BIRMINGHAM
A WALKABLE CITY

AGENDA
BIRMINGHAM ENVIRONMENTAL SUSTAINABILITY COMMITTEE
MONDAY, JUNE 23, 2025
BIRMINGHAM CITY HALL, 151 MARTIN ST, ROOM 202-203, BIRMINGHAM MI *
**************** 5:30 PM****************

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1) **Call to Order**
2) **Roll Call**
3) **Review the Minutes**
    - A. **Minutes**
4) **Review of the Agenda**
5) **New Business**
    - A. **Leaf Blowers**
    - B. **Community Engagement Plan**
    - C. **SCAP Ganttt Chart**
6) **Miscellaneous Communications**
    - A. **FloodWise Communities Cohort**
    - B. **SOCRRA Recycling Magnet**
7) **Open to the Public for Items Not on the Agenda**
8) **Adjournment**

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*Please note that board meetings will be conducted in person once again. Members of the public can attend in person at Birmingham City Hall, 151 Martin St., or may attend virtually at:

Link to Access Virtual Meeting: https://bhamgov-org.zoom.us/j/84305107066
Telephone Meeting Access: 833 928 4608 US Toll-free
Meeting ID Code: 843 0510 7066

Notice: Individuals requiring accommodations, such as interpreter services for effective participation in this meeting should contact the City Clerk's Office at (248) 530-3405 at least on day in advance of the public meeting.

Las personas que requieren alojamiento, tales como servicios de interpretación, la participación efectiva en esta reunión deben ponerse en contacto con la Oficina del Secretario Municipal al (248) 530-3405 por lo menos el día antes de la reunión pública. (Title VI of the Civil Rights Act of 1964).

A PERSON DESIGNATED WITH THE AUTHORITY TO MAKE DECISIONS MUST BE PRESENT AT THE MEETING.

City of Birmingham
Regular Meeting of the Environmental Sustainability Committee
May 19, 2025
Rooms 202-203
151 Martin Street, Birmingham, Michigan

Minutes of the regular meeting of the City of Birmingham Environmental Sustainability Committee held on May 19, 2025. The meeting convened at 5:30 p.m.

1) Roll Call

Present: Lara Edwards, Debra Horner, Joe Mercurio, Jess Newman, Sara Rubino, Trenton Chapman; Student Representatives Penelope Graves, Abhishek Thota

Absent: Harvey Bell

Staff: City Planner Aldred-Arens; Planning Director Dupuis, Assistant City Manager Fairbairn

2) Review of the Minutes

Staff noted the minutes from the April 2025 meeting would be available at the next ESC meeting.

3) Review of the Agenda
4) New Business
A. Leaf Blowers

PD Dupuis presented the item and answered informational questions from the ESC.

ESC members raised the following points during discussion:
- The ESC should study and include recommendations on four stroke leafblowers as part of this study process.
- Landscaping providers that currently service Birmingham may choose to stop servicing Birmingham instead of electing to upgrade their equipment, since they would be able to use they gas powered leafblowers in neighboring municipalities.
- Birmingham might have more success in banning some or all gas powered leafblowers if they were to collaborate with neighboring municipalities.
- The noise from two stroke leafblowers significantly impacts other residents.
- This issue should likely be addressed as part of a package of other relevant ESC recommendations rather than on its own.
- Addressing this more via community education to start could be appropriate.
- Some residents are likely more interested in banning leafblowers than they are other sustainability issues. This might be an opportunity to generate interest among those residents.
- Alternatively, it might be too narrow a topic for the ESC to focus its beginning efforts on.
- More dialogue with local landscaping providers might be useful.

- It would also be helpful to know whether there are already local landscaping companies using all electric equipment, what it would cost to transition the City entirely to electric leadblowers, how much of the City's landscaping is done by DPS and how much is contracted out, and whether there are any kinds of financial incentives available for switching to electric equipment.
- Transitioning the City to electric leafblowers makes sense, regardless of whether a further policy change for businesses and residents is pursued.
- Exploring other ways to incentivize the use of electric leafblowers over gas leafblowers could be useful. Expanded hours for electric leafblower use might be one option, and City contract offerings with a preference for electric might be another.

B. Community Engagement Plan

CP Aldred-Arens presented the item and answered informational questions from the ESC.

ESC members raised the following points during discussion:

- Being able to track and show data on impacts would be important.
- It would be helpful to have a list of constituencies specifically mentioned for engagement within the Plan.
- If the City would benefit from the support at some point, it might be useful to consider engaging a third party to assist with the Plan.
- It may be appropriate to consider creating a guide for residents who experience basement flooding.
- Putting easements and City spaces to work for sustainability benefits is a high priority.
- The City would likely be able to collaborate with sustainability students from the University of Michigan for implementing parts of this Plan.
- It would be helpful to have a more granular proposed timeline of actions for the next one to two years.
- The City's zoning update process would be an opportunity to include sustainability updates as well.

5) Miscellaneous Communications

6) Open to the Public for Items Not on the Agenda

Sam Surnow expressed his interest in learning more about sustainability.

7) Adjournment

No further business being evident, the meeting adjourned at 6:35 p.m.

Summer Aldred-Arens, City Planner　　　　Laura Eichenhorn, City Transcriptionist

BIRMINGHAM
A WALKABLE CITY

MEMORANDUM

Planning Department

DATE: June 23, 2025

TO: Environmental Sustainability Committee Members

FROM: Nicholas Dupuis, Planning Director

SUBJECT: Leaf Blowers and Gas Powered Lawn Equipment

On May 19, 2025 (Agenda), the Planning Department presented an overview of the leaf blower issue and a history of actions taken at the City. Ultimately, the Environmental Sustainability Committee (ESC) requested that the sustainability team spend some time reviewing and discussing the positives and negatives of all gas powered lawn equipment to ensure that any recommendations that are provided to the City Commission may be thoroughly vetted and representative of the climate goals of the City. To that end, the Planning Department has begun to pull together resources for the ESC to review related to gas powered lawn equipment (GPLE). When reviewing these materials, there are several common themes that may be extracted from each:

- Two-stroke engines are the worst offenders in terms of emissions.
- GPLE is responsible for a significant amount of carbon emissions in the United States annually, most sources say around 5% (24%−45% of all non-road gasoline emissions).
- Electric powered lawn equipment is a clear solution, and although the initial costs are higher, the lifetime costs are generally less expensive.
- The emissions issue is directly tied to a lack of emission standards, such as those that are commonplace in passenger vehicles.
- An alternate target related to this issue is the existence and/or over maintenance of turf grass lawns.
- The approach to eliminating the use of GPLE is dependent on the scale (i.e. whole states or regions) and economics.

At this time, the Planning Department requests that the ESC review the provided information (and any other relevant information) for the purpose of engaging in a discussion towards policy recommendations that align with the goals of the Birmingham Green: Healthy Climate Plan. The attached resources, as well as those linked on the following page are provided to help start the process and will not be the only resources used.

Other Resources:

- Lawn Maintenance and Climate Change - Princeton Student Climate Initiative
- Lawn care goes electric – Environment America Research & Policy Center
- It's Electric: The New Lawn Care Norm – Environmental Law Institute
- Lawn and garden equipment requirements – Colorado Department of Public Health & Environment.
- Electric-Powered Lawn Equipment – Fairfax County, Virginia
- Gas leaf blowers and lawn mowers are shockingly bad for the planet. Bans are beginning to spread. – USA Today
- Clean Cities Guide to Alternative Fuel Commercial Lawn Equipment – U.S. Department of Energy
- National report highlights measurable benefits of electrifying lawn and garden equipment – Regional Air Quality Council
- Lawn & Garden Equipment Replacement Program – Pima County, Arizona
- About the Equitable Gas Leaf Blower Phase-out – Portland, Oregon

National Emissions from Lawn and Garden Equipment

Jamie L Banks, PhD, MS*

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Robert McConnell, Environmental Engineer

US Environmental Protection Agency, Region 1, 5 Post Office Square, Boston, MA 02109

Abstract

Background: The contribution of gasoline-powered lawn and garden equipment (GLGE) to air pollutant emissions in the United States has not been extensively studied. Goal: Our goal is to provide annual US and state-level emissions estimates of volatile organic compounds (VOC): criteria pollutants (carbon monoxide [CO], nitrogen oxides [NOx], particulate matter [PM] <10 microns, including PM < 2.5 microns [PM 10, PM2.5]; and carbon dioxide (CO2) from GLGE, with a focus on 2-stroke engines. Methods: Pollutant emissions data were extracted from the Environmental Protection Agency's (EPA) 2011 and 2018 modeling platform (version 6), for GLGE (Source Code Classifications 2260004021−2265004071), and equipment population data were obtained from the EPA's nonroad model. Data were sorted by equipment type and characteristics. Aggregate and equipment-specific emissions were calculated and compared with emissions from all gasoline-fueled nonroad equipment. Results are presented as descriptive statistics. Results: In 2011, approximately 26.7 million tons of pollutants were emitted by GLGE (VOC=461,800; CO=5,793,200; NOx=68,500, PM10=20,700; CO2=20,382,400), accounting for 24%−45% of all nonroad gasoline emissions. Gasoline-powered landscape maintenance equipment (GLME; leaf blowers/vacuums, and trimmers, edgers, brush cutters) accounted for 43% of VOCs and around 50% of fine PM. Two-stroke engines were responsible for the vast majority of fine PM from GLME. State data (California, New York, Texas, Illinois, and Florida), 2018 projections, and additional comparisons are presented. Methodological issues are discussed. Conclusions: GLGE accounts for a major portion of US nonroad gasoline emissions. Two-stroke engines are an important source of VOCs and criteria pollutants.

*Corresponding Author: jamie@quietcommunities.org

INTRODUCTION

Gasoline-powered lawn and garden equipment (GLGE) ranging from string trimmers to stump grinders and tractors is a source of high levels of localized emissions that includes hazardous air pollutants, criteria pollutants, and carbon dioxide (CO_2).[1-4] Workers using commercial equipment are exposed when they are close to the emitting sources several hours each day, several days a week in seasons of use. Other members of the public, including children, may also be exposed to high levels of emissions from commercial landscape maintenance equipment (GLME) such as leaf blowers, trimmers, and mowers, used routinely around residential neighborhoods, schools, parks, and other public spaces. The commercial landscape maintenance industry has experienced strong growth over the last 15 years and depends largely on gasoline-powered equipment for most tasks once performed manually. These factors are raising concerns about the health impacts of GLGE emissions on workers and the public.

Extensive evidence exists on the adverse health effects of exhaust emissions and other fine particulates which include cardiovascular disease, stroke, respiratory disease, cancer, neurological conditions, premature death, and effects on prenatal development.[5-13] Short term and long term exposures are implicated. However, GLGE as a source of these emissions has received little attention. Understanding the characteristics of GLGE and GLME emissions can help estimate potential health impacts of these close-to-the-source emissions.

The goal of this study was to characterize annual emissions from GLGE at the national level and in selected states and to estimate the contribution of GLME to those emissions. Special attention is paid to 2-stroke GLME engines. The emissions contributions from the four of the five most populated states are derived from the NEI, and for California, from the emissions inventory of the California Air Resources Board (CARB).

METHODS

Study Design

The GLGE emissions analyzed are total volatile organic compounds (VOC) and individual VOCs (benzene, 1,3 butadiene, acetaldehyde, formaldehyde); criteria pollutants (carbon monoxide [CO], nitrogen oxides [NOx], particulate matter [PM] <10 microns, including PM < 2.5 microns [PM 10, PM2.5]); and carbon dioxide (CO_2). Equipment pollutant data were extracted from SCC summary reports from the EPA's 2011 and 2018 modeling platform (version 6), and equipment population data were obtained from the Nonroad model. GLGE included the equipment in **TABLE 1** and identified by Source Code Classifications 2260004021−2265004071. The GLME subset is defined as leaf blowers/vacuums; trimmers/edgers/brush cutters; and mowers. Groupings of equipment, eg, leaf blowers/vacuums, were predefined by the NEI.

"All Emissions" are defined as all emissions from stationary and mobile sources, excluding biogenic and naturally occurring emissions. "All Nonroad Emissions" are defined as all emissions from the equipment types accounted for within the Nonroad model; note that this does not include emissions from commercial marine, rail, and aircraft sources. "Gasoline Nonroad Emissions" are defined as emissions from gasoline fueled equipment accounted for within the Nonroad model. National emissions were analyzed by type of equipment and engine configuration as shown in **TABLE 1**. All results are presented as descriptive statistics.

