TITLE

A transdisciplinary, mixed methods research agenda for evaluating collective impact for tree planting: The CommuniTree initiative in northwest Indiana, U.S.

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Collective impact; northwest Indiana; transdisciplinary research; tree planting; post-industrial cities; mixed methods research

ABSTRACT

In this paper, we describe the theory and research design for a new collaborative tree-planting initiative in northwest Indiana in the Midwest United States. The CommuniTree initiative is attempting to alleviate some of the social and ecological issues experienced by post-industrial Rust Belt communities. Northwest Indiana was dominated by heavy industry, particularly steel, throughout much of the 20th century, until the decline of manufacturing and the closing of plants in the 1980s and 1990s, causing well-paying jobs to disappear and population to decline, leaving residential and commercial vacancies and a decimated tax base. The communities in northwest Indiana are still feeling the social, economic, ecological legacies of this post-industrial history, including environmental degradation, high industrial land use and impervious surfaces, and low tree canopy cover, creating air pollution, stormwater quantity and quality, urban heat island issues, among other problems. With a goal of helping alleviate some of these post-industrial challenges, the CommuniTree initiative was launched in 2017. CommuniTree is a new multi-organizational, collaborative urban forestry partnership that engages in grant- and donor-funded tree planting in several underserved northwest Indiana municipalities. The effort is loosely based on the collective impact model. Collective impact is a means of coordinating multiple organizations around a "shared vision" to solve a specific issue – in CommuniTree's case, the lack of urban forest governance and resources in northwest Indiana compounding the aforementioned post-industrial social and ecological issues. Supported by over a dozen stakeholder groups, CommuniTree plants and cares for trees and engages communities in urban forestry training. This paper describes CommuniTree programming in more detail, as well as presents an applied, transdisciplinary, mixed methods research agenda. Through research with stakeholders, we seek to understand the mechanisms through which CommuniTree activities translate resources into outcomes in the social-ecological context of northwest Indiana and evaluate the sustainability of CommuniTree.

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INTRODUCTION

The so-called "Rust Belt" of the United States is a swath of the country ringing the Great Lakes from Wisconsin and Illinois in the Midwest, to the mid-Atlantic in the east and up into the states of the northeast U.S. and New York. Dotted with numerous large and small formerly and presently industrial towns, the region was the heart of heavy industry and manufacturing for the Country through most of the 20th century (Kozlowski 2013). With the decline of manufacturing beginning in the 1970s and '80s, many cities in the region began to decrease in population and face high unemployment and poverty rates, vacant housing stock, and contaminated lands and waterways. However, in the early 21st century, post-industrial Rust Belt cities – also dubbed "legacy cities" (Carlet, Schilling, and Heckert, 2017) or, for those that have shrunk more than 25% in population since 1960, "shrinking cities" (Schilling and Logan 2008) – have begun to reinvent themselves, taking advantage of the opportunities left in the wake of factory closings, vacant lots, and brownfields to develop creative solutions to the numerous, post-industrial economic, social, and environmental issues they face.

Urban greening efforts in particular have risen to the challenge (e.g., Schilling and Logan 2008; Carlet, Schilling, and Heckert, 2017). For instance, Detroit, Michigan – perhaps the most internationally known of the Rust Belt cities, due to its infamous declaration of bankruptcy in 2013 and swift rebound (Klinefelter 2018) – has embraced urban farming (Pfleger 2018) as one way of coping with what is approximately 25 square miles (65 sq km) of vacant land in the city (Davidson 2012). And the post-industrial city of Pittsburgh, Pennsylvania, developed an Urban Forestry Master Plan (Tree Pittsburgh 2012) that has become a national model for urban forestry and green infrastructure strategic planning. Pittsburgh's master planning effort demonstrates a successful partnership between the nonprofit Tree Pittsburgh, the City parks department, and active community volunteers. As a city plagued by consistent flooding and stormwater management issues, Pittsburgh is looking to trees as a potential solution for both water quality and quantity issues (*ibid.*).

Much has been written about the potential of urban greening activities and green infrastructure planning to mitigate post-industrial woes (*e.g.,* turning vacant land into greenspaces to help "right size" these so-called "shrinking cities" by balancing housing and development opportunities with declining populations: Schilling and Logan 2008; turning brownfields, often-contaminated post-industrial properties, into greenspaces: De Sousa 2014). However, relatively little of this literature has examined the potential of tree planting on public and private lands across a post-industrial community to produce social and ecological outcomes that may lessen post-industrial issues.

In this paper, we describe the theory and research design for a new collaborative tree-planting initiative in northwest Indiana in the Midwest United States called CommuniTree that is attempting to alleviate some of the social and ecological issues experienced by post-industrial Rust Belt communities. We first set up the socio-economic, ecological, and institutional context of the northwest Indiana region that inspired CommuniTree and describe origin of the initiative as a multi-organizational community tree-planting partnership based off of the collective impact model for social impact (Kania and Kramer 2011; Hanleybrown et al., 2012). Next, we overview the objectives, framework, and research questions for a long-term transdisciplinary, mixed methods research agenda to evaluate the social and ecological outcomes of CommuniTree. Finally, we close with a brief description of the methodological paradigms through which CommuniTree research is being conducted (e.g., results presented in Abood and Vogt, *in prep.*). We hope that by describing the detailed research methods for this transdisciplinary (involving insights from multiple academic disciplines as well as professional practice) project, we might inspire such transparency in other research efforts.

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POST-INDUSTRIAL LEGACIES IN NORTHWEST INDIANA: Socio-economic, ecological, and institutional dimensions

Northwest Indiana is the 5-county region in the northwest part of the state of Indiana composed of Lake, Porter, LaPorte, Newton, and Jasper counties. These counties are part of the Chicago metropolitan statistical area (MSA) and operate on U.S. Central time (Chicago time) and contain many suburban communities connected to Chicago by Interstates 90 and 94 and the South Shore Line rail. Three of these counties (Lake, Porter, and LaPorte) are under the purview of a regional planning organization, the Northwestern Indiana Regional Planning Commission (NIRPC; http://nirpc.org/). The Cities of Gary and Hammond are the two largest cities in this region, both located in Lake County, which has nearly two-thirds of the total Northwest Indiana population. In the following sections, we outline the socio-economic, ecological, and institutional (governance) dimensions that impact current urban forests patterns and processes in social-ecological systems (cf., Vogt 2020) such as northwest Indiana.

Socio-economic issues: An industrial past and post-industrial future

The northwest Indiana region, and Lake County in particular, have a rich industrial history. It was built up around the steel industry in the early 1900s and cities like Gary and East Chicago are some of America's classic industrial towns (Sisson 2017; Coffin 2003). After World War II, the Chicagoland-northwest Indiana area was "the largest area of heavy industry in the world" (Westphal et al., 2010: p. 209). After the steel companies started to modernize production in the 1950s and 60s, these cities fell into hard times (*ibid.*), particularly after the merging of several large companies and subsequent closing of plants during the 1980s and 1990s (NIPRC 2016a/2018). As plants closed and many well-paying jobs went away, people started to move out of the region, populations declined, houses and commercial buildings were left vacant, and the county and municipal tax base declined precipitously.

