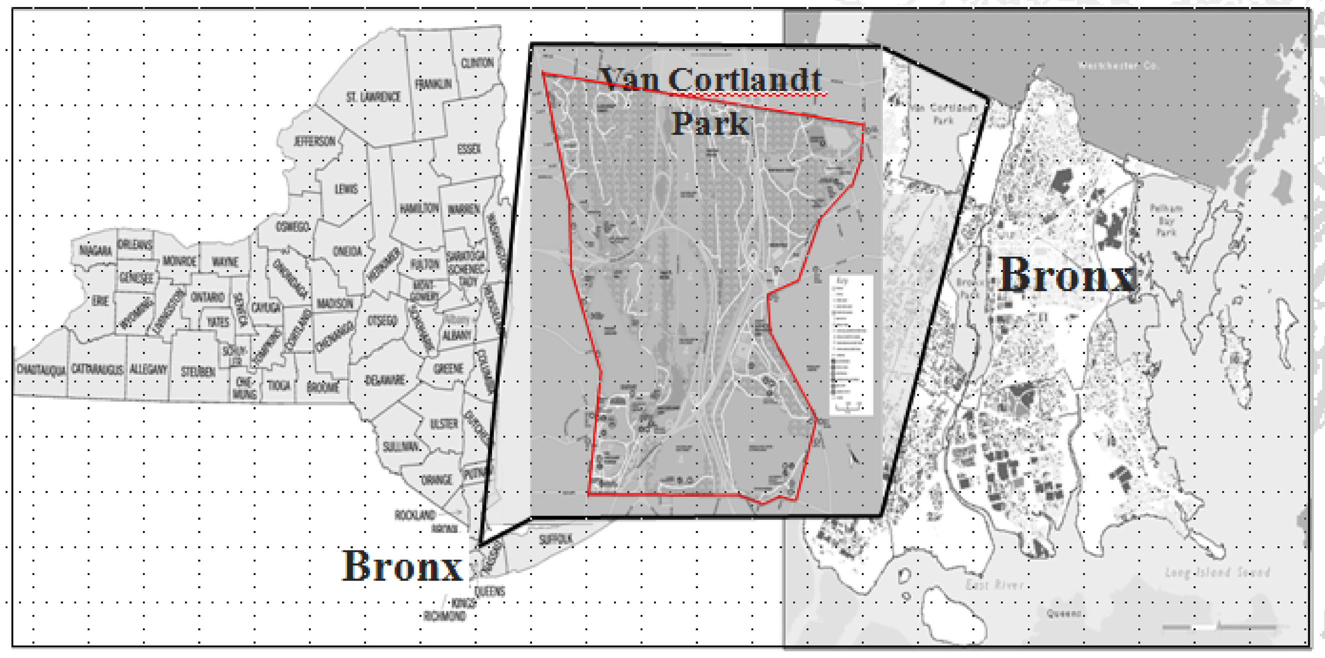

Figure 1. Van Cortlandt Park comprises 464 ha of mixed woodlands and playing fields making it New York City's third largest park under the NYC Department of Parks and Recreation scheme[2].

Study Aims:

- **Conduct point-center quarter surveys of the tree and herb-layer at VCP**
- **Construct NJ trees and calculate diversity indices and importance values (IV)**
- **Contrast the results from two sites to compare restoration methodologies**

Materials and Methods:

Two seasonal moist regions in VCP were surveyed pre' and post-restoration using a **point-center quarter method**[9] at year 0 and year 1, (+ year 8 for Site 1). At each **point**, the **four nearest trees** in the cardinal directions were **identified** with **distance** recorded plus **DBH$_{130cm}$**. Randomized placement of 20 **1 m^2 quadrats** were used to record **herb-layer** (defined as any plant ≤100cm[8]) using % cover and stem counts. **Presence/absence** data per point per region[10] was entered into Excel[11] to calculate **importance values** and to generate **rank abundance curves** (RAC). Data sheets were analyzed by **PAST** software v4.04[12] to construct **NJ trees** (cluster, Euclidean, 1000 bs) and compute **diversity indices**. **Results were compared between the two sites**, one of which employed **RoundUp**™ (Site 1), and the other which used **hand-clearance** (Site 2).

Results:

Neighbor-joining[12] results from the presence/absence data sets are shown in **Figure 2A-B** for **herbaceous plants** versus **woody plants**. Each site was compositionally unique from the other, regardless of sampling year. Pooling the analyses returns similar results. **Branch lengths** reflect compositional change in taxa; the length change most noticeable in Site 1 at the herbaceous level, one year post-restoration (Y1).