Table 1. Categorization scheme for analysis of GLGE emissions

Type of Equipment	**Engine Configuration**
GLME	
Leaf Blowers/Vacuums	2 stroke, 4 stroke
Trimmers/Edgers/Cutters	2 stroke, 4 stroke
Mowers	4 stroke
Other GLGE	
Chain Saws	2 stroke, 4 stroke
Rotary Tillers	2 stroke, 4 stroke
Snowblowers	2 stroke, 4 stroke
Turf Equipment	2 stroke, 4 stroke
Chippers/stump grinders	4 stroke
Tractors	4 stroke
Shredders	4 stroke
Other	4 stroke

Analyses

All analyses except for the 2018 projections represent 2011 estimates.

Equipment Populations

The national populations of all types of GLGE were obtained from the Nonroad model. The contribution of each type to the whole population was determined.

Contributions of All Nonroad and GLGE Sources

All Nonroad Emissions were compared to All Emissions. GLGE emissions were then calculated and compared with All Nonroad Emissions and All Emissions.

Contribution of Landscape Maintenance Equipment to GLGE Emissions

GLME emissions and their contribution to GLGE and All Nonroad Emissions were analyzed. Additional analyses were conducted to examine the relative contributions of 2-stroke GLME engine emissions.

Projected Growth of GLGE Emissions: 2011−2018

GLGE emissions projected for 2018 were obtained from the EPA's 2018 modeling platform, version 6, and compared with 2011 emissions.

GLGE Emissions in the Five Largest States

State level emissions data from the five most populated states (US Census) – California, Florida, Illinois, New York, and Texas – were extracted and analyzed. Estimates of GLGE emissions for Florida, Illinois, New York, and Texas were based on 2011 data from the EPA's 2011 modeling platform, version 6. Estimates of GLGE emission for California were based on data from the CARB's OFFROAD2007 Model and estimated for 2012. No adjustments were made for potential differences in annual emissions between 2011 and 2012 California data. The program structure of the OFFROAD2007 Model provides a general overview of the methodology used to estimate emissions from off-road sources (http://www.arb.ca.gov/msei/offroad/pubs/offroad_overview.pdf).

Each state's contribution to national GLGE Emissions was calculated and compared with its contributions to the US landscape maintenance labor force and the US population. Labor force statistics were sourced from the Bureau of Labor Statistics, May 2013 reports (www.bls.oes) and population data from the 2011 US Census.

Nonroad Air Emissions Model

EPA developed a nonroad air emissions model in the 1990s to provide estimates of emissions from most types of nonroad equipment, including construction equipment, recreational marine vessels, and lawn and garden equipment (LGE). The model is referred to simply as the "Nonroad" model, and it has been updated a number of times since its creation. Documentation for the model exists as a number of technical reports available on EPA's website (http://www.epa.gov/otaq/nonrdmdl.htm). Total emissions are determined by summing the exhaust and evaporative emission components.[14, 15] The preponderance of emissions from Nonroad equipment occurs as exhaust emissions due to the combustion of fuel. The methodologies for determining exhaust emissions are summarized below.

Exhaust Emissions from Nonroad Engines

The Nonroad model uses the following equation to calculate exhaust emissions from nonroad engines (ref: Median):

Emissions = (Pop) x (Power) x (LF) x (A) x (EF)

Where Pop = Engine population

Power = Average Power (hp)

LF = Load factor (fraction of available power)

A = Activity (hrs/yr)

EF = Emission factor (g/hp-hr)

The derivation of the default model data for each factor from the above equation is discussed below.

a. Equipment populations and average power (horsepower)

The technical report titled "Nonroad Engine Population Estimates"[16] indicates that equipment population data for most types of equipment were obtained from Power Systems Research, an independent marketing research firm, although in some instances other data source were used. Of interest for this analysis, for many LGE categories EPA used sales data obtained from equipment manufacturers during the development of its Phase 1 emission standards for small (less than 25 hp) gasoline fueled nonroad engines. This was done for the following LGE categories: lawn mowers, trimmers/edgers/brush cutters, leaf blowers/vacuums, and chainsaws. The report notes that an equipment population base year of either 1996 or 1998 was used for the LGE types.

Once estimates of equipment populations were derived, information obtained by the state of California was used to divide the equipment between the residential and commercial sectors. This step was needed because of the large difference in usage patterns between these two sectors. **TABLE 2** below contains an extract of data from Table 3 of the Nonroad Engine Population report mentioned above, and illustrates how the split between residential and commercial equipment was apportioned for a number of LGE types.

Table 2. Percentage split between residential and commercial equipment

SCC code	Application	Horsepower categories	Residential (% of equipment population)	Commercial (% of equipment population)
22xx004010 22xx004011	Lawn mowers	All	96.3	3.7
22xx004025 22xx004026	Trimmers/edgers/cutters	0-1 hp	100	0
		1-3 hp	85.3	14.7
		> 3 hp	0	100
22xx004020 22xx004021	Chainsaws	0-1 hp	100	0
		1-3 hp	97.0	3
		> 3 hp	0	100
22xx004030 22xx004031	Leaf blowers/vacuums	0-1 hp	100	0
		1-3 hp	92.5	7.5
		> 3 hp	0	100

i. Geographic allocation of residential LGE Populations (except snowblowers)

The Nonroad model uses US Census data on one and two unit housing to allocate national equipment populations to the county level. The population documentation report mentioned above notes that other variables are likely to also affect the distribution of LGE population, such as average yard size. However, no consistent, reliable data surrogates could be found to apportion the national level equipment populations based on these alternative factors, and so the model relies solely upon US Census data on one and two unit housing to allocate national LGE population data to the county level.

ii. Geographic allocation of commercial L&G Equipment Populations (except snowblowers)

The Nonroad model uses the number of employees in the landscaping services industry to dis-aggregate national level LGE population data to the county level. This was accomplished using data from the North American Industry Classification System (NAICS); specifically, for NAICS code 561730, landscaping services.

iii. Equipment population projections

The Nonroad model enables the user to obtain estimates of emissions for years other than the base year used for equipment populations. This is accomplished by the development of processes to handle the growth in equipment populations due to the purchase of new equipment as years pass, and adjustments made to account for the scrappage of old equipment. The reader is referred to the EPA technical reports "Nonroad Engine Growth Estimates,"[17] and "Calculation of Age Distributions in the Nonroad Model – Growth and Scrappage"[18] for further information on these topics. Both of these reports are available on the EPA website (http://www.epa.gov/otaq/nonrdmdl.htm).

b. Activity levels and load factors.

Equipment populations and horsepower levels alone are not sufficient for determining emissions from nonroad equipment; assumptions about frequency and patterns of use must also be made. The EPA report, "Median Life, Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling"[19] describes how the Nonroad model assigns default activity levels, in hours per year, and load factors in performing its calculations. Load factors are needed to account for the fact that equipment is not typically used at full power 100% of the time; load factors reflect that and are presented in terms of average percent of full power for the equipment as it is used. The activity levels and load factors for small (< or = to 25 hp) spark-ignition engines for many LGE types was taken from data supplied to EPA during the comment period for the regulation of these engines. **TABLE 3** below contains an extract of the default activity data, in annual hours of equipment use, and load factor data, expressed as fraction of full power, taken from Table 6 of the above mentioned report.

Table 3. Example default activity levels and load factors for LGE

Equipment type	Use	Activity level (Annual hours)	Load factor (fraction of full power)
Lawn mowers	Residential	25	0.33
	Commercial	406	0.33
Trimmers/Edgers/Cutters	Residential	9	0.91
	Commercial	137	0.91
Leaf blowers\Vacuums	Residential	10	0.94
	Commercial	282	0.94
Chainsaws	Residential	13	0.70
	Commercial	303	0.70

c. Emission factors

EPA's documentation for the source of the emission factors used within the Nonroad model are contained in the following two reports: "Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling: Compression-Ignition"[20] and "Exhaust Emission Factors for Nonroad Engine Modeling: Spark-Ignition." [21] Information pertaining to LGE contained in the latter report is discussed below.

Emission factors for spark-ignition engines rated at less than 25 hp were segregated into 5 engine classes based on primary use of the engine (handheld vs. non-handheld), and engine size according to engine displacement. Beginning in 1997, engines designed for both handheld and non-handheld applications became subject to several phases of regulation geared towards reducing fuel consumption (expressed in terms of brake-specific fuel consumption [BSFC]) and producing fewer air emissions in the combustion process. **TABLE 4** below contains an extract of information from Table 1 of the Exhaust Emissions 2010 report, and shows the impact of EPA's regulation on one such class of engines: small, hand-held, gasoline fueled two-stroke engines.

Table 4: Impact of regulation on small*, hand-held, gasoline fueled two stroke engines

Engine Tech Type	HC (g/hp-hr)	CO (g/hp-hr)	NOx (g/hp-hr)	PM (g/hp-hr)	BSFC (lb/hp-hr)
Baseline	261.00	718,87	0.97	7.7	1.365
Phase 1	219.99	480.31	0.78	7.7	1.184
Phase 2 (with catalyst)	26.87	141.69	1.49	7.7	0.822

BSFC: Brake-specific fuel consumption; CO: carbon monoxide; HC: hydrocarbon; NOx: nitrogen oxides; PM: particulate matter
* These emission factors are for engines sized from 0 to 1 hp.

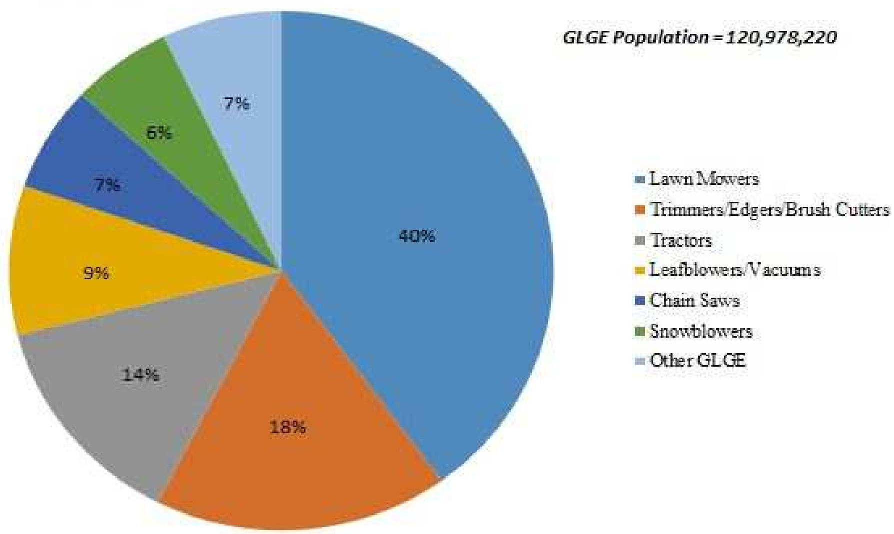
Other factors also influence the combustion related exhaust emissions from nonroad engines, such as fuel type, ambient temperature, and deterioration of equipment with age and use. The reader is referred to the EPA web-site (http://www.epa.gov/otaq/nonrdmdl.htm) for additional information on these topics.

RESULTS

Equipment Populations

Approximately 121 million pieces of GLGE are estimated to be in use in the United States (**FIGURE 1**). GLME accounts for two-thirds of all GLGE of which lawn mowers are the most numerous, followed by trimmers/edgers/ brush cutters, and then leaf blowers/vacuums. Projections from 2011 indicate a 13% increase across all equipment types after the combined effect of new equipment purchases and scrappage of old equipment are evaluated, resulting in an estimated 136 million pieces of GLGE in use by 2018.