The communities in northwest Indiana are still feeling the social, economic, ecological legacies of this industrial and post-industrial history (Table 1). Lake County was most affected. Even as the population surrounding counties in the region increased (LaPorte by 17% and Porter by 173%), the population of Lake County declined 3.4% between 1960 and 2011 (NIRPC 2016a/2018). However, some communities within Lake County have experienced this population decline more starkly than others. For instance, the population of Gary, Indiana went from a peak of 178,320 in 1960 (*ibid.*) to 116,646 in 1990 (NIRPC 2011) to just 76,677 in 2018, a decline of 57% that has yielded a 28% residential housing vacancy (U.S. Census Bureau 2019). Although manufacturing is still one of the top two industries (employing just over 35,000 of the regions 222,000+ employees as of 2017) in northwest Indiana as it is for the Chicago metropolitan area as a whole, the health care and social assistance industry nearly equals manufacturing across the region (Deloitte et al., 2019). In response to the changing employment landscape and to make up the loss of tax revenue due to the population decline, cities throughout the region have opened up casinos.

Table 1. Social, economic, governance, and ecological dimensions of select Northwest Indiana communities in which CommuniTree has planted trees, compared to the Lake County, Indiana, the 3-county region under the purview of the Northwest Indiana Regional Planning Commission (NIRPC), and the Chicago metropolitan statistical area (MSA). A dash (-) indicates that data for that particular parameter are unavailable at that level; n/a indicates "not applicable."

	Select CommuniTree cities			Lake County, IN	NIRPC Region, 2016[1]	Chicago MSA
	East Chicago	Gary	Hammond			
Social dimensions						
Population, 2018[2]	28,442	76,677	77,071	486,849	764,073	9.5 M

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Population, 1990[3]	33,892	116,646	84,236	475,594	751,413	8.1 M
Population, 1980[3]	39,786	151,953	93,714	522,965	711,592	7.9 M
% White, 2017[4]	6.5%	11.8%	39.3%	53.9%	64.7%	52.5%
% Black, 2017[4]	35.7%	80.2%	21.0%	23.0%	17.7%	16.0%
% Hispanic/ Latino, 2017[4]	57.0%	5.8%	36.6%	19.4%	14.4%	22.4%
Economic dimensions						
Poverty rate, 2017[4]	34.6%	35.8%	22.2%	16.8%	-	13.1%
Unemployment rate, 2018[2,5]	12.3%	13.8%	8.7%	8.0%	-	4.4% [a]
Residential housing vacancy rate, 2018[2]	24.3%	28.0%	11.4%	12.6%	11.2%	8.9%
Employed in Manufacturing, 2017[4]	17.0%	12.8%	16.5%	15.9%	17.0%	11.6%
Employed in Health Care, 2017[4]	14.1%	20.2%	12.2%	14.6%	14.5%	13.2%
Governance dimensions						
Incorporation date[6,7,8]	1889	1906	1883	n/a	n/a	n/a
Government expenditures, total (per capita), 2018[9]	$227.8 M ($7,928)	$234.4 M ($3,028)	$398.7 M ($5,123)	$1.4 B ($2,960)	n/a	n/a
Some minimal urban forest programming[10,b]	No	Yes	No	n/a	n/a	n/a
Ecological dimensions						
% Tree canopy cover, 2010[11,12,13,14]	6%	24%	16%	17%	-	20%
% Water, 2010[11,12,13,3,14]	3%	4%	5%	3%	1%	4%
% Impervious, 2011[11,12,13,3,14,c]	39%	20%	38%	14%	-	13%
% Industrial land use, 2010[11,12,13,3,14]	54%	39%	47%	-	5%	-
Median Air Quality Index (AQI), 2018[15]	-	-	-	-	-	57
# Days "Good" AQI (<50), 2018[15]	-	-	-	-	-	117
# O_3 days[15,d]	-	-	-	-	-	109
# PM2.5 days[15,d]	-	-	-	-	-	210

Demographic and economic statistics for the NIRPC region come from:

[1] Northwestern Indiana Regional Planning Commission (NIRPC). (2016b). *Northwest Indiana Regional Snapshot.* Accessed 24 January 2020 from https://www.nirpc.org/2040-plan/economy-and-place/regional-data-maps/regional-data/.

Data sources for demographic and economic statistics for East Chicago, Gary, Hammond, Lake County, and the Chicago MSA from:

[2] U.S. Census Bureau. (2019). "American Community Survey Data Profiles 2018." *U.S. Census Bureau* Accessed on 24 January 2020 from https://www.census.gov/acs/www/data/data-tables-and-tools/data-profiles/2018/.

[3] Northwestern Indiana Regional Planning Commission. (2011). *2040 Comprehensive Regional Plan: A Vision for Northwest Indiana.* Accessed on 24 January 2020 from https://nirpc.wpengine.com/2040-plan/plan-documents/

[4] Deloitte, Collective Learning group at The MIT Media Lab, & Datawheel. (2019). *DataUSA.io.* Accessed on 24 January 2020 from https://datausa.io.

[5] U.S. Bureau of Labor Statistics. (2019). "Economy at a Glance." *BLS.gov.* Accessed 24 January 2020 from https://www.bls.gov/eag/eag.il_chicago_md.htm.

Governance data for municipal units (East Chicago, Gary, Hammond, and Lake County):

[6] Vaillant, D. (2005). "East Chicago, IN." *Encyclopedia of Chicago.* Chicago Historical Society. Accessed 26 January 2020 from http://www.encyclopedia.chicagohistory.org/pages/402.html

[7] Mohl, R.A. (2005). "Gary, IN." *Encyclopedia of Chicago.* Chicago Historical Society. Accessed on 26 January 2020 from http://www.encyclopedia.chicagohistory.org/pages/503.html

[8] Bigott, J. (2005). "Hammond, IN." *Encyclopedia of Chicago.* Chicago Historical Society. Accessed on 26 January 2020 from http://www.encyclopedia.chicagohistory.org/pages/562.html

[9] ClearGov Inc. (2020). *ClearGov.com.* Accessed on 26 January 2020 from https://www.cleargov.com

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[10] Freeman-Day S, Fischer BC, Devoe CB, Moxley DJ. 2019. Active Indiana municipal urban forestry programs: How are they addressing sustainability/environmental change? Indiana Academy of Science 134th Proceedings, pp 88-89.

Land use/land cover data for East Chicago, Gary, Hammond, and Lake County come from: (Lake County data embedded as a comparison on each city-level summary.)

[11] Chicago Region Trees Initiative (CRTI). (No date a). "East Chicago Urban Forest Canopy Summary." *NIRPC.org* Accessed 24 January 2020 from https://www.nirpc.org/2040-plan/environment/communitree/community-canopy-summaries/.

[12] Chicago Region Trees Initiative (CRTI). (No date b). "Gary Urban Forest Canopy Summary." *NIRPC.org* Accessed 24 January 2020 from https://www.nirpc.org/2040-plan/environment/communitree/community-canopy-summaries/.

[13] Chicago Region Trees Initiative (CRTI). (No date c). "Hammond Urban Forest Canopy Summary." *NIRPC.org* Accessed 24 January 2020 from https://www.nirpc.org/2040-plan/environment/communitree/community-canopy-summaries/.

Land use/land cover data for the NIRPC region come from [3].

