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Botanical inventory of early successional species following pipeline construction along a dynamic urban creek

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ABSTRACT. — Following the installation of a large sewer pipeline on the property of the Litzsinger Road Ecology Center in St. Louis County, Missouri, restoration staff began a floristic survey of early successional species colonizing the deconstructed soils. Included are the results and analysis from that survey, an annotated table containing the full species list, data from prior floristic surveys, as well as descriptions of the habitat, soils, and construction project at the site. During the first growing season, total mean C-value and native mean C-value were both significantly lower within the pipeline path than in adjacent reconstructed habitats.

INTRODUCTION

In September 2019, the Metropolitan Sewer District of St. Louis (MSD) began construction of a sewage pipeline running through the 15.7 hectare (39 acre) property of the Litzsinger Road Ecology Center (LREC), an educational facility of the Missouri Botanical Garden. This 0.8 kilometer (0.5 mile) long pipeline construction path would ultimately remove all of the pre-existing plant cover from a 2 hectare (5 acre) area along Deer Creek. Both bottomland woodland restoration and bottomland prairie reconstruction habitat types at the LREC were heavily altered during this construction process. The prairie habitat reconstructions at the LREC began in 1989, making them some of the oldest prairie reconstructions in the St. Louis region. Once all vegetation was removed from the surface of this path, excavation of deep trenches began, followed by dynamiting of the limestone bedrock (ca. 15 ft of soil and 10 ft of bedrock, according to MSD). The resulting homogenized piles of all the soil horizons and pulverized bedrock were later backfilled into the 7.62 m (25 ft) deep trenches on top of the new sewer pipe. This resulted in a very different soil structure for the developing roots of the future plantings planned for this area.

In early 2019, prior to the beginning of the sewer project, LREC staff and volunteers conducted a woody plant inventory along the proposed pipeline path through the property. Pipeline construction activities resulted in the removal of 746 native trees and shrubs representing 41 different native species. Of these 746 woody plants, 289 were larger trees >15 cm (6 in) DBH that comprised the woodland canopy. The 289 canopy trees alone were valued by the U.S. Forest Service at a replacement rate of over $500,000, and ecologically they were an invaluable resource of food and shelter for wildlife (Faupel 2019, 2021).

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Additionally, the Institute of Botanical Training (IBT) conducted a botanical inventory of the area during three visits in the 2019 growing season. Their goal was to survey for plant species present in the various habitats onsite at the LREC, including the area of the proposed pipeline. These surveys documented 388 total plant species, 318 of which were native to Missouri (Thomas & Budach, 2019). Through additional botanical surveys by staff at the LREC following the IBT inventory, we believe we have closer to 450+ total plant species onsite.

Figure 1. Before and after the 0.8 km (0.5 mile) MSD pipeline construction path on the property of the LREC. Left: October 2018, right: March 2021 (Google Earth 2019, 2021).

Heavy disturbance within the construction path primarily ended by the spring of 2022, allowing for plants to begin colonizing the overturned soil throughout the 2022 growing season. Soil samples were taken in the summer of 2022 by interns Clara Barton, the senior author, and contracted geologist Scott George. Barton compared 2022 soil sample results with baseline soil samples taken by George in 2019, prior to the construction of the MSD path.

Barton found that many significant changes have occurred to the soil, which will have tremendous impacts on any plants that attempt to grow within the path. Some of the most important changes were the severe drops in available minerals necessary for plant growth, specifically nitrogen, phosphorus, and potassium. Additionally, there was an increase in soil alkalinity (pH) and a considerable drop in cation exchange capacity (CEC), both of which will directly hinder plants' abilities to access needed nutrients. Severe soil compaction has left the construction path with wetland-like soils/growing conditions (low pore space and oxygen, reduced water infiltration

and drainage). However, the riparian bottomlands of the LREC dry out more frequently than a wetland would naturally in summer. Lastly, all microbial soil samples from within this deconstructed soil showed that microbial life was almost non-existent, resulting in a collapsed soil food web that will take years to recover (Barton 2022). These unnatural growing conditions will likely benefit exotic "weedy" species that are prolific in our urban landscape. Compact urban soil conditions can lead to the less aggressive native plant species being selected out over time, as they do not have the capability to adapt to survive such irregular fluctuations in soil moisture that is common in a growing urban environment.