Figure 1. GLGE population, US, 2011



Contribution of Nonroad Emissions to All Emissions

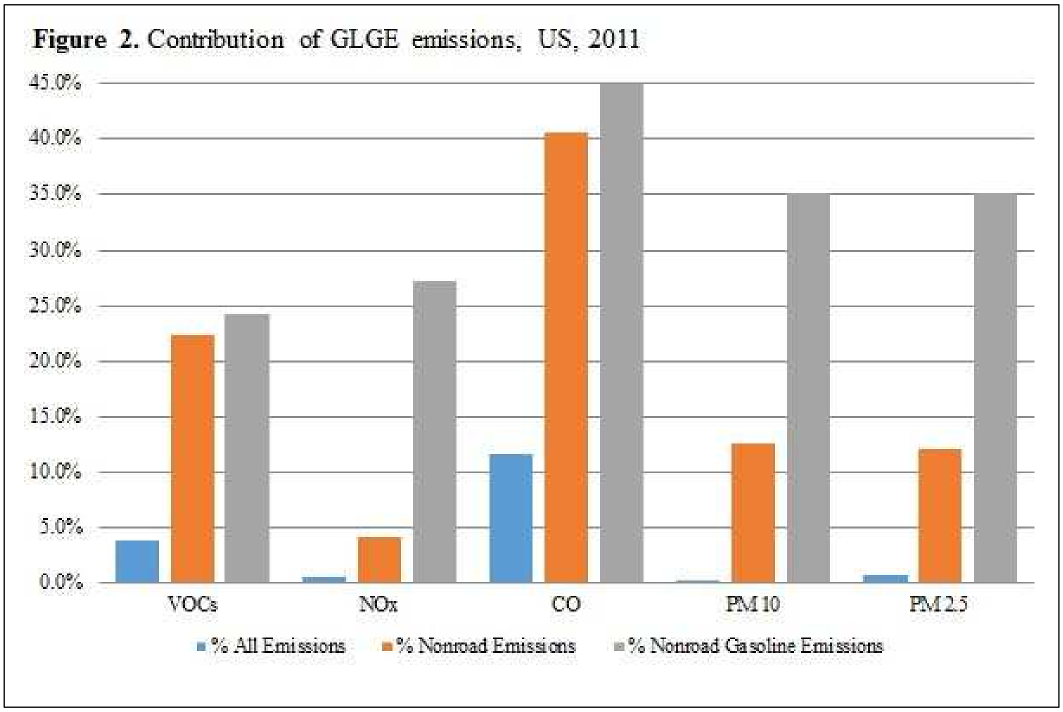
All Nonroad sources account for approximately 242 million tons of pollutants each year, accounting for 17% of all VOC emissions, 12% of NOx emissions, 29% of CO emissions, 4% of CO2 emissions, 2% of PM10 emissions, and 5% of PM2.5 emissions.

All Nonroad Emissions account for a substantial percentage of All Emissions of benzene (25%), 1,3 butadiene (22%), CO (29%), PM10 (2%), and PM2.5 (5%). Because of the relatively small contribution of GLGE CO2 to All Emissions (0.3%), it is not further considered in this report.

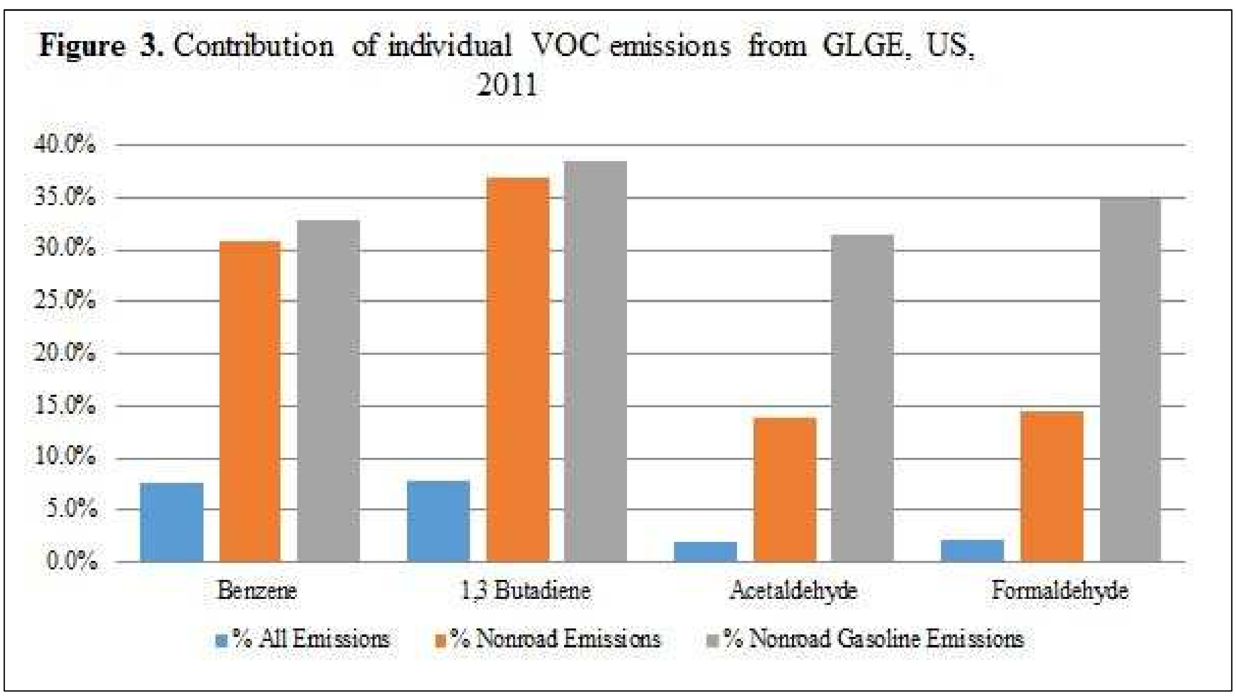
Contribution of GLGE to All Emissions and Nonroad Emissions

GLGE emitted approximately 6.3 million tons of VOCs (461,800) and criteria pollutants (CO=5,793,200; NOx=68,500, PM10=20,700 [19,000 of which is PM2.5]), and 20.4 million tons of CO2 in 2011. GLGE represented nearly 4% of All Emissions of VOCs and 12% of All Emissions of CO

(**FIGURE 2**). GLGE fine PM emissions constitute a fraction of a percent of All Emissions of fine PM, but is a major Nonroad source, accounting for nearly 13% of All Nonroad Emissions of fine PM and more than one-third of Gasoline Nonroad Emissions of fine PM.



Analysis of individual VOC emissions shows that GLGE contributes nearly 8% of All Emissions of both benzene and 1,3 butadiene (**FIGURE 3**). Within All Nonroad Emissions and Gasoline Nonroad Emissions, GLGE accounts for nearly one-third or more of benzene and 1,3 butadiene emissions, and also becomes a major source of aldehyde and formaldehyde emissions from Gasoline Nonroad sources.



Contribution of GLME to GLGE Emissions

Compared with the GLGE contributions of Nonroad Gasoline Emissions shown in **FIGURE 2**, contributions of VOCs and fine PM emissions from GLME are disproportionately high, and for NOx and CO, are disproportionately low (**FIGURE 4**). Small GLME engines account for more than 40% of VOC emissions and one-half of PM10 and PM2.5 emissions from GLGE. Close to 90% of fine PM emissions from GLME come from 2-stroke engines (**FIGURE 5**).

Figure 4. Contribution of GLME to GLGE emissions, US, 2011

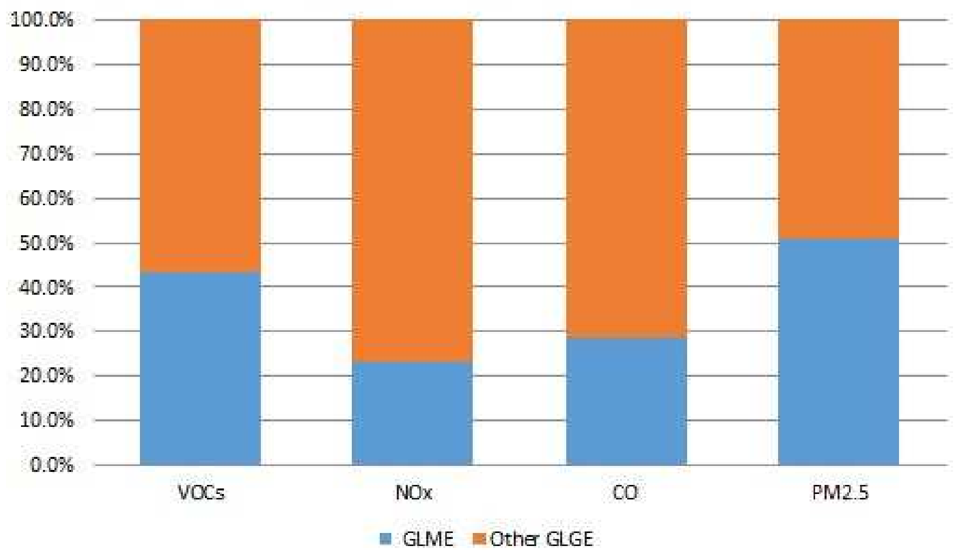
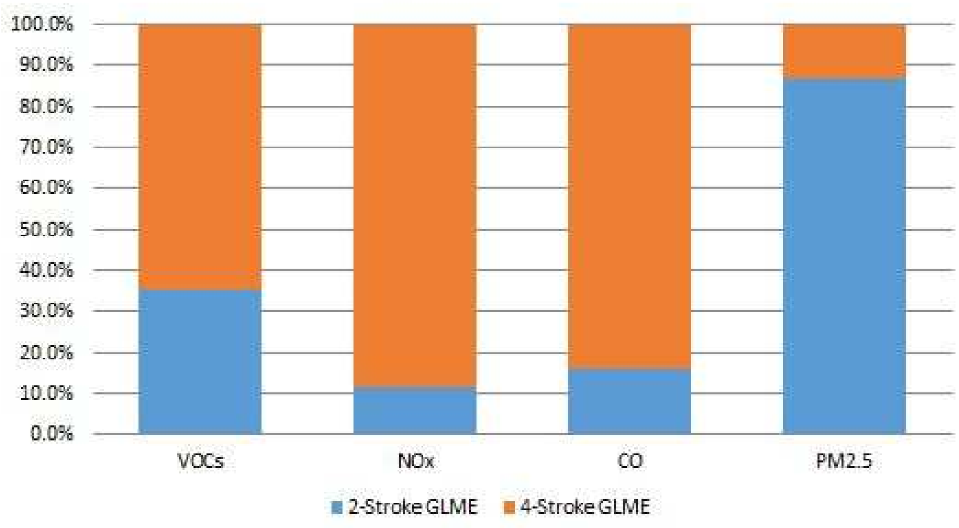


Figure 5. Contribution of 2-stroke engines to GLME emissions, US, 2011



Projected Growth of GLGE Emissions: 2011−2018

By 2018, the annual tonnage of ozone precursors, VOCs and NOx, emitted by GLGE is projected to decrease substantially from 2011, as more of the in-use fleet becomes represented by equipment built to meet EPA nonroad emission standards. CO emissions remain comparable to 2011 levels, while CO2 and fine PM emissions are projected to increase modestly.

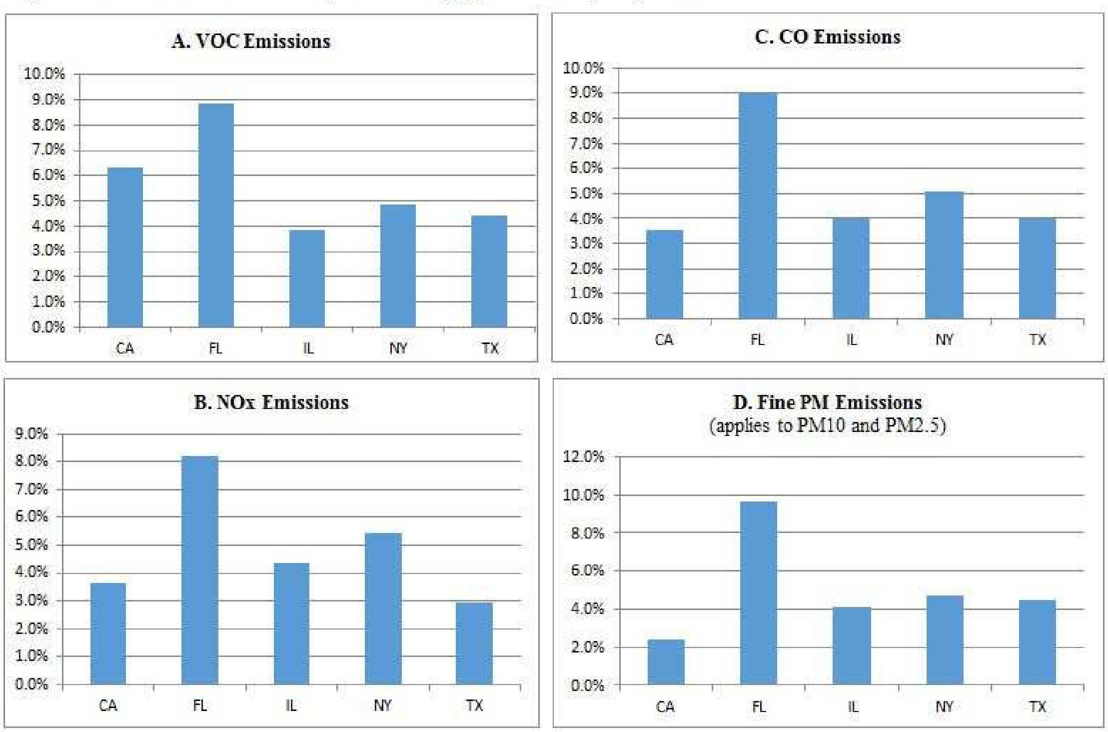
Table 5: Estimated Change in GLGE Emissions, 2018 vs 2011

Emissions	% Change
VOCs	-20.9%
NOx	-31.1%
CO	-4.9%
CO2	12.3%
PM 10	8.2%
PM 2.5	8.4%

GLGE Emissions in the Five Most Populated States

When considered together, GLGE emissions from California, Florida, Illinois, New York and Texas constitute approximately one-quarter of national GLGE emissions.