Land cover data for the Chicago region comes from:

[14] Chicago Region Tree Initiative (CRTI). (No date d). "CRTI Municipal Canopy Summaries." *ChicagoRTI.org*. Accessed 24 January 2020 from http://chicagorti.org/CanopySummaries

Air quality data for the Chicago MSA come from

[15] U.S. Environmental Protection Agency (EPA). (2019). "Outdoor Air Quality Data Air Quality Index Report." *United States Environmental Protection Agency*. Accessed 24 January 2020 from https://www.epa.gov/outdoor-air-quality-data/air-quality-index-report.

Additional notes:

[a] Unemployment rate unavailable at Chicago MSA level from the U.S. Census Bureau American Community Survey data, so this is the U.S. Bureau of Labor Statistics estimate for June 2018 from the Bureau of Labor Statistics.

[b] The idea of "minimal urban forest programming" comes from a personal communication with Burnell C. Fischer re: the data presented during a conference presentation Freeman-Day et al. (2019). A "yes" means that the municipality had at least an urban tree inventory, tree ordinance, or urban forest plan or similar and was included in the analysis presented in Freeman-Day et al. (2019).

[c] Impervious surfaces calculated as the sum of Buildings + Roads/Rails + Other Paved land cover types in Chicago Region Trees Initiative canopy summaries.

[d] Refers to the number of days for which the main air pollutant was ozone (O_3) or atmospheric particulate matter of diameter 2.5 micrometers or less.

Ecological issues: Calumet region ecology and land use

The combination of a history of polluting industries with a lack of a tax base to generate funds for reinvestment in these Northwest Indiana communities has resulted in environmental degradation in the Calumet ecosystem. The Calumet region comprises 160 square miles (414 sq km) of area, reaching from northwest Indiana into the City of Chicago (Westphal et al., 2010). The ecologically sensitive Northwest Indiana region is at the southernmost coastline of Lake Michigan. The coastal region comprises a wet low-lying region, flattened by glaciers that is a transition between the hardwood forest ecosystems of the northeastern United States to the east and tallgrass prairies to the west (NIRPC 2011). Patches of wetlands, dune and swale, prairie, savannah, and woodland habitat dot the region (Westphal et al., 2010). The largest of these, Indiana Dunes National Lakeshore was in February of 2019 designated a National Park and contains over 15,000 acres of unique habitats (U.S. Department of Interior National Park Service 2019). The region is also home to many plant and animal species: the 2002 Calumet Bioblitz involved over 130 local scientists and volunteers who identified more than 2,200 species (Westphal et al., 2010; see also The Field Museum 2002). The watershed containing the northernmost part of the Calumet region and Lake County is the Little Calumet-Galien Basin, which drains into the lake, contains several rivers, including the Little Calumet River, the floodplain of which contains significant areas of developed urban land including industrial properties in Gary, Hammond, and several other northwest Indiana cities (NIRPC 2011). Because of the legacy of polluting industries, urban runoff from the high percentage of impervious surfaces, as well as upstream agricultural runoff, many of the waterways in the region are impaired (*ibid.*).

Land use across the three-county region is dominated by agriculture and low-density residential (Figure 1a), but one look at the geographic distribution of land uses reveals that the majority of the high-impervious surfaces, high-polluting industrial land uses are in the northern part of the counties, right

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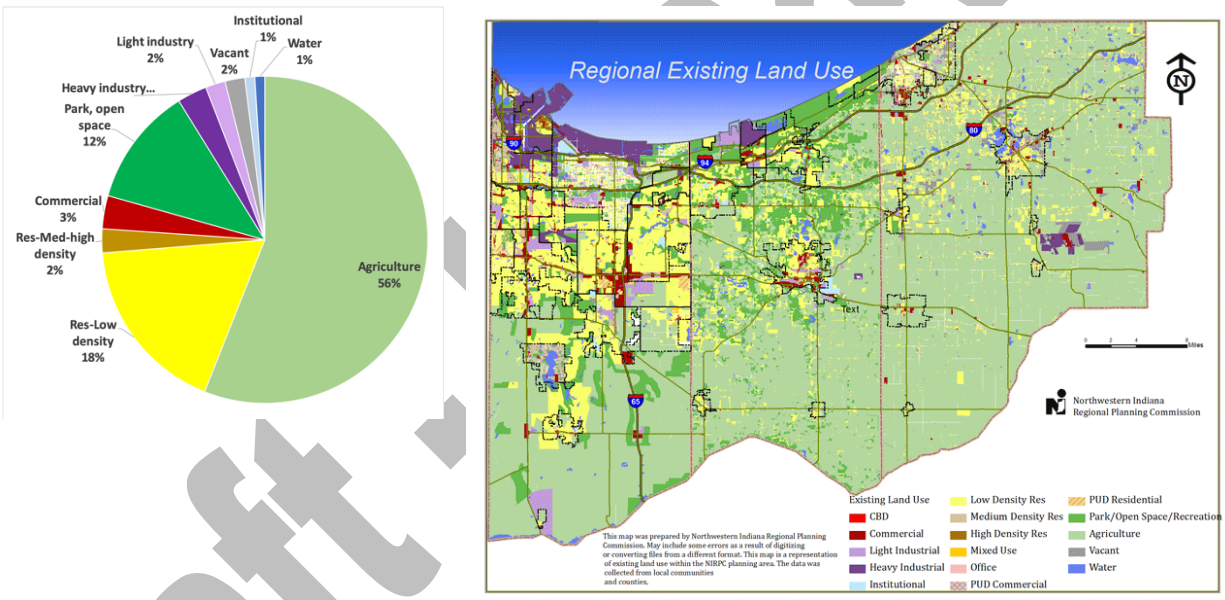
along the lake shore (Figure 1b). Agriculture accounts for more than half of all land use in the region (Figure 1a). Tree canopy cover is relatively low across the region, at 17% in Lake County as a whole, but as low as 6% in East Chicago where industrial land use accounts for over half of the City (Table 1). For the cities where CommuniTree is active, the percent impervious surface is between 20 and 40% (Table 1). This combination of low canopy cover with relatively high impervious surface cover means that the urban heat island effect can be oppressive. Although heat island data is not available for northwest Indiana specifically, research in adjacent Chicago has demonstrated a significant impact of tree canopy cover and impervious surfaces on temperatures: Coseo and Larsen (2014) found that in eight neighborhoods with tree canopy ranging from 4.7 to 60.4% and impervious cover from 95.7 to 54.6%, the more impervious surfaces and less tree canopy in a neighborhood, the higher the urban heat island effect. They observed the neighborhood with the lowest canopy cover (4.7%) exhibited a 2 a.m. air temperature differential of more than +2 °C (+3.6 °F) (relative to the standard taken at Midway Airport) while that with the highest canopy cover (60.4%) was almost -2 °C (-3.6 °F) cooler (*ibid.*). When controlling for weather, impervious surface and tree canopy percentage explain more than two-thirds of nighttime air temperature variation during clear days of normal summer temperatures and more than 90% of variation during extreme heat events (*ibid.*). The high impervious, low tree canopy communities in northwest Indiana (Table 1) likely experience similar urban heat island dynamics.



(a) **(b)**

Figure 1. Land use in Lake, Porter, and LaPorte Counties in northwest Indiana, 2010. **(a)** Percent land across the 3-county NIRPC region in different land use types. **(b)** Map of regional land use produced for the NIRPC 2040 Comprehensive Regional Plan. Data for (a) and map in (b) from Northwest Indiana Regional Planning Commission. (2011). *2040 Comprehensive Regional Plan: A Vision for Northwest Indiana*. Accessed on 24 January 2020 from https://nirpc.wpengine.com/2040-plan/plan-documents/.