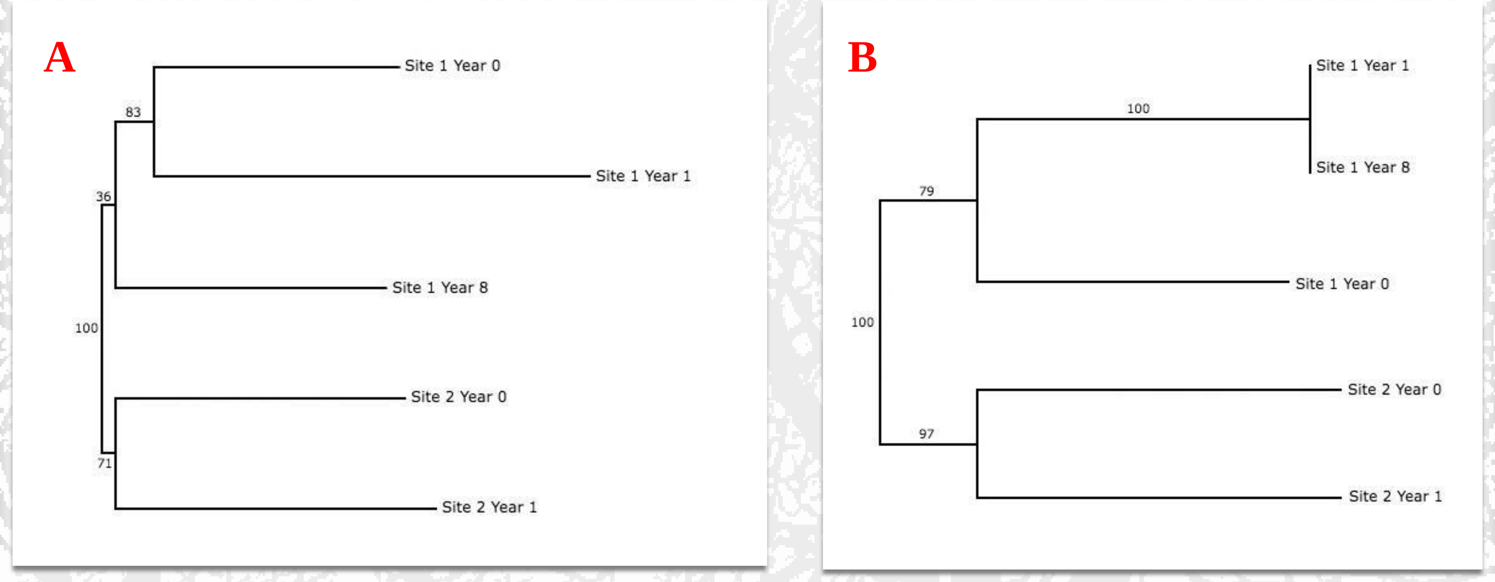

Figure 2. Neighbor-joining tree[12] for herbaceous data (A) and woody data (B) from both sites from differing survey periods (Euclidean, 1000 bootstraps). Strong support separates the two sites.

Diversity indices[11,12] reflect species change over time (see **Table 1**). Site 1 was sampled three times in 8 years (Y0, Y1, Y8) compared to Site 2, which was sampled twice (Y0, Y1). **Site 1** showed **herbaceous diversity increased dramatically** post-restoration (Y1), some of which were **state-listed**, which decreased *below* pre-restoration levels by Y8. **Site 2** had a **slight decrease in herbaceous diversity**. **Woody diversity increased** in **Site 1/Y1**, and was maintained (**Y8**). **Woody diversity decreased slightly** in **Site 2/Y1** with non-native removal.

Table 1A-B. Diversity indices for herbaceous and woody data, Site 1 vs Site 2, year 0-1. +/- 8 (Y0-1, +/-Y8).

A: Herb diversity	*Site 1/Y0*	*Site 1/Y1*	*Site 1/Y8*	*Site 2/Y0*	*Site 2/Y1*
Number of Taxa	55	115	42	50	52
Number of Individuals	1851	2906	1283	1406	1781
Dominance	0.06371	0.06015	0.2001	0.1096	0.1231
Simpson's Diversity Index	0.9363	0.9399	0.7999	0.8904	0.8769
Shannon's Diversity Index	3.169	3.53	2.322	2.861	2.608
Evenness	0.4326	0.2968	0.2427	0.3497	0.261
Brillouin's Diversity Index	3.107	3.456	2.265	2.794	2.554
Menhinick's Richness Index	1.278	2.133	1.173	1.333	1.232
Margalef's Richness Index	7.178	14.3	5.729	6.76	6.814