Figure 6. Emissions contributed by the 5 most populated states, US, 2011*

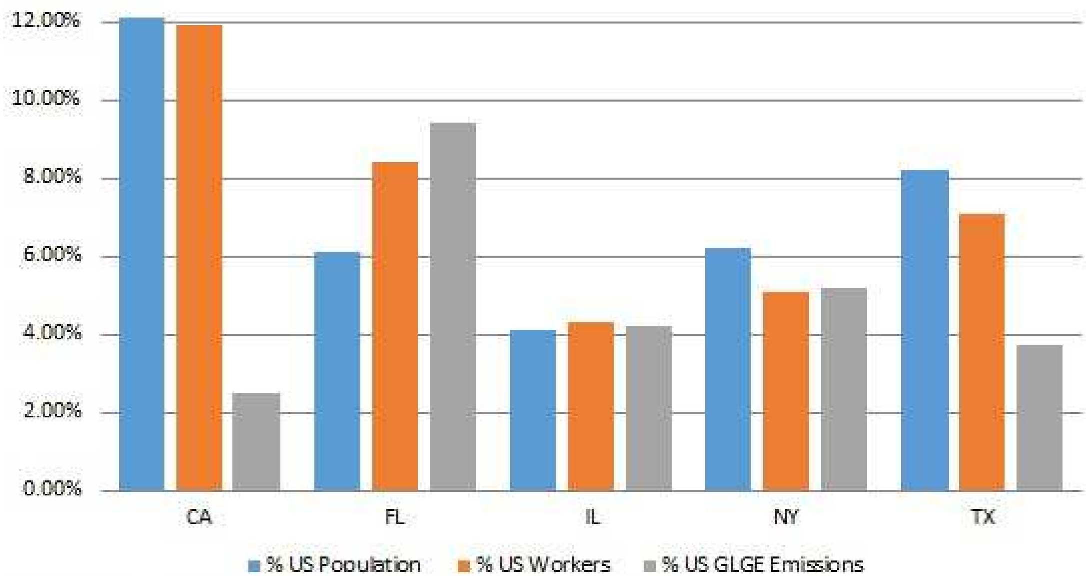


CA: California; FL: Florida; IL: Illinois; NY: New York; TX: Texas
*California data are from 2012.

Florida's GLGE emissions were 1.4 to 2.1-times higher compared with emissions in states having the next highest level of emissions in each GLGE pollutant category, and 2.2 to 4.4-times higher compared with emissions in states having the lowest level of emissions in each GLGE pollutant category (**FIGURE 6**).

For Florida, Illinois, and New York, state-specific contributions of GLGE emissions compared to the national total were relatively consistent with their contributions to the national population and the national grounds maintenance workforce. For California, its GLGE emission contribution was one-fifth that of its contribution to the national population and to the national grounds maintenance workforce. For Texas, its GLGE emission contribution was 40%−50% that of its contribution to the national population and to the national grounds maintenance workforce (**FIGURE 7**).

Figure 7. State contributions to US national population, grounds maintenance workforce, and GLGE emissions*



CA: California; FL: Florida; IL: Illinois; NY: New York; TX: Texas
*California data are from 2012 CARB estimates; all other state data are from 2011 NEI estimates.

DISCUSSION

The main findings of this study are: 1) GLGE is a prevalent source of toxic and carcinogenic emissions; 2) GLGE contributes substantially to nonroad emissions of benzene,1,3 butadiene, formaldehyde, CO, and fine PM; 3) GLME accounts for a disproportionately large share of VOC and fine PM emissions; 4) 2-stroke engines account for most fine PM emissions from GLME; 5) VOCs and NOx are projected to decrease substantially by 2018; CO emissions remain comparable to 2011 levels; and CO2 and fine PM emissions are projected to increase modestly; and 6) the GLGE emissions contributions from the the largest states are not always consistent with contributions to national population and national grounds maintenance workforce.

The large volume of emissions from GLGE found in this study is consistent with findings previously reported by the EPA[1] and from other studies.[2-4] The very substantial contribution of VOC, in particular benzene and 1,3 butadiene, deserves attention especially because of their localized nature.

While VOC emissions are expected decrease 21% on average by 2018, the rates of equipment replacement on which those projections are based are only approximated.

Adverse health effects from the GLGE emissions are well known. Benzene, 1,3 butadiene, and formaldehyde are listed among the four top ranking cancer-causing compounds.[22] They cause lymphomas, leukemias, and other types of cancer (International Agency for Research on Cancer, World Health Organization).[23, 24] Ground level ozone (formed by VOCs and NOx in the presence of sunlight) and fine PM cause or contribute to early death, heart attack, stroke, congestive heart failure, asthma, chronic obstructive pulmonary disease, and cancer.[5-11] Growing evidence suggests these pollutants also contribute to developmental and neurological disorders, including autism.[7-9, 12, 13] The mounting evidence on the dangers of short term exposure are especially concerning.[7, 9, 11]

The high levels of VOCs and fine PM from GLME are health risks for workers and other members of the public close to the emitting source. Although no studies of grounds maintenance workers were found, studies of gas station workers have shown that regular exposure to gasoline vapors can produce hematological and immunological abnormalities and elevate the risk of cancer.[25-27] In addition, children, seniors, and persons with chronic illnesses are especially vulnerable to the negative health impacts of GLME emissions.[28] Routine use of GLME in the vicinity of residential neighborhoods, schools, parks, and other public spaces may be exposing the public to unnecessary and preventable health risks. New equipment standards do not affect fine PM emissions; in fact, those emissions are expected to increase.

School buses represent another example of a close-to-emitting source in which children are subjected to increased exposure from diesel exhaust.[29] Tests of school buses found that diesel exhaust entering through the front door of the bus results in elevated levels of PM over time. When queuing, PM built up rapidly in the bus cabin when the front doors were open.

The variation in emissions levels observed among the five most populated states should be explored further. The reasons for the high emissions contribution from Florida and relatively low emissions contributions from Texas and California are not clear. Differences between CARB data and NEI data may account for some of the difference between California and other states. For example, the NEI baseline equipment population data are older compared with those of CARB. Other factors that may be involved include but are not limited to emissions estimation procedure, geographic and climate factors, regulations and their effectiveness, and efforts to promote cleaner alternatives.

This study has several limitations. Not all potentially harmful emissions were characterized; for example, polycyclic aromatic hydrocarbons. Other limitations concern the source data. Although the NEI is a comprehensive source of GLGE emissions data, the accuracy of the reported data is uncertain. Baseline equipment population data for the Nonroad model is 15−20 years old and does not account for growth of the commercial industry. This older population data supplies emission estimates to NEI, which in turn is used to create EPA's 2011 and 2018 modeling platforms. Although the residential and commercial CARB inventories and activity data are newer, they depend largely upon telephone survey data.[30, 31] Methodological weaknesses with the commercial survey data are discussed in the survey report.[31] For both data sources, the rates of replacement of older equipment by newer, cleaner equipment that meets the newer Phase 3 standards[32] can only be approximated.

CONCLUSIONS

GLGE is an important source of toxic and carcinogenic exhaust and fine particulate matter. Improved reporting and monitoring of localized GLGE emissions should be implemented. Medical and scientific organizations should increase public awareness of GLGE and GLME and identify GLGE as an important local source of dangerous air pollutants. Communities and environmental, public health, and other government agencies should create policies and programs to protect the public from GLGE air pollutants and promote non-polluting alternatives.

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Electrifying: Facilitating the Transition To Electric Lawn and Garden Equipment

Bryan Hull and Ryan Murphy[*]

INTRODUCTION

As the automobiles on America's roads have grown more environmentally friendly in recent decades, a different fleet of emitters has continued to lurk in the nation's garages and backyards. Some small gas-powered lawn and garden equipment products ("LGE")[1] sold in hardware and big box stores today, emit pollutants at levels exceeding those of cars and trucks.[2]

For instance, a 2011 Edmunds study concluded a simple two-stroke leaf blower emitted twice the quantity of nitrogen oxides as a 6,200-pound Ford F-150 SVT Raptor.[3] The leaf blower also emitted twenty-three times as much carbon monoxide and 299 times as many non-methane hydrocarbons as the large truck.[4] According to the study, the Raptor would have to travel for 3,887 miles to produce as many hydrocarbon emissions as the leaf blower generates in thirty minutes of ordinary yard work.[5] Although nearly a decade has passed since this study was taken, the Environmental Protection Agency ("EPA") has yet to

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[1] *See* 40 C.F.R. § 1054.1 (2010) (regulating new spark-ignition engines with maximum power at or below 19 kilowatts or 25 horsepower covering LGE which includes lawn mowers, leaf blowers, trimmers, edgers, cutters, chippers, rotary tillers, stump grinders, shredders, snowblowers, tractors, turf equipment, and other lawn tools).

[2] *See* Jason Kavanagh, *Emissions Test: Car vs. Truck vs. Leaf Blower*, EDMUNDS (Dec. 5, 2011), https://www.edmunds.com/car-reviews/features/emissions-test-car-vs-truck-vs-leaf-blower.html [https://perma.cc/P2HU-JCJW].

[3] *Id.*; *see also* Center for Science Education, *Nitrogen Oxides*, UNIVERSITY CORPORATION FOR ATMOSPHERIC RESEARCH (2017), https://scied.ucar.edu/nitrogen-oxides [https://perma.cc/R84B-7VKM] (describing nitrogen oxides as highly reactive combustion byproducts contributing to the formation of ozone, acid rain, and smog).

[4] *Id.*

[5] *Id.*

substantially increase federal emissions standards applicable to most small nonroad engines.[6]

Many of the gas-powered LGE products sold in the U.S. today emit startling amounts of harmful gases because they continue to rely on decades-old designs.[7] Policymakers have compelled automobile manufacturers to reduce the output of vehicle emissions over the years through technologies like catalytic converters, advanced combustion techniques, and computer-controlled fuel injection.[8] Unfortunately, regulators have devoted far less attention to driving emissions reductions in LGE engines.[9]

The regulatory gaps allowing heavy-emitting LGE to persist in the U.S. create significant environmental and health hazards.[10] One EPA study found gas-powered LGE generates eight percent of the United States dangerous benzene and "1,3 butadiene"[11] emissions.[12] The study also found two-stroke engines like those used in many types of LGE are a major source of fine particulate exhaust, which is known to elevate risks of cancer,[13] heart disease, stroke, lung disease, and premature death.[14] Although gas-powered LGE undoubtedly serve as valuable landscaping tools throughout the U.S., they are responsible for roughly five percent of America's air pollution,[15] substantial

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[6] *See* 40 C.F.R. § 1054.101 (2010).

[7] *See* Ryan Cooper, *The government must regulate lawn equipment. Seriously.*, THE WEEK (Nov. 28, 2017), https://theweek.com/articles/739688/government-must-regulate-lawn-equipment-seriously [https://perma.cc/Y2H9-E38D].

[8] *Id.*

[9] *Id.*

[10] *See* Jamie L. Banks & Robert McConnell, *National Emissions from Lawn and Garden Equipment*, EPA (2015), https://www.epa.gov/sites/production/files/2015-09/documents/banks.pdf [https://perma.cc/WHD3-5S9N].

[11] *See* Daniel I. Rubenstein & Sheryl Telford, *Final Report of the New Jersey Comparative Risk Project* (2003), https://www.state.nj.us/dep/dsr/njcrp/njcrp-final.pdf (explanatory parenthetical) [https://perma.cc/7NWB-Y69X].

[12] *See* Banks & McConnell, *supra* note 10.

[13] *See* Kurt Straif et al., *Air Pollution and Cancer*, INTERNATIONAL AGENCY FOR RESEARCH IN CANCER, WORLD HEALTH ORGANIZATION (2013), https://publications.iarc.fr/Book-And-Report-Series/Iarc-Scientific-Publications/Air-Pollution-And-Cancer-2013 [https://perma.cc/F7JA-2U6S].