Tree canopy in northwest Indiana (and the Midwest as a whole) has also suffered in the last decade from the invasion of the emerald ash borer (EAB), which has decimated tree canopies in both urban and rural communities alike. EAB attacks the living tissue just below the bark of ash trees, causing at first canopy dieback and eventually killing entire trees. The pest was confirmed in Indiana in April of 2004 and as of 2016 has been reported in all 92 Indiana counties (IDNR *n.d.*). In Lake, Porter, and LaPorte counties,

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thousands of trees have been affected and hundreds already removed from city parks, boulevards or parkways, and other public places, at the expense of municipal governments (Bierschenk 2017). And even though the most recent estimates of tree canopy in Lake County and northwest Indiana communities range from 6 to 24% (Table 1), because these numbers are based on 2010 land cover data they likely do not fully reflect EAB impacts, which have resulted in the removal of large numbers of mature trees in the last decade, and so local tree canopy is likely even lower than estimated.

Institutional dimensions: Green infrastructure and urban forest governance

Regional and local governance for green infrastructure including urban forests in northwest Indiana is limited but expanding. One of four substantive components of the NIRPC *2040 Comprehensive Regional Plan* is green infrastructure, including a vision for a "green infrastructure network" that would protect "natural, rural, and agricultural assets" (p. Intro-6) in between the metropolitan areas and small communities throughout the region in "Greenways and Blueways" such as "stream corridors, utility rights-of-way, off-road trails and road corridors" (NIRPC 2011, p. I-46). However, urban forestry and strategies for tree planting and care in individual communities are less concrete. While the NIRPC *Comprehensive Plan* recommends planting street trees as one of several "green streets" strategies (*ibid.*, p.I-44), in the NIRPC region, just 11 of 41 total communities (7 in Lake County, 2 in Porter, and 2 in LaPorte) have some sort of at least minimal urban forestry programming such as being a Tree City USA (Table 2), having an urban tree inventory, tree ordinance, or urban forest plan or similar (personal communication, B.C. Fischer, 26 January 2020 re: Freeman-Day et al., 2019). Thus, institutions—i.e., the rules, norms, and strategies that structure formal and informal interactions between people and with the environment (*a la* Ostrom 2005)—for urban forest management in the region are relatively thin.

Table 2. Tree City USA in Northwest Indiana. Communities must meet four requirements for being designated as a Tree City USA by the Arbor Day Foundation. These standards are a relatively low threshold for urban forestry in a city or town and may not accurately reflect the actual capacity of a municipality to plant or care for trees in the urban forest. Cities with at least some minimal urban forestry programming in the 3-county NIRPC planning region are listed. Cities in which CommuniTree has planted and cared for trees directly with the SCA tree crew indicated with an asterisk (*). All cities listed have benefitted from tree-planting subgrants through NIRPC and CommuniTree.

Tree City USA Requirements[1]

1. A tree board or department.
2. A tree care ordinance.
3. Budget of at least $2 per capita spent on urban forestry activities.
4. An Arbor Day observance or proclamation.

Cities with at least some minimal urban forestry programming in Northwest Indiana[2] *(Tree Cities as indicated*[3]*)*

Lake County

Crown Point – *Tree City for 18 years*
Dyer – *Tree City for 13 years*
*East Chicago – *former Tree City, lapsed*
*Highland – *Tree City for <1 year, but active urban forestry program with tree inventory*[2]
Merrillville – *Tree City for 10 years*
Munster – *Tree City for 24 years*
*Whiting – *Tree City for 28 years*

Porter County

Chesterton – *Tree City for 24 years*
Valparaiso – *Tree City for 17 years*

LaPorte County

Michigan City – *Tree City for 19 years*
LaPorte – *Tree City for <1 year*

Sources:

[1] Arbor Day Foundation. (2019). "Tree City USA Standards." *Arbor Day Foundation.* Accessed on 27 January 2020 from https://www.arborday.org/programs/treecityusa/standards.cfm

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[2] Personal communication, B.C. Fischer, 26 January 2020 re: Freeman-Day S, Fischer BC, Devoe CB, Moxley DJ. 2019. Active Indiana municipal urban forestry programs: How are they addressing sustainability/environmental change? Indiana Academy of Science 134th Proceedings, pp 88-89.

[3] Arbor Day Foundation, 2019. "2018 Tree City USA Communities in Indiana" *Arbor Day Foundation.* Accessed on 22 February 2020 from https://www.arborday.org/programs/treecityusa/treecities.cfm?chosenstate=Indiana Updates from personal communication, C. Tausher and D. Hart, 11 March 2020.

COLLECTIVE IMPACT FOR TREE PLANTING AND CARE IN NORTHWEST INDIANA—CommuniTree

It is in this historical, socio-economic, ecological, and institutional context that the CommuniTree tree-planting initiative was born. CommuniTree is a new multi-organization, collaborative urban forestry partnership that engages in grant- and donor-funded tree planting in several underserved northwest Indiana municipalities.

Trees as a way to help alleviate social and environmental issues

The theory of change for the CommuniTree initiative is that some of the post-industrial issues faced by the northwest Indiana region can be alleviated through tree planting (cf., Westphal and Isebrands, 2001). In an environmental context, trees decrease air pollution (e.g., Nowak et al., 2013; but cf., Grote et al., 2016); help manage the quality and quantity of stormwater (Berland et al., 2017); reduce the urban heat island effect (e.g., Coseo and Larsen 2014); sequester carbon dioxide (Nowak and Crane 2002); among other ecological benefits. Benefits for people include decreased building energy demands for heating and cooling (Ko 2018); noise reduction (e.g., Ow and Ghosh 2017; cf., e.g., Mueller et al., 2020, and Van Renterghem 2019, re: perceived noise reduction); increased human health (e.g., decreased incidence of mortality from cardiovascular disease and decreased upper respiratory illness: Donovan et al. 2013); influence pro-environmental behaviors (e.g., Whitburn et al., 2018); and may possibly improve neighborhood cohesion (e.g, Watkins et al., 2018) and sense of community (e.g., Ames 1980).

When the environment has been compromised through industrial pollution, the benefits of trees and other green infrastructure become even more important in maintaining the health of the environment and of the people living within it, even while environmental injustices may mean that post-industrial areas have less tree canopy cover. In Gary, Hammond, and East Chicago – three of the cities in which CommuniTree plants trees – for example, canopy cover is 24%, 16%, and just 6%, respectively (NIRPC 2019). However, relatively little research has been conducted on the impact of tree planting activities on the social and environmental conditions in post-industrial areas.