The two previously mentioned 2019 plant inventories can serve as a baseline plant list against which to compare future habitat reconstruction of the pipeline path; however, taking into account how much the soil composition has changed, all of the same pre-existing plant species will likely never be successfully reintroduced in such growing conditions in our lifetimes. Initial plant community reconstruction work within the path will begin with seeding a mix of annual grasses, turnips, legumes, and mustards as cover crops for two growing seasons, to start the process of breaking up the soil compaction and reintroducing organic material into the soil in hopes of restarting microbial activity.

The purpose of this 2022 inventory was to survey and catalog all early successional vascular plant species occurring within the boundaries of the MSD pipeline construction path during its first growing season, post major disturbances, and before any grassland reconstruction work by the LREC staff begins. This flora checklist will act as the new baseline for the present disrupted soil conditions.

Figure 2. View of the riparian pipeline path. Once covered by woodland tree canopy, it is now colonized by early successional species after one growing season. Photo by James Faupel.

METHODS

Floristic surveys of the MSD path were conducted by LREC staff. The MSD path was broken into three sections based upon its two intersections with Deer Creek, and these were surveyed on August 17-19, 2022. Each survey was a thorough, *systematic meander* (Thomas & Budach 2019) consisting of walking the site in a row-by-row fashion to visually survey the entire site. Plant species that could not be identified in the field were collected for later identification by the senior author using Steyermark's *Flora of Missouri* (Yatskievych 1999, 2006, 2013). Several follow-up walkthroughs were conducted in the ensuing weeks to confirm identifications and finalize additions to the species list.

Upon compiling the final list of species present at the site, the *Ecological Checklist of the Missouri Flora for Floristic Quality Assessment* (Ladd & Thomas 2015) was referenced for conservatism rankings (C-values), wetness index values, nomenclature, and other relevant ecological information. A general floristic quality assessment (FQA) was completed from these C-values (**Table 1**). Ecological values were used to assess relative proportions of relevant functional/ecological groups within this plant community (**Tables 2** & **3**). The total species list (**Table 4**) is arranged by scientific name and includes life-cycle type, physiognomic class, W-value, and C-value for each species.

RESULTS AND DISCUSSION

The 2022 survey of the MSD pipeline path documented 141 plant species. Native plants comprised 69.50% of this total at 98 species, and introduced plants comprised 30.50% at 43 species. Although there were more native species than exotics in our survey area, we observed that exotic species likely outnumbered natives by abundance. Unfortunately, abundance was not measured for this report. *Echinochloa crus-galli*, an exotic barnyard grass, was observed to be among the most dominant and abundant graminoid species throughout the site, and covered approximately 80-90% of the soil surface. Total mean C-value of the pipeline path (including introduced plants) was 1.7. The mean native C-value (excluding introduced plants) was 2.5. For comparison, the data from the 2019 IBT survey showed the mean C-value of the restored woodlands and reconstructed prairies adjacent to the pipeline path (including introduced plants) was 3.2, while the mean native C-value (excluding introduced plants) was 3.9 (Thomas & Budach 2019).

The total destruction of the preexisting plant community within the MSD path means the plant community there is fundamentally different from elsewhere within the LREC property. In general, sites with mean C-values of at least 3.5 are considered to retain remnant ecological integrity worthy of preservation (Thomas & Budach 2019). The relatively low total mean C-value of 1.7 within the recently disrupted MSD path suggests the ruderal character of this plant community. It is worth noting that this species list is approximate, especially for such a dynamic and early-successional plant community. It is also possible that some spring/early summer flora was missed due to the late summer timeframe of this floristic survey.

One major concern following this pipeline's completion is that it has allowed an easy access point for additional exotic invasive plant species to begin colonizing restored habitats at the LREC. This survey did record a handful of new invasive species to the site, such as *Phragmites australis*, that could cause long term problems for ecological restoration efforts. Continuing the floristic surveys of this area in the future will not only be of botanical interest to students and staff, but will also provide invaluable information to maintain the land management mission of the Missouri Botanical Garden at the LREC.

More data needs to be collected and available from early successional systems in the region. Future LREC interns and staff will have the opportunity to repeat this survey's methods in future years, to watch and learn from this dynamic habitat reconstruction that will remain highly influenced by seed pressures of the surrounding invasive species, urban isolation, and disturbance history. Future floristic survey data will continue to be shared publicly.

Table 1. Floristic Quality Assessment for MSD pipeline construction path on the property of LREC.

	Species	**Mean C-value**
All taxa	141	1.7
Native taxa	98	2.5

Table 2. Number and percentage of species by nativity, life cycle strategy, and relevant physiognomic class.