B: Tree diversity	*Site 1/Y0*	*Site 1/Y1*	*Site 1/Y8*	*Site 2/Y0*	*Site 2/Y1*
Number of Taxa	18	19	19	17	10
Number of Individuals	80	80	72	49	41
Dominance	0.145	0.09281	0.08681	0.1279	0.1767
Simpson's Diversity Index	0.855	0.9072	0.9132	0.8721	0.8233
Shannon's Diversity Index	2.39	2.609	2.656	2.408	1.942
Evenness	0.6064	0.7151	0.7496	0.6538	0.6972
Brillouin's Diversity Index	2.097	2.293	2.311	2.013	1.654
Menhinick's Richness Index	2.012	2.124	2.239	2.429	1.562
Margalef's Richness Index	3.879	4.108	4.209	4.111	2.424

Importance values[9,12] show non-native, invasive ***Alliaria*** returned **top ranking** in both sites, pre' and post-restoration. In Site 1, *Alliaria* was pernicious, increasing **IV** from **24.02** (Y0) to **61.13** (Y8) by supplanting other herbs. Both sites cleared non-native, invasive *Reynoutria*. Each **RAC** also reflects the prominence of *Alliaria* in all periods (**fig. 3**). **Woody IV** is dominated by **native plants**, post-renovation, as *Robinia* and Norway maple decline.

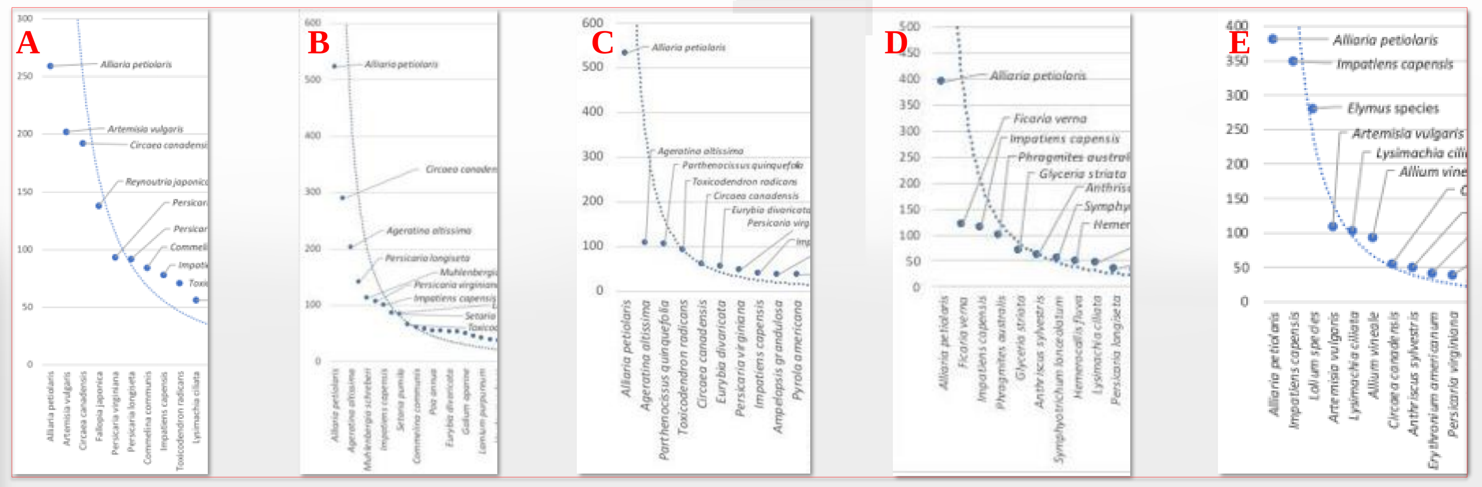

Figure 3A-D. RAC[11] for: A. Site 1/Y0, B. Site 1/Y1, C. Site 1/Y8, D. Site 2/Y0, E. Site 2/Y1.

Discussion:

Greenspaces in **NYC** contain complex admixtures of **native and non-native flora** as **novel ecosystems**. Although most non-natives are benign, some are capable of becoming **invasives** that supplant native vegetation. As a result, NYCPDR maintains an active invasive removal campaign[13]. Until recently, this relied on clearance of sites targeted for restoration through use of the glyphosate, **RoundUp**, a known carcinogen[14], which is now banned by the Parks Department. We were able to compare a restored site that used **RoundUp for clearance** (Site 1) versus another area (Site 2) restored several years later that relied on **hand-clearance**. This also allowed us to explore **Gilliam's hypothesis**[8] that diversity in Eastern seaboard forests is largely a result of the herb layer.

Overall richness was initially higher in the RoundUp restored area (Site 1), which saw a profusion of herbaceous plants appear the year following treatment, many as opportunistic ruderal non-natives, but some as **state-listed rarities**, such as ***Agastache nepetoides*** (L.) Kuntze, ***Senna hebaclada*** (Fernald) Irwin & Barneby, and ***Oenothera laciniata*** Hill (see fig. 4A-C). Richness and diversity *decreased* dramatically in Site 1 by Year 8 once a closed canopy was formed by the young replanted saplings.