The collective impact model

The CommuniTree effort (described in the subsequent paragraphs) is loosely based on the collective impact model (originating in the business and philanthropy fields by Kania & Kramer 2011; Hanleybrown et al., 2012; as applied to urban forestry by Driscoll & Ries 2015; Figure 2). Collective impact is "the commitment of a group of important actors from different sectors to a common agenda for solving a specific social problem" (Kania & Kramer, 2011, p. 36). For its enactment, collective impact requires three preconditions – an influential champion, financial resources, and "urgency for change" (Hanleybrown et al. 2012) – and five core components: 1) a common agenda and "shared vision for change"; 2) "shared measurement systems" enabling the measuring and reporting of success metrics; 3) "mutually reinforcing activities," meaning that each stakeholder is able to "undertake the specific set of activities at which it excels in a way that supports and is coordinated with the actions of others"; 4) continuous communication in a "common vocabulary" that fosters trust and accountability; and 5) a

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"backbone" or support organization(s) with dedicated staff, sometimes with grant-writing or fundraising expertise, and the administrative savvy to coordinate a large group of potentially diverse stakeholders in the activities necessary for components 1 through 4 (Kania and Kramer, 2011, p. 39-40). The collective impact model is useful in coordinating large groups of stakeholders towards ambitious ends, particularly in the absence of a single organization dedicated to those ends.

CommuniTree origins

CommuniTree was envisioned as a collective impact effort (Table 3) to motivate and martialize various parties to increase tree planting in the region and overcome the relatively low existing urban tree canopy and urban forest capacity in the region. In January of 2016, participants at an Urban Waters Federal Partnership meeting in northwest Indiana identified the lack of urban forestry resources as a major challenge facing the region. Throughout 2016, U.S. Department of Agriculture Forest Service (USFS) Chicago (region) Natural Resources Liaison (the "influential champion" and instigator for CommuniTree, and adviser to the CommuniTree research) began meeting with various organizations and assembled a group of stakeholders invested in improving the state of the urban forest in the region. In January of 2017, CommuniTree was launched.

Table 3. The CommuniTree initiative in northwest Indiana was modeled after collective impact, which requires three pre-conditions (Hanleybrown et al. 2012) and five core components (Kania and Kramer 2011). How CommuniTree has interpreted and operationalized these elements emerged through participant observation and stakeholder interviews.

Collective impact component	CommuniTree interpretation
Pre-conditions	
i. Influential champion	The USFS Liaison is the key instigator of the CommuniTree initiative and is responsible for drawing all the stakeholders together.
ii. Adequate financial resources	To date, CommuniTree has applied for grants from foundations and federal agencies to fund its activities. Local nonprofit, partnership, municipal, and private stakeholder organizations have also contributed matching resources.
iii. Urgency for change	The paucity of urban forest governance resources (particularly at the municipal level) in the northwest Indiana region combined with post-industrial social and ecological issues and compounded by the decimation of urban tree canopy by emerald ash borer in the past decade makes the case for improving urban forest capacity in the region.
Core components	
1. Common agenda	The mission statement from the CommuniTree website is "CommuniTree is supported by a dynamic partnership of community, industry and government agencies with the ultimate goal of creating a healthier and more diverse tree population."[1]
2. Shared measurement systems	The CommuniTree program currently promotes the iTree tree inventory program with all of its stakeholders and partner organizations involved in the three tree planting modalities. Trees are inventoried using the same fields and data is shared with all stakeholders and partners. Additionally, planting and maintenance protocols/practices are mutually agreed and tree species selection is discussed upon by all stakeholders and partners.
3. Mutually reinforcing activities	The three modalities by which CommuniTree plants trees – NIRPC tree-planting subgrants to communities, SCA tree crew and volunteer tree plantings on public property, and WHC-led industry tree plantings on private properties – are different yet complementary ways of engaging numerous public and private parties in local urban forestry activities, all with the goal of increasing canopy cover. Urban forestry trainings (re: planting/maintenance, inventory, etc.) complement the planting efforts, while community engagement, the least-developed of CommuniTree activities, seeks to build community support for and participation in tree planting and other urban

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	forestry activities. CommuniTree also provides urban forestry basic training to all partners to ensure consistent messaging, application, and practices.
4. Open and continuous communication	CommuniTree stakeholders have been meeting quarterly and as necessary since 2017. A separate group of university stakeholders has met 3 times since 2018. Additionally, the continuous work of the USFS Liaison to build, maintain, and strengthen relationships among stakeholders is crucial to keeping communication channels open.
5. Backbone/ support organization	The Northwestern Indiana Regional Planning Commission (NIRPC) currently plays the lead backbone role. However, the Student Conservation Association (SCA) increasingly plays a supporting role as it wrangles significant grant funds for the CommuniTree effort.

[1] CommuniTree website: https://www.nirpc.org/2040-plan/environment/communitree/

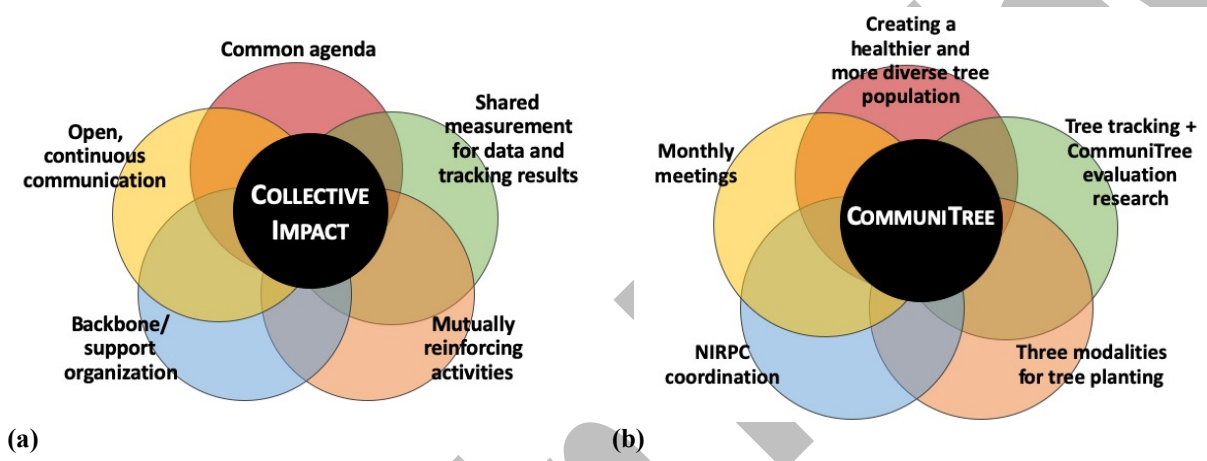

Figure 2. The Kania and Kramer (2011) collective impact model **(a)** is composed of 5 core components and is the basis for the CommuniTree initiative in northwest Indiana **(b)**.

In its own words, CommuniTree is "a dynamic partnership of community, industry and government agencies" that "grew out of the need to promote tree planting, after-planting care and maintenance of trees…with the ultimate goal of creating a healthier and more diverse tree population" (https://www.nirpc.org/2040-plan/environment/communitree/). Most broadly, CommuniTree seeks to positively impact the ecology and social dynamics of the post-industrial communities in which it operates. The effort is a largely informal conglomeration of interested stakeholder groups, comprised of representatives from nonprofit organizations, state and federal government agencies and local municipalities, and private companies. Stakeholders at its founding in 2016 were (the most significantly involved listed first; all remain involved as of the writing of this paper, 3 years into the CommuniTree effort): USFS State & Private Forestry Eastern Region; the Student Conservation Association; the Northwestern Indiana Regional Planning Committee; the Indiana Department of Natural Resources Coastal Program; the Northern Indiana Public Service Company; the Northwest Indiana Urban Waters Partnership; the Wildlife Habitat Council; the Dunes Learning Center; and, The Nature Conservancy. As the partnership began planting trees, municipalities in northwest, Indiana began getting involved; several of the earliest included the Cities of Gary, Hammond, and East Chicago.