Life cycle strategy:

	Native		**Introduced**		**Combined**	
Annual/biennial	37	26.24%	26	18.44%	63	44.68%
Perennial	61	43.26%	17	12.06%	78	55.32%

Physiognomic class:

	Native		**Introduced**		**Combined**	
Forb	65	46.10%	28	19.86%	93	65.96%
Grass	13	9.22%	11	7.80%	24	17.02%
Sedge	8	5.67%	1	0.71%	9	6.38%
Shrub	0	0.00%	1	0.71%	1	0.71%
Tree	9	6.38%	2	1.42%	11	7.80%
Woody vine	3	2.13%	0	0.00%	3	2.13%

Table 3. Number and percentage of species by wetness rating (W). Wetness designations denote species' overall ecological pattern and were assigned by Lichvar (2012, 2013) for wetland delineation purposes. Because wetness designations can vary between regions, we used W-values for Missouri from Ladd & Thomas (2015). Each species is assigned one of five wetness designations: obligate wetland (OBL), facultative wetland (FACW), facultative (FAC), facultative upland (FACU) or upland (UPL) (Lichvar 2012, 2013).

Wetness Rating	Native		Introduced		Combined	
OBL	21	14.89%	0	0%	21	14.89%
FACW	24	17.02%	4	3%	28	19.86%
FAC	21	14.89%	6	4%	27	19.15%
FACU	27	19.15%	26	18%	53	37.59%
UPL	4	2.84%	7	5%	11	7.80%

Table 4. Project area flora arranged alphabetically by scientific name, with Conservatism rankings (C), life-cycle/physiognomy (PHYSIOG), wetness index values (W), and common names. Exotic species are denoted with a [*] in the C column. This table uses ratings from Ladd & Thomas (2015). Annuals, perennials, and biennials are denoted A-, P-, and B-, respectively under the physiognomy column. Relevant physiognomic classes include forbs (FORB), grasses (GRASS), sedges (SEDGE), shrubs (SHRUB), trees (TREE), and woody vines (W-VINE).

C	SCIENTIFIC NAME	PHYSIOG	W	COMMON NAME
*	*Abutilon theophrasti*	A-FORB	FACU	velvetleaf
1	*Acalypha rhomboidea*	A-FORB	FACU	three-seed mercury
1	*Acer negundo*	TREE	FAC	boxelder
2	*Acer saccharinum*	TREE	FACW	silver maple
*	*Albizia julibrissin*	TREE	UPL	mimosa tree
0	*Amaranthus tuberculatus*	A-FORB	FACW	roughfruit amaranth
0	*Ambrosia artemisiifolia*	A-FORB	FACU	annual ragweed
0	*Ambrosia trifida*	A-FORB	FAC	giant ragweed
6	*Ammannia coccinea*	A-FORB	OBL	scarlet toothcup
5	*Andropogon gerardii*	P-GRASS	FAC	big bluestem
3	*Apocynum cannabinum*	P-FORB	FACU	dogbane
4	*Arnoglossum atriplicifolium*	P-FORB	UPL	pale Indian plantain
*	*Artemisia annua*	A-FORB	FACU	annual wormwood
*	*Artemisia vulgaris*	P-FORB	UPL	mugwort
1	*Bidens aristosa*	A-FORB	FACW	swamp marigold
2	*Bidens frondosa*	A-FORB	FACW	beggarticks
4	*Campanula americana*	A/B-FORB	FAC	tall bellflower
2	*Carex blanda*	P-SEDGE	FAC	common wood sedge
2	*Carex frankii*	P-SEDGE	FAC	Frank's sedge
2	*Catalpa speciosa*	TREE	FACU	Northern catalpa