[14] *Id.*

[15] *See* PEOPLE POWERED MACHINES, *Cleaner Air: Gas Mower Pollution,* https://www.peoplepoweredmachines.com/faq-environment.htm [https://perma.cc/N2L5-BPCG] *Facts*; *see also* Banks & McConnell, *supra* note 10, at 7 (finding that gas-powered LGE contributes significantly to the nation's total GHG emissions, including approximately 17% of all volatile organic compound emissions, 12% of nitrogen oxide emissions, 29% of carbon monoxide emissions, and 4% of carbon dioxide emissions); *see also Outdoor Carbon Monoxide Poisoning Attributed to Tractor Exhaust* (1997), CDC

ground level ozone pollutants, greenhouse gas emissions ("GHG"), and other harmful emissions.[16] Even as the unjustifiable environmental and health risks associated with gas-powered LGE have grown more conspicuous in recent years, many manufacturers have been slow to integrate new technologies such as electric motors into their products to mitigate those risks.[17]

This Article examines how policy deficiencies have slowed progress toward electrification and decarbonization within the LGE industry in recent decades and identifies specific federal, state, and local policies capable of addressing these shortcomings. At the federal level, a combination of strong and predictable retail tax incentives and national LGE emissions standards growing stringent over time would do much to promote emissions reductions within the industry. And, although each state faces its own unique challenges with respect to LGE, state governments and electric utilities regulated at the state level would be well suited to offer various programs capable of further promoting the adoption of electric LGE technologies. Even at the municipal government level, there are myriad potential ways to promote reductions in LGE-related emissions. Collectively, such proactive government efforts at all levels could drive much more rapid electrification of the equipment used in the nation's backyards and gardens.

Part I of this Article sets forth detailed background information on the LGE equipment industry and its public

MORBIDITY & MORTALITY WEEKLY REPORT, https://www.cdc.gov/mmwr/preview/mmwrhtml/00050544.htm [https://perma.cc/ZB77-AXK3] (last viewed Nov. 8, 2020) (attributing carbon monoxide poisoning to inhaling tractor exhaust).

[16] *See* PEOPLE POWERED MACHINES, *Cleaner Air: Gas Mower Pollution Facts,* https://www.peoplepoweredmachines.com/faq-environment.htm [https://perma.cc/N2L5-BPCG] (last viewed Oct. 5, 2020); *see also* Banks & McConnell, *supra* note 10, at 7 (finding that gas-powered LGE contributes significantly to the nation's total GHG emissions, including approximately 17% of all volatile organic compound emissions, 12% of nitrogen oxide emissions, 29% of carbon monoxide emissions, and 4% of carbon dioxide emissions); *see also* MORBIDITY AND MORTALITY WEEKLY REPORT, *Outdoor Carbon Monoxide Poisoning Attributed to Tractor Exhaust* (1997), CENTER FOR DISEASE CONTROL https://www.cdc.gov/mmwr/preview/mmwrhtml/00050544.htm [https://perma.cc/ZB77-AXK3] (attributing carbon monoxide poisoning to inhaling tractor exhaust).

[17] *Compare* Tim Palucka, *Doing the Impossible*, INVENTION & TECHNOLOGY (2004), https://www.inventionandtech.com/content/doing-impossible-0 [https://perma.cc/VST5-K5JD] (describing the quick technological improvements made in the auto industry with secondary air injection, exhaust gas recirculation, and catalytic converters) *with* Cooper, *supra* note 7 (arguing that gas-powered LGE was responsible for 24–45 percent of non-road gasoline emissions and that within in a few years gas-powered LGE will be the biggest source of ozone pollution in California).

health, environmental, and economic effects. Part II describes and critiques the existing set of policies governing LGE and their emissions within the U.S. Part II further explains how the limitations of existing federal, state, and local governments have hampered the national push to transition to electric LGE. Part III describes specific policies implementable at the federal, state, and local levels that could facilitate a more accelerated and cost-effective transition toward an all-electric LGE industry.

I. LAWN AND GARDEN EQUIPMENT: SMALL ENGINES -BIG EMITTERS

Lawn care and the regular tending of front and backyard areas are practices existing for hundreds of years.[18] Originating centuries ago in agricultural and animal husbandry settings with grazing pens and other enclosed grassy areas, lawns have gradually developed into areas where people could gather in idyllic outdoor spaces managed by their own hands.[19] LGE technologies aimed at simplifying lawn and garden care are traceable back to at least 1830, when English engineer Edwin Bunning created the first wheel-driven push lawn mower.[20] Championed as a time-saving tool, these first lawn mowers could do the work of more than a half dozen people using handheld devices.[21]

Technological advancements continued to dramatically reshape the lawn and garden care industry throughout the early twentieth century, when internal combustion engines and early push-reel lawn mower designs made it possible to keep lawns and gardens tidy without nearly as much time or intense physical labor.[22] As technologies improved over this period, lawn and

[18] *See* Planet Natural Research Center, *Lawn History*, PLANET NATURAL (2019), https://www.planetnatural.com/organic-lawn-care-101/history/ [https://perma.cc/PQ2X-MZS9].

[19] *See* Courtney Ruby, *Let it Grow: Freeing the Lawn from Aesthetically Rigid and Environmentally Damaging Real Covenants*, 87 UMKC L. REV. 435, 436 (2019).

[20] *See* Mary Bellis, *Greener Pastures: The Story of the First Lawn Mower*, THOUGHTCO. (Mar. 1, 2019), https://www.thoughtco.com/first-lawn-mower-1991636 [https://perma.cc/D6GT-DPHZ].

[21] *See* Louise Harmon, *Honoring our Silent Neighbors to the South: The Problem of Abandoned or Forgotten Asylum Cemeteries*, 34 TOURO L. REV. 901, 952-53 (2018) (citing MEG GREENE, REST IN PEACE: A HISTORY OF AMERICAN CEMETERIES 46-47 (2008)).

[22] *See* Matt Jonas, *Cleaner Air: The Environmental Impacts of Gas Lawn Mowers*, CENTER FOR ENVTL. TRANSFORMATION (Feb. 14, 2020), https://www.cfet.org/cleaner-air-the-environmental-impacts-of-gas-lawn-mowers/ [https://perma.cc/AH55-2HEV].

garden tools were seen less as labor-saving devices and more as work-expanding tools.[23] Unfortunately, these powerful combustion engine-driven technologies also brought air emissions with them having since posed significant environmental and human health risks.[24]

By the 1960s, United States policymakers began to notice the dangers of air emissions from gas-powered engines and to seek ways to reduce those dangers.[25] In 1963, Congress enacted the Clean Air Act ("CAA" or "the Act"), a comprehensive statute aimed at reducing harmful emissions from a variety of sources.[26] Among other things, the Act empowered the EPA to regulate emissions of air pollutants from a wide range of sources, including LGE engines.[27] LGE combustion engines were not substantially regulated, however, until 1998.[28] Although technological strides during the late twentieth century included some early electric designs, most still lacked the power and durability of gas-powered models.[29]

Sadly, the regulatory environment since that time has not sufficiently incentivized LGE manufacturers to pursue a transition more aggressively toward all-electric product fleets even though the technologies needed for such a transition have increasingly been available.[30] Indeed, electric motor technologies today are often capable of supporting the development of LGE products comparable to or better than gas-powered counterparts in the same price range.[31]

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[23] *See* Dale C. Doerhoff et al., *Facing the Lawn Boy Conundrum at Home and at the Office*, 59 J. MO. B. 114, 140 (2003).

[24] *The Evolution of Lawn Mowers Throughout History,* POWERPRO EQUIPMENT, https://www.powerproequipment.com/evolution-lawn-mowers-throughout-history [https://perma.cc/G243-DJWN] (last viewed Jan. 20, 2021).

[25] *See* U.S. ENVTL. PROT. AGENCY, *History of Air Pollution* (2020), https://www.epa.gov/air-research/history-air-pollution [https://perma.cc/D9FD-W42Y].

[26] *See* 42 U.S.C. § 7401 (West 1963).

[27] *See* U.S. ENVIRTL. PROT. AGENCY, *Clean Air Act Requirements and History* (2020 https://www.epa.gov/clean-air-act-overview/clean-air-act-requirements-and-history [https://perma.cc/A56W-2HH7]

[28] *See* Bellis, *supra* note 20, at 452.

[29] *See* James M. Liston, *GE Introduces the Electric Tractor*, POPULAR MECHANICS (1970) (e.g., General Electric introduced the first production-line, electric-powered home tractor in 1970; the Electrak was able to mow 3.5 acres without recharging and touted a "cool, quiet, safe, and vibration-free" engine that could outperform conventional 10, 12, and 14 horsepower tractors of the time.)

[30] *But see EPA sets lower emissions regulations for mowers*, CONSUMER REPORT NEWS (Oct. 2, 2008, 4:09 AM), https://www.consumerreports.org/cro/news/2008/10/epa-sets-lower-emissions-regulations-for-mowers/index.htm [https://perma.cc/NN83-GHQA].

[31] *See* Paul Hope, *Electric Lawn Mowers That Rival Gas Models*, CONSUMER

Transitioning from gas-powered to electric LGE technologies is becoming ever more imperative as concerns continue to mount regarding the adverse environmental impacts of fossil fuel engines.[32] Despite these concerns, gas-powered lawn and garden care tools comprise a multi-billion-dollar industry with the U.S. market alone likely to reach roughly thirteen billion dollars in revenue within the next five years;[33] even though electric models increasingly lead their markets in almost all performance categories.[34]

Incredibly, although electric LGE models are the smart choice in new equipment, the global market share for electric lawn mowers is still less than 30 percent and the U.S. plays a relatively minor role in the market.[35] LGE manufacturers continue to profit handsomely from gas-powered technologies, and their reluctance to embrace electric-powered models has made LGE among the most unjustifiable polluters in the world.

A. Compare and Contrast: Gas vs. Electric LGE

Transitioning to an all-electric LGE industry could benefit the nation and the world in several ways, many of such benefits are not fully accounted for under existing policies governing LGE products. Operating gas-powered LGE produces many negative externalities, including potentially harmful emissions and noise levels.[36] Conversely, the use of clean, sustainable electric LGE

REPORTS (Apr. 6, 2017), https://www.consumerreports.org/push-mowers/electric-lawn-mowers-that-rival-gas-models/ [https://perma.cc/KES2-SNFS].

[32] *See Electrification: The Time is Now*, Analysis, ELECTRIFICATION COALITION (2011), https://www.electrificationcoalition.org/electrification-the-time-is-now/ [https://perma.cc/2TJG-ZH99].

[33] *See* Arizton, *US Lawnmowers Market - Opportunity and Growth Assessment 2019-2024*, RESEARCH & MARKETS (May 2019), https://www.researchandmarkets.com/reports/4771009/us-lawnmowers-market-opportunity-and-growth [https://perma.cc/H8U4-YUQS].

[34] *See* Paul Hope, *How Green Are Electric Lawn Mowers?*, CONSUMER REPORTS (Jul. 28, 2018), https://www.consumerreports.org/lawn-mowers-and-tractors/how-green-are-electric-lawn-mowers/. [https://perma.cc/WXM3-UQSU].

[35] *See* Market Research Report, *Lawn Mowers Market Size, Share & Trends Analysis Report By Product (Petrol, Electric, Manual, Robotic), By End Use (Residential, Commercial & Govt.), By Region (MEA, Asia Pacific, North America), And Segment Forecasts, 2019 - 2027*, GRAND VIEW RESEARCH (Feb. 2020), https://www.grandviewresearch.com/industry-analysis/lawn-mowers-market [https://perma.cc/CLL9-Y3CJ].

[36] *See* ARTHUR PIGOU, THE ECONOMICS OF WELFARE 183 (4th ed. 1932) (defining an externality as a cost or benefit imposed on a third party resulting from an action taken by someone other than that third party).

produces positive externalities.[37] While transitioning to an almost entirely electric LGE industry could be difficult and costly in the short term, the net long-term environmental, health and economic gains from such a move are likely to outweigh the costs of continued reliance on gas-powered equipment.

i. Air emissions impacts

In an era of unending policy debates over strategies for curbing harmful emissions and climate change, gas-powered LGE have gone largely unnoticed.[38] Many gas-powered LGE emit substantial amounts of carbon monoxide, volatile organic compounds (key in the formation of ground-level ozone),[39] nitrogen oxides, and other harmful emissions.[40] Gas-powered LGE also contribute to numerous human health risks including lung cancer, cardiopulmonary disease, emphysema, respiratory infections, and carbon monoxide poisoning.[41] Emissions from gas-powered LGE can even inhibit plant growth, thereby further exacerbating their climate change-inducing effects.[42] Indeed, it will be difficult for the nation to reach its long-term GHG reduction goals without greatly reducing emissions from gas-powered LGE.

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[37] *See* HARVEY S. ROSEN, PUBLIC FINANCE 86 (10th ed. 2014) (explaining positive externality problems and how such problems may be addressed through Pigouvian subsidies).