The Northwestern Indiana Regional Planning Commission (NIRPC) is the backbone or convening organization of the CommuniTree effort, but the USFS Chicago Natural Resources Liaison (the instigator of CommuniTree; hereafter "USFS Liaison") and the Student Conservation Association (SCA; a manager of major CommuniTree grants) are also crucially involved. While the CommuniTree program has no

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permanent staff and no permanent funding, it aims to synergize previously disconnected local resources towards tree planting and outreach (and thereby social and ecological change).

CommuniTree activities

CommuniTree stakeholders meet monthly or quarterly as necessary and in the effort's early months worked to solicit the assistance of the marketing and public relations department of the local utility company who helped create the name, logo, and mission statement, and to develop a website to house information regarding the program (https://www.nirpc.org/2040-plan/environment/communitree/). Most importantly, they also submitted several successful grants to fund tree planting, post-planting tree care (maintenance), and education and outreach activities. CommuniTree has engaged in 3 years of urban forestry activities beginning in the spring 2017 planting season and, as of September 2019, has planted over 5,000 trees of ~1-2-inch (2-5 cm) diameter.

Through grant funds awarded to key stakeholder organizations, CommuniTree accomplishes tree planting on several types of properties in three primary ways. First, there are the trees that CommuniTree plants directly on public property. Funding from grants has enabled the Student Conservation Association (SCA) to hire a seasonal CommuniTree crew of four members plus one crew leader to plant trees on public property (parks, public right-of-way, golf courses, nature preserves, etc.). The SCA also organizes tree-planting events, soliciting volunteers from local schools and community organizations to join SCA staff and the CommuniTree crew for a day of tree planting.

Second, there are the trees planted through a sub-granting process. In this arm of CommuniTree, NIRPC has received several grants and oversees the award of tree-planting sub-grants to local municipalities, school and park districts, and other nonprofit or community groups committed to planting on mostly public properties and rights-of-way (or front yards where there is no public right-of-way). Grant funding also enables NIRPC to provide free workshops in basic tree planting and care that potential grant recipients are required to take in order to be eligible for free trees and other interested community members can attend. In addition to these basic workshops, NIRPC provides additional training opportunities for local groups and individuals to learn about in tree inventories, grant writing, tree ordinances, and other topics relevant to urban forestry. Expert and certified arborist staff from stakeholder groups also conduct site visits to aid in the selection of tree planting locations for all grant recipients.

Third, there are the trees planted on industrial properties that are directly funded by the company on whose property they are planted. In this third modality, a local branch of an international conservation and greening nonprofit (the Wildlife Habitat Council [WHC]) is funded by a separate Great Lakes Restoration Initiative grant (among other sources of public and private funding) to work with local industry to plant and care for trees on industrial property. To date, the WHC has planted over 1,000 trees on industrial properties throughout the region, engaging employees of these companies in the planting. Together, these three tree-planting modalities – the SCA tree crew, the NIPRC sub-granting process, and WHC industrial plantings – form the basis of CommuniTree in its current state.

SOCIAL-ECOLOGICAL RESEARCH ON COMMUNITREE

Since the CommuniTree initiative seeks to improve social and ecological outcomes in northwest Indiana, it was recognized that tracking activities (tree planting, tree care, education/trainings, etc.) and outcomes would be crucial to understanding potential successes and areas for improvement. Development and use of a shared measurement system is also one of the five collective impact components (recall Table 3, Figure 2). Because of this, in fall of 2016, the USFS Liaison and instigator of the CommuniTree initiative

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contacted DePaul University professor (the lead author) to seek assistance conducting research on a new tree planting effort, CommuniTree. In spring 2017, the author engaged students in her environmental science and studies upper-level undergraduate research methods course (including the second author) in an applied class project to design research procedures, including data collection methods, to evaluate social and ecological outcomes of CommuniTree. (See Vogt, *in prep.* for more on the involvement of students in the design of an applied, mixed methods research project.) At the course's end, the lead author's research group, LUFA, the Lab for Urban Forestry in the Anthropocene (DePaul University, Chicago, Illinois, www.lufa-depaul.org/communitree), took over the project and began conducting *transdisciplinary*, *mixed methods* research (see the "Methodological Paradigm" section below as well as Table 5 below in Methods for definitions of these terms) to set up long-term monitoring of the outcomes of CommuniTree.

Broadly, the CommuniTree research project seeks to understand the mechanisms through which CommuniTree activities translate resources into outcomes in the social-ecological context of northwest Indiana. Figure 3 contains the conceptual framework for the research. Long-term research objectives are: to understand the motivators and mechanisms of stakeholder involvement in CommuniTree; to evaluate the social and ecological impact of CommuniTree activities; and examine how all of these processes and relationships are influenced by the social-ecological context of post-industrial Northwest Indiana, with the ultimate intent of improving the operations and long-term sustainability of the CommuniTree initiative in a manner consistent with stakeholder values and visions. The inclusion of examination of the post-industrial urban context of northwest Indiana is particularly important for two reasons: First, urban forests are social-ecological systems and in order to understand urban forest outcomes we need to also examine social-ecological context (Vogt and Fischer, 2014; Vogt et al., 2015; Vogt 2020). Second, this approach is consistent with the collective impact model; in a commentary proposing best practices for evaluation of collective impact projects, Parkhurst and Preskill (2014) argue that considering the entire system and the changes wrought by collective impact partners across the system is essential to evaluating success. According to these authors, good evaluation "requires examining four levels of the initiative: the initiative's context, the initiative itself, the systems that the initiative targets, and the initiative's ultimate outcomes" (*ibid.*, p. 17). The conceptual model in Figure 3 includes the first and third of these levels as the three dimensions of social-ecological systems, and the second and fourth are represented where stakeholder resources are transformed into CommuniTree activities that lead to outcomes.