C	SCIENTIFIC NAME	PHYSIOG	W	COMMON NAME
2	*Chamaecrista fasciculata*	A-FORB	FACU	partridge pea
4	*Chasmanthium latifolium*	P-GRASS	FAC	creek oats
*	*Chenopodium album*	A-FORB	FACU	white goosefoot
*	*Cichorium intybus*	P-FORB	FACU	chicory
*	*Commelina communis*	A-FORB	FAC	Asiatic dayflower
*	*Commelina diffusa*	A-FORB	FACW	climbing dayflower
3	*Conoclinium coelestinum*	P-FORB	FAC	blue mistflower
4	*Cuscuta campestris*	A-FORB	UPL	field dodder
*	*Cynodon dactylon*	P-GRASS	FACU	bermudagrass
*	*Cyperus esculentus*	P-SEDGE	FACW	yellow nutsedge
3	*Cyperus squarrosus*	A-SEDGE	OBL	bearded flatsedge
1	*Cyperus strigosus*	P-SEDGE	FACW	straw-colored flatsedge
3	*Desmanthus illinoensis*	P-FORB	FACU	Illinois bundleflower
3	*Desmodium paniculatum*	P-FORB	FACU	panicledleaf tick trefoil
4	*Dichanthelium clandestinum*	P-GRASS	FACW	deertongue
	Dichanthelium sp.	P-GRASS	---	rosette panicgrass
*	*Digitaria ischaemum*	A-GRASS	FACU	smooth crabgrass
*	*Digitaria sanguinalis*	A-GRASS	FACU	large crabgrass
*	*Echinochloa crus-galli*	A-GRASS	FAC	barnyard grass
2	*Echinochloa muricata*	A-GRASS	OBL	rough barnyard grass
3	*Eclipta prostrata*	A-FORB	FACW	false daisy
*	*Eleusine indica*	A-GRASS	FACU	goosegrass
5	*Elymus canadensis*	P-GRASS	FACU	Canada wild rye
7	*Elymus riparius*	P-GRASS	FACW	riverbank wild rye
*	*Eragrostis minor*	A-GRASS	UPL	little lovegrass
1	*Erechtites hierarchiifolius*	A-FORB	UPL	fireweed
1	*Erigeron annuus*	A-FORB	FACU	annual fleabane
0	*Erigeron canadensis*	A-FORB	FACU	horseweed
1	*Eupatorium serotinum*	P-FORB	FAC	late boneset
3	*Euphorbia humistrata*	A-FORB	FAC	spreading spurge
0	*Euphorbia maculata*	A-FORB	FACU	spotted spurge
0	*Euphorbia nutans*	A-FORB	FACU	nodding spurge
*	*Euphorbia prostrata*	A-FORB	FACU	prostrate spurge
3	*Euthamia graminifolia*	P-FORB	FAC	grass leaved goldenrod
5	*Fimbristylis autumnalis*	A-SEDGE	FACW	slender fimbry
2	*Fraxinus pensylvanica*	TREE	FACW	green ash
*	*Glechoma hederacea*	P-FORB	FACU	ground ivy
5	*Helenium autumnale*	P-FORB	FACW	sneezeweed

C	SCIENTIFIC NAME	PHYSIOG	W	COMMON NAME
4	*Hibiscus laevis*	P-FORB	OBL	halberdleaf rosemallow
5	*Hibiscus lasiocarpos*	P-FORB	OBL	woolly rosemallow
*	*Humulus japonicus*	A-FORB	FACU	Japanese hops
3	*Hypericum punctatum*	P-FORB	FAC	spotted St. John's wort
*	*Ipomoea hederacea*	A-FORB	FACU	ivy-leaved morning glory
*	*Kummerowia striata*	A-FORB	FACU	Japanese clover
3	*Lactuca canadensis*	B-FORB	FACU	Canada lettuce
3	*Leersia oryzoides*	P-GRASS	OBL	rice cutgrass
0	*Lepidium virginicum*	A/B-FORB	FACU	pepperweed
*	*Lespedeza cuneata*	P-FORB	FACU	Chinese bushclover
3	*Leucospora multifida*	A-FORB	FACW	obi wan conobea
4	*Lindernia dubia* var. *anadallidea*	A-FORB	OBL	false pimpernel
4	*Lobelia siphilitica*	P-FORB	OBL	blue lobelia
*	*Lonicera japonica*	P-FORB	FACU	Japanese honeysuckle
*	*Lonicera maackii*	SHRUB	UPL	Amur bush honeysuckle
3	*Ludwigia peploides*	P-FORB	OBL	water primrose
6	*Lythrum alatum*	P-FORB	OBL	winged loosestrife
*	*Melilotus albus*	A/B-FORB	FACU	white sweetclover
*	*Mollugo verticillata*	A-FORB	FAC	carpetweed
0	*Oenothera biennis*	B-FORB	FACU	evening primrose
0	*Oxalis stricta s.l.*	P-FORB	FACU	yellow woodsorrel
0	*Panicum capillare*	A-GRASS	FAC	witch grass
0	*Panicum dichotomiflorum*	A-GRASS	FACW	fall panicgrass
3	*Parthenocissus quinquefolius*	W-VINE	FACU	Virginia creeper
3	*Paspalum pubiflorum*	P-GRASS	FAC	hairy-seed bead grass
3	*Penthorum sedoides*	P-FORB	OBL	ditch stonecrop
*	*Perilla frutescens*	A-FORB	FAC	beefsteak plant
4	*Persicaria hydropiperoides*	P-FORB	OBL	wild water pepper
0	*Persicaria lapathifolia*	A-FORB	FAC	heartsease
*	*Persicaria longiseta*	A-FORB	FACU	Oriental lady's thumb
*	*Persicaria maculosa*	A-FORB	FACW	spotted lady's thumb
1	*Persicaria pensylvanica*	A-FORB	FACW	Pennsylvania smartweed
3	*Persicaria punctata*	P-FORB	OBL	dotted smartweed
*	*Phragmites australis*	P-GRASS	FACW	common reed
3	*Phyla lanceolata*	P-FORB	OBL	fogfruit
2	*Phytolacca americana*	A-FORB	FACU	pokeweed
4	*Pilea pumila*	A-FORB	FACW	clearweed
*	*Plantago lanceolata*	P-FORB	FACU	lance leaf plantain