[38] *See generally* Michael P. Vandenbergh, *From Smokestack to SUV: The Individual as Regulated Entity In the New Era of Environmental Law*, 57 VAND. L. REV. 515, 549 (2004) (describing lawn and gardening equipment as among some of the most innocuous polluters other than vehicles).

[39] *See* American Lung Association, *State of the Air 2019: 20th Anniversary* (2019), https://www.lung.org/assets/documents/healthy-air/state-of-the-air/sota-2019-full.pdf [https://perma.cc/B2AE-YWJQ].

[40] *See* Rubenstein & Telford, *supra* note 11, at 12 (stating that in addition to cancer, pollutants from LGE cause or contribute to early death, heart attack, stroke, congestive heart failure, and chronic obstructive pulmonary disease).

[41] *See* Brian Palmer, *How bad for the environment are gas-powered leaf blowers?*, WASHINGTON POST (Sept. 16, 2013) (explaining how the leading culprit in harmful emissions is the two-stroke engine which emits a significant number of air pollutants as a byproduct of its function including, large quantities of carbon monoxide, nitrous oxides and hydrocarbons) https://www.washingtonpost.com/national/health-science/how-bad-for-the-environment-are-gas-powered-leaf-blowers/2013/09/16/8eed7b9a-18bb-11e3-a628-7e6dde8f889d_story.html?noredirect=on [https://perma.cc/DE2X-SA3S].

[42] *See* Ozlem Kar Kurt, Jingjing Zhang, Kent E. Pinkerton, *Pulmonary Health Effects of Air Pollution*, CURRENT OPINION IN PULMONARY MEDICINE (Mar. 2016), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4776742/ [https://perma.cc/WUX8-QJ44].

Unfortunately, under existing policies, many of the environmental and health costs of gas-powered LGE are not presently reflected in the retail prices Americans pay for these products.[43] And many of the costs associated with air pollution are borne disproportionately by low income and minority communities.[44]

The gasoline fuel used to fuel the nation's vast fleet of gas-powered LGE creates its own set of costs.[45] Americans annually consume more than 1.2 billion gallons of gasoline for lawn mowing alone.[46] Even worse, the exhaust produced from burning this fuel accounts for between 24 and 45 percent of all non-road gasoline emissions.[47] Moreover, the EPA estimates, during the seemingly simple process of refueling LGE, at least 17 million gallons of gasoline are spilled annually,[48] exceeding all of the oil spilled in the infamous Alaska Exxon Valdez oil spill.[49] This spilled gasoline often pollutes groundwater and seeps into waterways throughout the U.S.[50]

In addition to contaminating groundwater, evaporated fuel can substantially add to ground level ozone pollution and smog problems in metropolitan areas.[51] Indeed, these evaporative

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[43] *See generally* Matthew E. Kahn, *The Beneficiaries of Clean Air Act Regulation*, REG. MAG., at 34–37 (Spring 2001) (showing that less wealthy people and minorities in the Los Angeles Basin experienced greater improvements in air quality than wealthier people based on the spatial distribution of air pollutants while wealthier people tended to bear the costs of newer, cleaner vehicle ownership).

[44] *See id.*

[45] *See generally Alternative Fuel and Advanced Technology Commercial Lawn Equipment*, DEP'T. OF ENERGY (2014) https://afdc.energy.gov/files/u/publication/lawn_equip_2014.pdf [https://perma.cc/P4Q7-ZNW7].

[46] *See id.* (stating that commercial lawn mowing accounts for about 35% of gasoline consumption).

[47] *See* Rubenstein & Telford, *supra* note 11, at 1.

[48] *See* Cecil Adams, *How Much Pollution Do Gasoline-Powered Lawn Mowers Cause?*, WASHINGTON CITY PAPER (Nov. 12, 2010), https://www.washingtoncitypaper.com/columns/straight-dope/article/13039806/straight-dope-how-much-pollution-do-gasoline-powered-lawn-mowers [https://perma.cc/9UY3-2E9R].

[49] *See* United States Environmental Protection Agency, *Exxon Valdez Spill Profile* (Jan. 19, 2017), https://www.epa.gov/emergency-response/exxon-valdez-spill-profile [https://perma.cc/FGT2-4K8F].

[50] *See* Illinois Department of Public Health, *Gasoline*, Cancer in Illinois, http://www.idph.state.il.us/cancer/factsheets/gasoline.htm [https://perma.cc/9XDK-NSX9] (last viewed Nov. 8, 2020) (analyzing the different health risks associated with gasoline exposure).

[51] *See* David Piantanida, *Green Things Come in Large Packages*, THE EPA BLOG (Aug. 5, 2008), https://blog.epa.gov/2008/08/05/green-things-come-in-large-packages/ [https://perma.cc/6AK9-N7NK].

emissions are often more harmful than exhaust emissions because they are directly emitted into the atmosphere.[52] Gas-powered LGE raise a unique evaporative emissions concerns because they are commonly stored in enclosed spaces.[53] Authorities have warned vapors escaping from gas-powered LGE inside of attached garages can potentially intrude into homes and pose health risks to anyone inside.[54] Accordingly, reducing gasoline use in LGE by transitioning to electric products could produce significant public health benefits.[55]

As air emissions regulations affecting other industries and products have become more stringent over the years, the lax rules governing gas-powered LGE have increasingly stood out like a sore thumb. For instance, gas-powered LGE will soon be the largest source of ozone pollution in California.[56] And fossil-fuel power plants have long been required to comply with emissions standards stricter than those applicable to gas-powered LGE.[57] Some have argued even if the nation's power were supplied solely from fossil fuel sources, electrifying all LGE would still be beneficial because it avoids emitting pollution in citizens' backyards where equipment users and bystanders often breathe in the harmful exhaust.[58] Regardless, as electric utilities in the U.S. steadily increase their reliance on renewable energy sources,[59] the benefits of transitioning to all-electric LGE continue to grow.

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[52] *See* John H. Johnson, *Automotive Emissions*, MICH. TECHN. UNIV'Y. (1988), https://www.ncbi.nlm.nih.gov/books/NBK218144/ [https://perma.cc/JJ5L-VA57].

[53] *See* Stuart Silverstein, *California Throttles Down Pollution from Small Engines*, KCET (Nov. 14, 2017), https://www.kcet.org/shows/socal-connected/california-throttles-down-pollution-from-small-engines [https://perma.cc/9C7C-QF6N].

[54] *See id.*

[55] *See generally* Roberta Barkman James, *Oil and the Environment: Reducing Oil Dependency in the Automotive Sector*, 15 U. BAL. J. ENVTL. L. 1 (2007) (arguing that reducing oil dependency is appropriate due to the environmental harm oil causes, the global conflicts surrounding access to oil, and oil's non-renewable character).

[56] *See* California Air Resources Board, *Small Engines in California* (Aug. 9, 2017), https://ww2.arb.ca.gov/resources/fact-sheets/small-engines-california [https://perma.cc/5V6J-7ZSX].

[57] *See* Center for Climate and Energy Solutions, *Regulating Power Sector Carbon Emissions*, C2ES (providing an overview of power plant emissions and correlative regulations) https://www.c2es.org/content/regulating-power-sector-carbon-emissions/ [https://perma.cc/CK89-E2GZ].

[58] *See generally* Alexandra B. Klass & Andrew Heiring, *Life Cycle Analysis and Transportation Energy*, 82 BROOK. L. REV. 485, 511–21 (2017) (comparing the net environmental effects of electric vehicles between direct (or tailpipe) emissions and life cycle emissions).

[59] *See* Nat'l Renewable Energy Lab'y, *Renewable Electricity Futures Study*,

ii. Occupational hazard and noise impacts

In addition to improving urban air quality, a transition to all-electric LGE would benefit the hundreds of thousands of landscaping industry employees throughout the country who have long borne a disproportionate share of the hidden health costs associated with maintaining America's lawns. Operating gas-powered LGE presents unique occupational hazards and health risks to the nearly one million people who regularly operate gas-powered LGE.[60] Among other things, landscaping workers who spend countless hours operating gas-powered LGE are exposed to elevated levels of particulates known to pose breathing hazards.[61] Asthmatics and those with other respiratory conditions are particularly likely to experience aggravating problems from the relatively high concentrations of particulates emitted by many types of gas-powered LGE.[62]

In addition to emissions-related health hazards, LGE can also produce high levels of noise potentially contributing to hearing loss with prolonged use.[63] Many gas-powered LGE products produce maximum decibel levels in excess of eighty-five decibels ("dBA").[64] Such noise not only makes communicating on

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DEP'T OF ENERGY (2012), https://www.nrel.gov/analysis/re-futures.html [https://perma.cc/5T82-F4EG].

[60] *See* Jackie DiFrancesco, Asha Brogan & Bryan Beamer, *Grounds for Change: Reducing Noise Exposure in Grounds Management Professionals – Part 1*, NIOSH SCI. BLOG (July 25, 2018), https://blogs.cdc.gov/niosh-science-blog/2018/07/25/landscape-noise1/ [https://perma.cc/YJP9-PPG5] (noting an estimated 912,360 people in the US are employed as landscapers or groundskeepers, with another 100,320 employed as first-line supervisors of landscaping, lawn service and grounds keeping workers); *see also* Ellen Kerns, Elizabeth A. Masterson, Geoffrey M. Calvert, *Cardiovascular conditions, hearing difficulty, and occupational noise exposure within US industries and occupations*, AMERICAN JOURNAL OF INDUSTRIAL MEDICINE (June 2018), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6897488/ [https://perma.cc/D78U-RC5J].

[61] A recent Fair Warning test concluded that the concentration of particulate matter near gas-powered LGE equipment was more than 50 times higher than at a nearby traffic-clogged intersection. *See* Hovaness C. Dekeyan, *Industrial Hygiene Survey*, HEALTH SCI. ASSOCIATES 9–14 (Aug. 9, 2017), https://www.fairwarning.org/wp-content/uploads/2017/09/HSA-Report.pdf [https://perma.cc/SM6X-MPYS].

[62] *See* N.H. Dep't of Env't Services, *Take Steps to Limit Air Emissions: Use Electric Lawn & Garden Equipment* (2018), https://www.des.nh.gov/organization/commissioner/pip/factsheets/ard/documents/ard-22.pdf [https://perma.cc/PY7E-KMZR].

[63] *See* Consumer Prod. Safety Comm'n, 39 Fed. Reg. 26,662, 26,662 (July 22, 1974) (finding that noise hazards from power lawn equipment create the potential for hearing loss and non-auditory trauma from exposure to excessive noise).

[64] A study of occupational noise exposure among groundskeepers in North

the job more difficult for many landscapers, it can also potentially damage hearing function if sustained over extended periods.[65]

Hearing loss is considered one of the most common occupational injuries in the U.S., and excessive exposure to noisy gas-powered engines significantly contributes to this problem.[66] Chronic noise exposure and accompanying hearing loss may also contribute to mental health issues such as anxiety and depression.[67] Using electric motor technologies to reduce the noise levels associated with LGE equipment thus creates additional public health benefits by reducing the incidence of hearing damage for LGE users and bystanders.[68]

iii. Economic impacts

In addition to generating the environmental and public health benefits just described, a transition to electric LGE could produce significant economic benefits across the nation. A growing number of electric LGE are commercially available, and the electric LGE industry is currently producing rapid improvements in technology, efficiency, and price.[69] These improvements, together with advancements in electric battery technologies[70] and declining battery costs, are already helping

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Carolina found noise levels from lawn mowers to be between 85 and 96 decibels, with other lawn equipment as high as 109 dBA. *See* Jo Anne G. Balanay, Gregory D. Kearney & Adam J. Mannarino, *Assessment of Occupational Noise Exposure among Groundskeepers in North Carolina Public Universities*, ENV'T HEALTH INSIGHTS 2 (Jan. 2016), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4909058/ [https://perma.cc/9W55-KFMD].

[65] *See* Nat'l Inst. on Deafness and Other Commc'n Disorders, *Noise-Induced Hearing Loss*, U.S. DEP'T OF HEALTH & HUM. SERVICES (last updated May 31, 2019), https://www.nidcd.nih.gov/health/noise-induced-hearing-loss [https://perma.cc/5CXV-CX5J].

[66] *Id.*

[67] *See* Stig Arlinger, *Negative consequences of uncorrected hearing loss—a review*, INT. J. OF AUDIOL. (2003), https://www.ncbi.nlm.nih.gov/pubmed/12918624 [https://perma.cc/D427-TYST].