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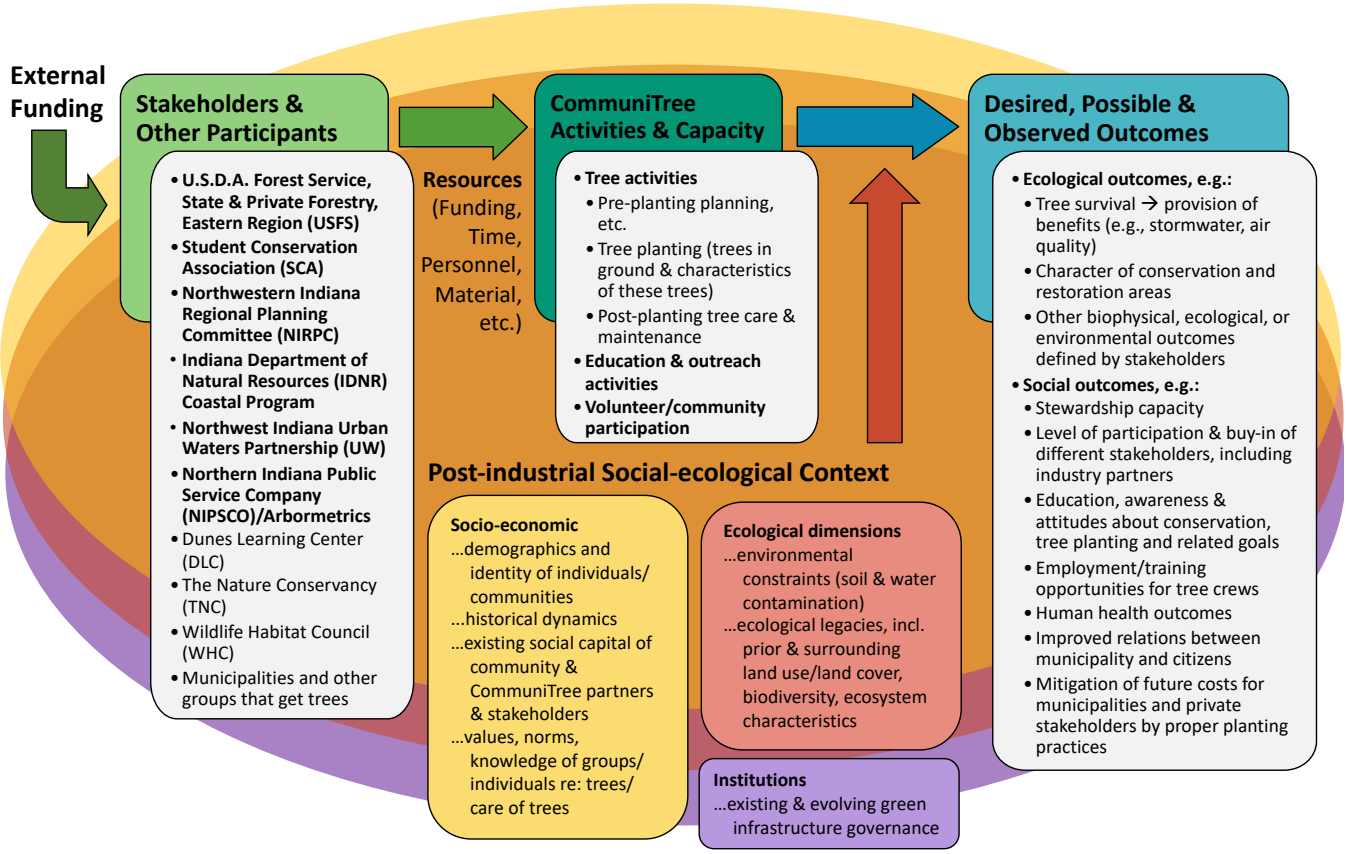

Figure 3. A conceptual framework for the CommuniTree initiative shows how the resources (funding, time, personnel, etc.) contributed by stakeholders and participants influence CommuniTree capacity to achieve desired outcomes. All of these efforts are occurring within (and therefore mediated by) the socio-environmental context of the northwest Indiana region. **Bolded stakeholders** are primary stakeholders, those that were revealed in this research to be of pivotal importance to the persistence of CommuniTree.

Within the context of these objectives and conceptual model, CommuniTree research inquiry centers around four sets of research questions related to stakeholders; resources, activities, and capacity; outcomes and system context. and sustainability (Table 4). The first three sets align with each of the three main components of the conceptual framework in Figure 3, while the last set of questions concerns the overall sustainability and resilience of the CommuniTree program and of benefits it seeks to provide northwest Indiana communities. In the traditions of social-ecological systems research (a la Cox 2011) and sustainability science research (cf., Hirsch Hadorn et al. 2006), both of which examine multi-faceted questions in dynamic, complex systems, many of our research questions are diagnostic in nature—that is, we seek to identify the panoply of features or problems within a system, with the goal of diagnosing responses or system modifications appropriate to each facet of the problem with the long-term goal of achieving sustainability. As stated by Cox (2011), "Implicit here is the empirically well-established premise that no one solution can solve all problems" (p. 348). This means, with respect to our fourth set of question on the sustainability of CommuniTree, that no single, grand, sweeping change to the initiative's operations is likely to yield instant sustainability. Instead, it is likely to be a series of tweaks to the system, each addressing a particular vulnerability or sustainability criteria. In this manner, the first three sets of research questions we hope will yield systems information that can help inform the

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refinement and re-asking of the fourth set of questions, an iterative answering of which will yield the type of learning desirable for transdisciplinary sustainability research and practice (see also next section).

Table 4. Research questions for the CommuniTree research effort. Key constructs are *italicized* in each question.

	QUESTIONS
1. Stakeholders	1a. Who are the organizations – particularly, those most involved partners or *stakeholders* – involved with CommuniTree?
	1a.i. What *roles* do stakeholders play in the CommuniTree program?
	1b. Why are stakeholders *motivated* to be involved with CommuniTree?
	1c. What are stakeholders' *desired outcomes* from CommuniTree?
	1d. What are stakeholders' *visions* for the future of CommuniTree?
	1e. Who are the *other participants* in CommuniTree (e.g., volunteers who help plant trees), what *motivates* their participation, and what do they want to get out of the program?
	1e.i. What *gaps* are there in who participates in and benefits from CommuniTree?
	1e.ii. How can new participants *be engaged* in CommuniTree?
2. Resources, activities, and capacity	2a. What *resources* (funding, time, personnel, material, etc.) are stakeholders allocating to the CommuniTree effort and to what *activities* are these resources dedicated?
	2b. How does this allocation of resources impact CommuniTree *capacity* (activities before, during and after tree planting) and outcomes obtained?
	2c. What are the *vulnerabilities* associated with funding and resource use/allocation and capacity throughout the CommuniTree effort?
3. Outcomes and system context	3a. What are the *observed ecological* (and environmental) and *social* (or community) *outcomes* of CommuniTree on the households, neighborhoods, communities, and urban ecosystems in which trees are planted?
	i. What is the survival, growth, and health/condition of the trees planted?
	ii. Are the cohort of trees planted each season by CommuniTree surviving to produce increasing social and ecological benefits (i.e., ecosystem services)?
	3b. How do observed outcomes compare to the *desired outcomes* of stakeholders?
	3c. How does the surrounding *social-ecological context* (socio-economic, ecological, and institutional dimensions) influence CommuniTree stakeholders, resources, activities, capacity, and, in particular, outcomes?
4. Sustainability	a. How can the CommuniTree initiative (activities, capacity) be *sustainable* and long-lasting?
	i. How do *sustainability criteria* align with stakeholder *visions* for the future of CommuniTree?
	b. How can the *benefits* (i.e., positive social and ecological outcomes) of CommuniTree be *sustained* over time?
	c. How can the initiative become more *resilient* to shocks or system *disturbances* (economic, social, ecological, or otherwise)?

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METHODOLOGICAL PARADIGM

It is partially in the tradition and methods of sustainability science that the CommuniTree research is being conducted. Although rarely made explicit, all research is conducted through the lens of a particular paradigm, or worldview, held by the researchers. Scientific paradigms refer to the confluence of methods, logic, epistemology, values, ontology, etc., that together define the approach through which scientific research is conducted (Teddlie and Tashakkori, 2009). In the increasingly normative context within which sustainability research is necessarily conducted, transparency and reflexivity in process and perspective is critical (Popa et al., 2015). The CommuniTree research project exploits an explicitly transparent,

transdisciplinary, pragmatic, mixed methods approach (Table 5) informed primarily by sustainability science, social-ecological systems, and urban greening scholarship. Transdisciplinary research involves both academic and non-academic participants and is informed by practice and theory from many disciplines. In the research described here, we have both an academic researcher (lead author), student researcher-in-training (second author), and non-academic urban forestry practitioners involved in design and conduct of this research. In particular, we benefit from the considerable applied expertise of our practitioner project advisor, the USFS Liaison and instigator of CommuniTree, plus insights from numerous stakeholders who participated in interviews that will guide future phases of research (interview method and results presented in Abood and Vogt, *in prep.*). We also draw from the theories, methods, and research of urban forestry, urban ecology, business and philanthropy (collective impact), social-ecological systems, and sustainability science, among other fields to inform the conduct of our research.