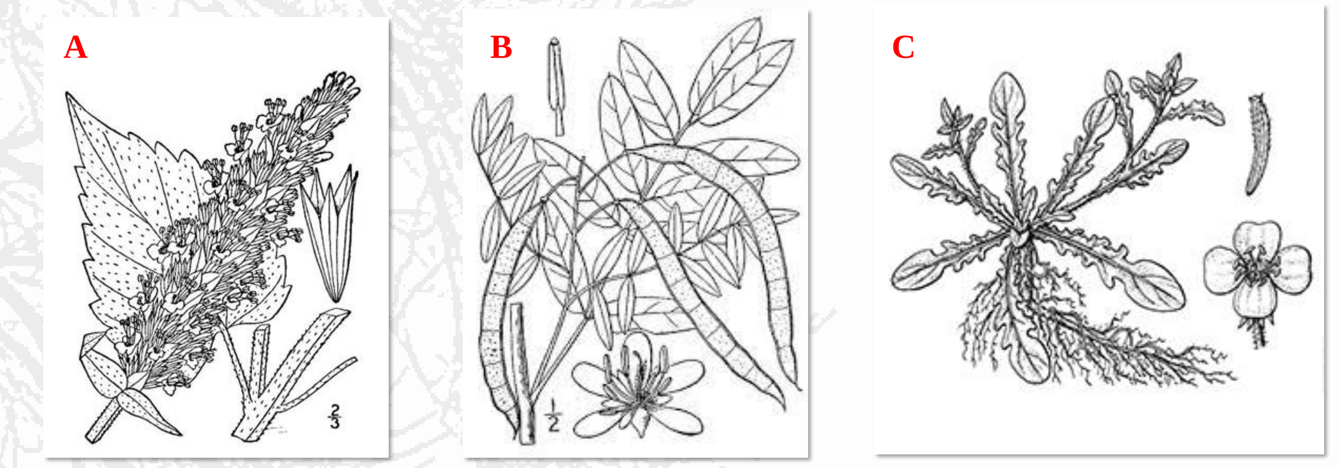

Figure 4A-C. Unusual flora found in VCP following park restorations: A. *Agastache nepetoides*[15], B. *Senna hebecarpa*[16], C. *Oenothera laciniata*[17]. All three taxa were lost by Y8 in Site 1 once the canopy reclosed.

Site 2 was painstaking hand-cleared, resulting in a smaller replanted area than Site 1, and a smaller resampling site for Site 2/Y1. **Richness and diversity decreased slightly in Site 2** following restoration, which was largely a factor of non-native eradication. Non-native woody *Robinia* decreased in prominence in Site 1, but still returns the highest IV in Site 2, both Y0&Y1. What both treatments shared in common, however, was support for Gilliam's view that the **majority of diversity is found in the herb layer**[8]. Considering that restoration in most NYC parks is mainly concerned with replanting woody stock[13], the **importance of the herb layer** should be emphasized since it harbors most of the **diversity** and **increases pollinator services** that woody plants may not always provide. That state-listed flora can still be found in NYC parks illustrates their potential to act as **refugia**. Since **restoration allows re-emergence of herbaceous rarities**, opening the canopy from time-to-time should be encouraged.

Conclusions:

- **Van Cortlandt Park has greatest diversity at the herb-layer**
- **A dramatic increase in herbaceous diversity in a RoundUp-cleared site was lost following canopy closure showing restoration favors native woody plants**
- **Clearance of sites increases diversity by promoting environmental heterogeneity; restorations creating openings should therefore be encouraged**

References: 1.Blaustein (2013) *Bioscience* 63, 2.NYCDPR (2016), 3.Pons (1986) *VCP History*, 4.Corey (1999) *Norwood News* 12, 5.Ellis *et al.* (2012) *PLOS*, 6.Pickett *et al.* (2008) *Bioscience* 58, 7.Henning (2015) thesis, 8.Gilliam (2007) *Bioscience* 57, 9.Mitchell (2007) *arXiv*, 10.Rachlin *et al.* (2008), 11.Microsoft Excel (2010), 12.Hammer (2021) *PAST* v4.04, 13. NYSDEC (2014), 14. Vasquez *et al*. (2021) *Microbiologia*, 15. *wisflora.herb.wisc.edu*, 16. *namethatplant.net*, 17. *Trugreen.com*

Contributions: Asher and Peña were responsible for all data collection, analyses, and write up as part of a Macauley's Honor Project conducted as a BIO 489/490 tutorial. Henning assisted plant identification.

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