[68] *See* Jackie DiFrancesco, Asha Brogan, Bryan Beamer, *Grounds for Change: Reducing Noise Exposure in Grounds Management Professionals*, NIOSH (Jul. 25, 2018), https://blogs.cdc.gov/niosh-science-blog/2018/07/25/landscape-noise1/ [https://perma.cc/5QNR-XYTM].

[69] *See, e.g.,* Electric Tractor Inc., *The Electric Tractor*, http://www.electrictractor.com/ [https://perma.cc/33E5-WU4S].

[70] *See* Energy Efficiency & Renewable Energy, *Clean Cities Guide to Alternative Fuel Commercial Lawn Equipment*, DEP'T OF ENERGY at 6 (2011) (describing how new battery powered LGE can last up to 80 minutes, creating the potential for electric LGE on a commercial scale).

facilitate this transition, but much more could be done to accelerate it.[71]

Although purchasing electric LGE often involves higher up-front costs than merely purchasing gas-powered models, the long-term benefits of electric LGE make them an increasingly attractive option. This is because the fuel, operation, and maintenance costs of electric LGE are usually lower than their gas-powered alternatives and these savings can offset differences in purchase price over the electric product's useful life.[72] For instance, factoring in the cost of fuel, maintenance, and blade replacement, an average gas-powered mower costs an estimated $725 over the course of ten years.[73] In contrast, a corded electric mower, including electricity and blade replacement, would cost only about $359 over the same period.[74] And a cordless electric mower, including electricity, battery replacement, and blade replacement, would cost approximately $506.[75]

Many electric LGE are also arguably more convenient to use and refuel because users can simply charge them at home rather than having to drive to service stations to refill their gas can. Electric LGE likewise typically have fewer moving parts and do not rely on ignition start systems, making them generally easier and safer to operate and store.[76] And electric LGE tend to require significantly fewer maintenance costs over their useful life than gas-powered LGE.[77]

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[71] *See* Camila Domonoske, *As More Electric Cars Arrive, What's The Future For Gas-Powered Engines?*, NPR (Feb. 16, 2019), https://www.npr.org/2019/02/16/694303169/as-more-electric-cars-arrive-whats-the-future-for-gas-powered-engines [https://perma.cc/V6JS-9KNW].

[72] *See* Andrew Twite, *Electrifying cars and buses*, FRESH ENERGY (2017), https://fresh-energy.org/electrifying-cars-and-buses/ [https://perma.cc/YWB5-JRP7].

[73] *See* Dr. Penny Pincher, *We Do the Math: Will an Electric Mower Trim Lawn Care Costs?*, WISEBREAD (Aug. 2, 2017), https://www.wisebread.com/we-do-the-math-will-an-electric-mower-trim-lawn-care-cost [https://perma.cc/5SBR-4H2M].

[74] *Id.*

[75] *Id.*

[76] *See* Sarah Eberle, *Best Electric Start Self Propelled Lawn Mower for the Money*, SARAH EBERLE LANDSCAPE DESIGN (Sep. 8, 2020), https://www.saraheberle.com/electric-start-self-propelled-lawn-mower/, [https://perma.cc/QF67-ZXTU]; *see generally* Daniel Wroclawski, *Lawn Mower Face-Off: Ego Battery-Powered Electric Mower vs. Honda Gas Mower*, CONSUMER REP. (May 18, 2019), https://www.consumerreports.org/lawn-mowers-and-tractors/ego-electric-mower-vs-honda-gas-mower-face-off/ [https://perma.cc/2EW3-M88X] (comparing advantages and disadvantages of gas and electric LGE).

[77] *See, e.g.,* Pincher, *supra* note 73 (comparing the maintenance costs of electric and gas lawnmowers).

B. The History of EPA Emission Regulations of Small Non-road Spark-Ignition Engines

The small non-road spark-ignitions found in many types of LGE today have largely fallen through the cracks of EPA policymaking despite being major sources of airborne pollution.[78] Prior to 1995, all emissions from small non-road engines were unregulated, allowing inefficient gas-powered engines to pollute with few constraints. [79] In 1995, the EPA first adopted regulations, spearheaded by California under its CAA waiver authority, for small non-road spark-ignition engines.[80] The EPA's primary focus in these early regulations was to combat the contributions of these engines to ground-level ozone and reduce other major adverse impacts on the natural environment and human health.[81]

The EPA's existing emissions standards applicable to small spark-ignition engines like those found in many LGE models restrict emissions of nitrogen oxides, hydrocarbons, particulate matter, and carbon monoxide.[82] By reducing toxic

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[78] *See* U.S. EPA, *Frequently Asked Questions from Owners and Operators of Nonroad Engines, Vehicles, and Equipment Certified to EPA Standards*, OFFICE OF TRANSP. & AIR QUALITY (Aug. 2012), https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100U8YP.pdf, [https://perma.cc/8SVB-R69H].

[79] *See* Emission Standards for New Nonroad Spark-ignition Engines at or Below 19 Kilowatts, 60 Fed. Reg. 127 (July 3, 1995) (to be codified 40 C.F.R. pt. 90).

[80] *See id.* at 2; *see also* CAL. AIR RESOURCES BOARD, *California & the Waiver: The Facts* (Sept. 17, 2019), https://ww2.arb.ca.gov/resources/fact-sheets/california-waiver-facts, [https://perma.cc/J3RE-3LM9] (providing the elements for California to utilize its waiver authority); *see generally* CAL. AIR RESOURCE BOARD, *Small Engines in California* (Aug. 9, 2017), https://ww2.arb.ca.gov/resources/fact-sheets/small-engines-california [https://perma.cc/8ZYC-PC5J] (stating that CARB adopted emissions standards for small engines in 1990 and was the first agency in the world to control emissions from these engines).

[81] *See* Emission Standards for New Nonroad Spark-ignition Engines at or Below 19 Kilowatts, 60 Fed. Reg. 127, 2; *see generally* Agency for Toxic Substances and Disease Registry, *ToxFAQs for Nitrogen Oxides*, CENTER FOR DISEASE CONTROL: DIVISION OF TOXICOLOGY & HUMAN HEALTH SERVICES (Mar. 25, 2014), https://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=396&tid=69, [https://perma.cc/6LMJ-XKD7] (explaining that exposure to these unhealthy pollutants poses serious health risks to humans and their emission into the atmosphere contributes to the formation of smog and acid rain).

[82] *See EPA Finalizes Emission Standards for New Nonroad Spark-Ignition Engines, Equipment, and Vessels*, U.S. EPA OFFICE OF TRANSP. & AIR QUALITY (Sep. 2008), https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P10017GK.pdf [https://perma.cc/8RR9-XVPH] [hereinafter U.S. EPA].

emissions from gas-powered LGE, these basic restrictions do help to mitigate some of the dangers these equipment pose to both human health and the environment.[83] These federal regulations usually apply to manufactures and distributors of small spark-ignition engines and address both evaporative and exhaust emissions.[84]

Although LGE manufacturers must comply with federal standards set by the EPA, they are not required to use any specific emission control methods to meet those standards.[85] Instead, manufacturers must only ensure each new fleet of engines meet the latest emission standards, meaning once a manufacturer has placed the certified engine into the market, no further action is required.[86] Products built before EPA emission standards became applicable are generally not impacted by these regulatory requirements, commonly known as being "grandfathered in," and owners are not required to retire old equipment no longer meeting modern day emission standards.[87]

EPA regulation of small non-road spark-ignition engines to date has progressed in three phases.[88] First, the EPA issued the "Phase 1" rules, which established standards for new non-road spark-ignition engines at or below 19 kilowatts.[89] Secondly, "Phase 2" emission standards aimed to reduce hydrocarbons and nitrogen oxide emissions by 59 percent beyond the "Phase 1" standards.[90] These provisions were put in place to minimize the compliance burden on manufacturers while maintaining the environmental benefits of the rule.[91] Tighter emission standards allowed for an efficient transition of engine designs and

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[83] *See id.*

[84] *See New Phase 3 Engine Standards Affecting Retailers and Importers of Lawn and Garden Equipment*, U.S. EPA OFFICE OF TRANSP. & AIR QUALITY (Aug. 2009), https://nepis.epa.gov/Exe/ZyPDF.cgi/P1006P00.PDF?Dockey=P1006P00.PDF, [https://perma.cc/W39D-E4TQ].

[85] *See* U.S. EPA, *supra* note 82, at 2.

[86] *Id.* at 1.

[87] *Id.*

[88] *Id.*

[89] *See* Emission Standards for New Nonroad Spark-ignition Engines at or Below 19 Kilowatts, 60 Fed. Reg. 127, 1.

[90] *See New Phase 2 Standards for Small Spark-Ignition Nonhandheld Engines,* U.S. ENVTL. PROTECTION AGENCY (Mar. 1999), https://nepis.epa.gov/Exe/ZyPDF.cgi/P1001Z8R.PDF?Dockey=P1001Z8R.PDF. [https://perma.cc/NKM9-YD7D].

[91] *Id.* at 5.

technologies from "Phase 1" standards to those necessary to meet the "Phase 2" requirements.[92]

Currently, LGE are regulated under the EPA's "Phase 3" requirements for exhaust emissions for small non-road spark-ignition engines. Taking effect in 2011 or 2012, depending on the size of the engine,[93] "Phase 3" compelled manufacturers of gas-powered LGE to further cut smog-forming emissions, continuing the process of establishing non-road engine standards authorized under the CAA.[94] "Phase 3" also requires proper labeling for engines and emission control systems.[95]

The EPA's existing regulations have helped small non-road spark-ignition engines to become cleaner, more efficient, and less harmful to both humans and the environment, but regrettably they have not been updated in over a decade.[96] In the interim, emissions control technologies and electric motor and energy storage technologies have substantially improved. In light of these changes, stricter EPA emissions regulations on LGE are long overdue.

C. Existing State and Local LGE Electrification Policies

Although the federal government is the primary agency responsible for enacting emissions standards for LGE, state implementation plans ("SIPs") allow states to help enforce EPA regulations in some ways affecting the LGE industry.[97] Under

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[92] *Id.* at 3; *see also Regulations for Emissions from Small Equipment & Tools,* U.S. ENVTL. PROTECTION AGENCY, https://www.epa.gov/regulations-emissions-vehicles-and-engines/regulations-emissions-small-equipment-tools [https://perma.cc/3HPW-SURT] (last viewed Oct. 2, 2020)

[93] *See Control of Emissions from Nonroad Spark-Ignition Engines and Equipment,* U.S. ENVTL. PROTECTION AGENCY (Oct. 8, 2008), https://www.govinfo.gov/content/pkg/FR-2008-10-08/pdf/E8-21093.pdf [https://perma.cc/WYC3-M9EX].

[94] *See* Jasmin Melvin, *EPA tightens lawn mower, motor-boat emission rules*, REUTERS (Sept. 5, 2008), https://www.reuters.com/article/us-epa-emissions-rules/epa-tightens-lawn-mower-motor-boat-emission-rules-idUSN0547157820080905 [https://perma.cc/9JWV-VHZJ].

[95] *New Phase 3 Engine Standards Affecting Retailers and Importers of Lawn and Garden Equipment,* U.S. ENVTL. PROTECTION AGENCY (Aug. 2009), https://nepisa.epa.gov/Exce/ZyPdf.egi/P1006P00.PDR?Dockery=P1006P00.PDF [https://perma.cc/C8NK-HL4B].

[96] Control of Emissions From Nonroad Spark-Ignition Engines and Equipment, 73 Fed. Reg. 59034-01 (Oct. 8, 2008), www.federalregister.gov/documents/2008/10/08/E8-21093/control-of-emissions-from-nonroad-spark-ignition-engines-and-equipment [https://perma.cc/SG26-M9KA].

[97] *State Implementations Plans,* U.S. ENVTL. PROTECTION PLAN (Feb. 23, 2016),

this "cooperative federalism" approach, state laws function as the core of environmental programs, but only after receiving EPA approval.[98] The CAA generally prohibits states from implementing air quality laws more stringent than the national standard.[99] However, as an exception, California can receive a waiver from CAA preemption upon satisfaction of three specific requirements: (1) California's standards are at least as protective as federal standards, and that the state's determination of that fact was not arbitrary and capricious; (2) California's standards are needed to meet compelling and extraordinary conditions; and (3) California's standards are not inconsistent with certain CAA provisions relate to technical feasibility and lead time to manufacturers.[100] Other states can likewise receive a waiver from federal preemption by adopting California's standards,[101] but as of 2017, California had not enacted any recent emissions standards for LGE.[102] Accordingly, until California attempts to implement new LGE emissions standards states desiring to impose rules more stringent emission standards on LGE than the federal rules have few options.[103]

Despite having limited authority, a number of states across the country have enacted innovative policies to help

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https://www3.epa.gov/region02/air/sip/ [https://perma.cc/SGG7-V3HF].