In the CommuniTree research project, we use mixed methods – i.e., an integration of qualitative and quantitative methods for data gathering and analysis (*a la* Teddlie and Tashakkori 2009) – as well as pragmatic research approach, which means that the values of scientists and non-scientists are critically considered and reflected on during the research, in order to develop useful results (*a la* Popa et al., 2015). Both mixed methods and pragmatic research have at their core an emphasis on acknowledging and using 'what works' in research practice. For mixed methods, this means the research question(s) necessarily drive the selection of particular quantitative and qualitative data gathering and analytical tools (Teddlie and Tashakkori 2009). For instance, the descriptive nature of the first set of research questions enumerated above (regarding stakeholder roles, motivations, and desired outcomes; as presented in Abood and Vogt, *in prep.*) lends itself most clearly to qualitative, exploratory methods such as open-ended, semi-structured interview questions, as well as pragmatic use of inductive logic that does not presuppose a set of hypotheses or predictions about expected results. However, in subsequent phases of this research, which will be informed by stakeholder interviews, we may be able to develop a set of hypotheses, with respect to desired versus observed social and ecological outcomes, for instance, which we then are able to test using the hypothetico-deductive scientific method. Hence, our application of the pragmatic paradigm will allow for the use of both inductive and deductive logic in uncovering evidence for and developing theory. With respect to pragmatic epistemology, values, and ontology, this research uses both a subjective and objective point of view depending on the phase of the project and research questions being asked. Specifically, the pragmatic approach allows for explicit consideration of both scientist and stakeholder values. Throughout CommuniTree research, we explicitly acknowledge the values of the researchers, and we highly value the perspectives of stakeholders, interviews and continuous conversations with whom will form the groundwork for subsequent phases of the research aligned with the second and third set of research questions above.

Table 5. Definitions of key terms related the methodological paradigm informing CommuniTree research.

Term	Definition (Source)
Transdisci-plinary research	Transdisciplinary research "integrates academic researchers from different disciplines and non-academic participants to research real world problems and create new knowledge and theory. Transdisciplinarity combines *interdisciplinarity* with a *participatory* approach" and involves the engagement of scientists and non-academic stakeholders throughout the research process. (Rice, 2013, p. 410; after Cronin 2008, p. 4-5; *emphasis added*)
Mixed methods	Mixed methods is a methodology (i.e., philosophy) of research "in which the investigator collects and analyzes data, integrates the findings, and draws inferences using both qualitative and quantitative approaches or methods in a single study or program of inquiry." The research objectives, questions, and context drive the selection of appropriate qualitative and quantitative methods. (Tashakkori and Creswell, 2007, p. 4)
Pragmatism	A pragmatic approach to transdisciplinary research views "knowledge production as a social and reflexive process whereby criteria of scientific credibility and legitimacy are jointly defined

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> within a community of inquiry," with the aim of reflexivity "to encourage processes of critical assessment and social learning on the background values and assumptions guiding research, and on the socio-institutional structures supporting particular norms and practices" (Popa et al., 2015, p. 47). Pragmatism "advocates for the use of mixed methods in research" and focuses on "what works" for answering the research question (Tashakkori and Teddlie, 2003, p. 713).

Ultimately, the CommuniTree research seeks to generate knowledge that the CommuniTree program can use to refine and improve its operations as a collective impact effort, particularly for the long-term sustainability and resilience of the initiative to disturbances such as changes in organization personnel or priorities, or funding availability, etc. From a transdisciplinary sustainability perspective, this might look like generating systems, target, and transformation knowledge, where systems knowledge seeks to understand how the system functions, target knowledge seeks to what improvements to system functioning could look like, and transformation knowledge seeks to understand how practices and activities within the system should be transformed (Hirsch Hadorn et al., 2006; Adler et al., 2018; see also Abood and Vogt, *in prep.* for an application to CommuniTree). However, in addition to its utility to CommuniTree, we also hope this research can provide transferable insight for urban forest governance broadly, into how a loose group of stakeholders coordinated using collective impact might yield green infrastructure improvements in an area underserved by formal urban forest governance and institutions.

CONCLUSION

In this paper, we have described a unique program of research and practice that is being undertaken in order to understand a new collaborative, multi-organizational, collective impact-style, tree-planting initiative in post-industrial northwest Indiana. Post-industrial communities face a large list of social and ecological issues, including low tree canopy cover and high impervious surface and industrial land cover, historic population declines and subsequent increase in vacancy rates, and the resulting disinvestment in green infrastructures such as trees and environmental quality concerns such as air quality and stormwater management. The CommuniTree effort was started in 2017 to use trees and tree planting with an aim to help solve some of these issues. However, as a new initiative without adequate research and evaluation to date, it remains to be seen whether or how the trees planted and communities engaged in tree-planting and outreach will actually yield the outcomes stakeholders desire; how the post-industrial social-ecological context will impact the health, survival, and growth of the trees and production of tree benefits and other desired program outcomes; or whether the CommuniTree program itself is sustainable in the long-term. The research agenda described above will help provide practical knowledge for the CommuniTree program itself, transferable findings to similar programs in other geographies, as well as an existing gap in the research on the contributions of tree planting to post-industrial urban revitalization.

DISCIPLINARY INFLUENCES DISCLAIMER

As hinted at in the Methodological Paradigm section above, all scientific research is conducted within the worldview of its personnel, who are trained in particular academic disciplines. For transdisciplinary research of the sort presented above, these disciplinary backgrounds and paradigms can yield biases and omissions (see Vogt 2018). As part of the transdisciplinary practice of the research group of the lead author (LUFA, Lab for Urban Forestry in the Anthropocene), we place this Disclaimer at the end of all our manuscripts to explicitly and transparently acknowledge the disciplinary perspectives influencing the text above. For this article, we draw from scholarship on collective impact, post-industrial urban greening,

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and from the broader fields of urban forestry, urban ecology, social-ecological systems and coupled natural-human systems theory, and sustainability science, and both authors are trained in the methods and theories of environmental sciences and studies. Any omissions of relevant literature, methods, or theory – either intentional or unintentional – are likely due to the necessary blinders we wear as scholars and students of these fields.

AUTHOR CONTRIBUTION CRediT STATEMENT

Author contributions for the above work, as defined by the Contributor Roles Taxonomy (https://casrai.org/credit/), are as follows:
Jess Vogt (pronouns: she/her/hers), principal investigator, LUFA, the Lab for Urban Forestry in the Anthropocene, and assistant professor, Department of Environmental Science and Studies, DePaul University: Conceptualization, Methodology, Data curation, Supervision, Validation, Visualization, Writing-original draft, Writing-review and editing, Project administration, Funding acquisition.
Margaret Abood (pronouns: she/her/hers), at the time of this research, undergraduate research assistant, LUFA: Conceptualization, Methodology, Writing-review and editing.

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