C	SCIENTIFIC NAME	PHYSIOG	W	COMMON NAME
0	*Plantago rugellii*	P-FORB	FAC	Rugel's plantain
3	*Platanus occidentalis*	TREE	FACW	American sycamore
*	*Polygonum aviculare*	A-FORB	FACU	low knotweed
2	*Populus deltoides*	TREE	FAC	cottonwood
0	*Portulaca oleracea*	A-FORB	FACU	purslane
*	*Robinia pseudoacacia*	TREE	FACU	black locust
4	*Rotala ramosior*	A-FORB	OBL	toothcup
1	*Rudbeckia hirta*	B-FORB	FACU	black eyed Susan
5	*Rudbeckia subtomentosa*	P-FORB	FACU	sweet coneflower
2	*Rumex altissimus*	P-FORB	FACW	tall dock
*	*Rumex crispus*	P-FORB	FAC	curly dock
4	*Sagittaria latifolia*	P-FORB	OBL	broadleaf arrowhead
3	*Salix interior*	TREE	FACW	sandbar willow
2	*Salix nigra*	TREE	OBL	black willow
5	*Schoenoplectus tabernaemontani*	P-SEDGE	OBL	soft stemmed bulrush
3	*Scirpus atrovirens*	P-SEDGE	OBL	dark green bulrush
5	*Scirpus pendulus*	P-SEDGE	OBL	nodding bulrush
3	*Scrophularia marilandica*	P-FORB	FACU	late figwort
4	*Senna marilandica*	P-FORB	FAC	wild senna
*	*Setaria faberi*	A-GRASS	FACU	nodding foxtail
*	*Setaria pumila*	A-GRASS	FAC	yellow foxtail
*	*Setaria viridis*	A-GRASS	UPL	green foxtail
*	*Sida spinosa*	A-FORB	FACU	prickly sida
0	*Solanum carolinense*	P-FORB	FACU	Carolina horsenettle
*	*Solanum lycopersicum*	A-FORB	UPL	tomato
1	*Solanum ptychanthum*	A-FORB	FACU	American black nightshade
1	*Solidago altissima*	P-FORB	FACU	tall goldenrod
3	*Solidago gigantea*	P-FORB	FACW	goldenrod
*	*Sorghum halepense*	P-GRASS	FACU	Johnsongrass
2	*Strophostyles leiospermum*	A-FORB	UPL	small fuzzy bean
3	*Symphyotrichum lanceolatum*	P-FORB	FACW	lance-leaf aster
3	*Symphyotrichum lateriflorum*	P-FORB	FACW	side-flowering aster
*	*Taraxacum officinale*	P-FORB	FACU	dandelion
2	*Teucrium canadense*	P-FORB	FACW	germander
1	*Tridens flavus*	P-GRASS	FACU	purpletop tridens
*	*Trifolium hyrbidum*	P-FORB	FACU	Alsike clover
*	*Trifolium repens*	P-FORB	FACU	white clover
0	*Typha angustifolia*	P-GRASS	OBL	cattail

C	SCIENTIFIC NAME	PHYSIOG	W	COMMON NAME
	Ulmus sp.	TREE	FAC	elm
*	*Verbascum thaspus*	B-FORB	UPL	mullein
2	*Verbena urticifolia*	P-FORB	FAC	nettle leaved vervain
4	*Verbesina alternifolia*	P-FORB	FACW	wingstem
3	*Vitis cinerea*	W-VINE	FACU	graybark grape
4	*Vitis riparia*	W-VINE	FACW	frost grape
0	*Xanthium strumarium*	A-FORB	FAC	rough cocklebur

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