[98] Kristen Engel, *State and Local Climate Change Initiatives: What is Motivating State and Local Governments to Address a Global Problem and What Does This Say About Federalism and Environmental Law?*, 38 URB. LAW. 1015, 1020 (2006) https://papers.ssm.com/so13/paper.s.cfm?abstract_id=933712 [https://perma.cc/82Z9-Y2C5].

[99] *See* Ann E. Carlson, Meredith J. Hankins, Julia E. Stein, *Shifting Gears: The Federal Government's Reversal on California's Clean Air Act Waiver*, AM. CONST. SOC'Y. (Feb. 2019), https://www.acslaw.org/wp-content/uploads/2019/02/CA-Car-Standards-IB-2019.pdf [https://perma.cc/C6R8-EXWA].

[100] *California & the waiver: The Facts,* CAL. AIR RESOURCES BOARD (Sept.17, 2019) https://ww2.arb.ca.gov/resources/fact-sheets/california-waiver-facts [https://perma.cc/797X-2GK5].

[101] *See* OR. REV. STAT. ANN. § 468A.363 (West 2017).

[102] *See Small Engines in California, CAL. AIR RESOURCES* BOARD (Aug. 9, 2017), https://ww2.arb.ca.gov/resources/fact-sheets/small-engines-california [https://perma.cc/DKJ8-3NZ2].

[103] *See* William B. Johnson, Annotation, *Preemption of State and Local Regulation of Nonroad Engines or Vehicles by Section 209(e) of the Clean Air Act (42 USCA Section 7543(e))*, 54 AM. L.REP. FED. 2d 447 (2011); *see also* Erick Norem III, *An Electric Future for Today: An Analysis of Policy Options for State and Provincial Electric Vehicle Impact Standards to Expand Electric Vehicle Use*, 8 LA. ST. U. J. ENERGY L. & RESOURCES 127, 142 (2019), https://digitalcommons.law.lsu.edu/cgi/viewcontent.cgi?article=1175&context=jelr [https://perma.cc/X94B-LYG3] (showing how California can be a influential "first-player" in creating innovative environmental policies under their CAA waiver authority).

accelerate the transition from gas-powered to electric LGE.[104] Many of these programs are highly popular, with demand for incentives outpacing program limits.[105] In some cases states have also delegated some authority to implement these policies to local authorities responsible for managing air quality issues ("air quality districts").[106]

i. Arizona

Voluntary emissions reduction policy strategies like those in Arizona are one potential means for states to promote reduced emissions from gas-powered LGE. Arizona's "Voluntary lawn and garden equipment emissions reduction program" helps reduce citizens' retail costs of transitioning to electric LGE. [107] A statutory law in Arizona specifically empowers counties with at least 500,000 residents to adopt emissions reductions programs so long as such programs "provide for real and quantifiable emissions reductions."[108] Participating counties must also submit annual progress reports of the cost-effectiveness of such programs.[109]

In 2018, Maricopa County, Arizona, launched its "Mowing Down Pollution" program, which seeks to improve air quality by incentivizing residents to switch to electric LGE.[110] To participate

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[104] *See Modernizing the Electric Power System to Support the Development and Deployment of Increasingly Clean Technologies,* NAT'L ACADEMIC SCI. ENGINEERING MED. (2016), https://www.nap.edu/read/21712/chapter/10 [https://perma.cc/S6EU-H53N].

[105] *See* Paul Hope, *Get a Discounted Mower at a Lawn Mower Exchange*, CONSUMER REP. (Mar. 24, 2017), https://www.consumerreports.org/lawn-mowers-and-tractors/get-a-discounted-mower-at-a-lawn-mower-exchange/ [https://perma.cc/DSQ2-QAW5] (exchanging lawn mower program in San Diego, people began lining up at 4:30 a.m. in order to guarantee access to the purchase of a discounted electric mower.).

[106] *See Government Partnerships to Reduce Air Pollution,* ENVTL. PROTECTION AGENCY (Jan. 19, 2017), https://www.epa.gov/clean-air-act-overview/government-partnerships-reduce-air-pollution [https://perma.cc/RV3S-VD7R].

[107] Ark. CODE ANN. § 49-474.02 (West 2009) [https://perma.cc/X3S3-JRDT]; *see also* MARICOPA COUNTY RECEIVES 31 NATIONAL ACHIEVEMENT AWARDS (June 6, 2019), https://www.maricopa.gov/CivicAlerts.aspx?AID=699 [https://perma.cc/8LYF-TFUS] (receiving a national achievement award for Maricopa County's 'Mowing Down Pollution' program for increasing residents' well-being and improving the use of technology to transform how the county does business).

[108] *See* ARK. CODE ANN. § 49-474.02(A) (West 2009).

[109]ARIZ. REV. STAT. § 49-474.02(G) (LexisNexis 2020).

[110] *See* Maricopa Cnty. Air Quality Dep't, *Mowing Down Pollution Program*, CLEAN AIR MAKE MORE, https://cleanairmakemore.com/lawn/ [https://perma.cc/B5KM-7QCY] (last viewed Oct. 3, 2020) [hereinafter Maricopa Cnty. Air Quality Dep't]; *see also* Cecilia Chan, *Residents warming to lawn mower exchange program*, AHWATUKEE FOOTHILLS NEWS, https://www.ahwatukee.com/news/article_ded8aa04-8f98-11e8-a0ff-

in the program, residents must submit a voucher application, donate their working, gas-powered LGE to the county government, and submit a verification form.[111] Once the process is completed, the applicant receives a $150 voucher for an electric lawn mower or a fifty dollar voucher for other LGE.[112] The new LGE purchased must be for residential use, be zero-emission electric, cordless or corded, and if cordless, must include battery and charger.[113] In its inception year, 894 old lawn mowers were turned in and 864 new lawn mowers were purchased through the program.[114]

ii. South Coast Air Quality Management District Programs

The South Coast Air Quality Management District ("SCAQMD"), a California state agency responsible for controlling air pollution in the greater Los Angeles area, has also introduced programs aimed at promoting the transition to electric LGE.[115] SCAQMD's residential "Electric Lawn Mower Rebate Program" offsets the cost of purchasing an electric lawn mower by allowing residents to turn in their old gasoline-powered machines in exchange for a rebate on the price of a new electric lawn mower.[116] Although other air quality districts in the state offer rebates on other types of electric LGE, including leaf blowers, chain saws, hedge trimmers, and even additional batteries, the SCAQMD's rebate program is limited to battery-powered lawn

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9f26496e47ff.html [https://perma.cc/8K8L-AJCQ] (last viewed Oct. 3, 2020) (providing an approximation of the start date of the program).

[111] Maricopa Cnty. Air Quality Dep't, *supra* note 110.

[112] *Id.*

[113] *Id.*

[114] Memorandum from Jon Sherrill on Meeting Notification and Transmittal of Tentative Agenda to Members of Maricopa Association of Governments Air Quality Technical Advisory Committee 7 (May 16, 2019), https://azmag.gov/Portals/0/Documents/MagContent/AQTAC_2019-05-23_Agenda.pdf [https://perma.cc/M9TK-XQ2T] (on file with Maricopa Association of Governments).

[115] *See generally Frequently Asked General Questions,* S. COAST AIR QUALITY MGMT. DIST., http://www.aqmd.gov/nav/about/frequently-asked-questions [https://perma.cc/2MKS-65VG] (last viewed Oct. 5, 2020) (answering questions about the agency and their processes); *Climate Change*, S. COAST AIR QUALITY MGMT. DIST., http://www.aqmd.gov/nav/about/initiatives/climate-change [https://perma.cc/6SPY-ACEB] (last viewed Oct. 5, 2020) (outlining previous actions taken against climate change).

[116] *See Electric Lawn and Garden Equipment*, S. COAST AIR QUALITY MGMT. DIST., http://www.aqmd.gov/home/programs/community/community-detail?title=lawn-equipment [https://perma.cc/UT7X-J397] (last viewed Oct. 3, 2020).

mowers.[117] The participant must also intend to own and operate the new electric lawn mower within the district for a minimum of three years from the date of purchase.[118]

C. Limitations of Existing Policies

Although policies like those just described are a good start, they do not go nearly far enough in driving a nationwide transition to electric LGE. For example, although these local incentive programs help to increase demand for electric LGE, they do not require manufacturers to comply with any new targets or standards.[119] Without any such mandates, there are minimal incentives for manufacturers to invest aggressively in new electric LGE technologies.[120] Of course, it is not possible for states or localities to impose manufacturing standards because federal law would rightly preempt any such rules to prevent unnecessary patchworks of state standards.[121]

Current policies also do not adequately deter new gas LGE purchases. Despite EPA findings revealing gas-powered LGE are a major source of toxic and carcinogenic emissions, annual sales of gas-powered LGE continue to soar.[122] Moreover, those with new gas LGE products are deterred from transitioning to electric because they will face sunk costs from their gas equipment

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[117] Cal. Air Res. Board, *Zero-Emission Landscaping Equipment Incentive Programs*, STATE OF CAL., https://ww2.arb.ca.gov/our-work/programs/zero-emission-landscaping-equipment/zero-emission-landscaping-equipment-incentive [https://perma.cc/Z4W5-DFXP] (last viewed Oct. 3, 2020).

[118] *Electric Lawn Mower Rebate Program*, S. COAST AIR QUALITY MGMT. DIST., http://www.aqmd.gov/home/programs/community/electric-lawn-mower-rebate-program [https://perma.cc/3F64-FASG] (last viewed Oct. 3, 2020).

[119] *See Economic Incentives*, U.S. ENV'T PROT. AGENCY, https://www.epa.gov/environmental-economics/economic-incentives (last viewed Oct. 6, 2020) [https://perma.cc/48L8-62DK].

[120] *Cf.* ENV'T LINK, COMPARATIVE ASSESSMENT OF THE ENVIRONMENTAL PERFORMANCE OF SMALL ENGINES–MARINE OUTBOARDS AND PERSONAL WATERCRAFT 58 Austrl. Dep't. of the Env't & Water Res. ed., 2007), https://ecoboats.com.au/wp-content/uploads/2018/09/Comparative-Assessment-Small-Marine-Engines.pdf [https://perma.cc/HG2B-CY4K] (last viewed Jan. 20, 2021).

[121] *Contra* Note, *Antitrust Federalism, Preemption, and Judge-Made Law*, 133 HARV. L. REV. 2557, 2578 (2020).

[122] Rubenstein & Telford, *supra* note 11, at 11; *Small gas Engines Market: Rising Trends with top Countries data, Technology and Business Outlook 2020 to 2026*, MARKETWATCH, https://www.marketwatch.com/press-release/small-gas-engines-market-rising-trends-with-top-countries-data-technology-and-business-outlook-2020-to-2026-2020-09-30 (last viewed Oct. 6, 2020) [https://perma.cc/CQ9U-FLLQ].

purchase.[123] In the face of these challenge, the EPA has suggested increased cooperation between communities, government agencies and medical and scientific organizations to increase public awareness of gas-powered LGE.[124]

There are some signs stronger cooperation among multiple levels of government could help to accelerate the transition to electric LGE.[125] For example, American Green Zone Alliance ("AGZA"), a California organization aiming to "kick gas off grass," has helped local governments, commercial landscaping businesses, and residents in California transition from gas to electric operations for lawn care.[126] In summary, stronger and more coordinated policies at all levels of government are needed to effectively phase out gas-powered LGE use.

II. ACCELERATING THE TRANSITION TO ELECTRIC LAWN & GARDEN TOOLS

Given the many shortcomings of the nation's existing policies surrounding LGE, there are ample opportunities to significantly improve them at all levels of government. This Section describes several actions federal, state, and local policymakers could take to facilitate a faster and more efficient transition to electric LGE. These recommendations are based in part on "environmental federalism" principles, which inform questions about the optimal balance between federal and local governance with respect to environmental policy.[127]

"Classical" environmental federalism principles suggest the size of the geographic area affected by a specific pollution source should primarily determine the appropriate governmental level for responding to the pollution, based on the notion such level of governance is necessary to ensure internalization of the

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[123] *Cf.* LISA WOOD ET AL., RECOVERY OF UTILITY FIXED COSTS: UTILITY, CONSUMER, ENVIRONMENTAL AND ECONOMIST PERSPECTIVES 11 (Future Elec. Util. Regul. ed., 2016).

[124] *See* Rubenstein & Telford, *supra* note 11, at 13.

[125] *Cf.* Daniel C. Esty & Damien Geradin, *Regulatory Co-Opetition*, 3 J. INT'L ECON. L. 235, 235 (2000).

[126] *See AGZA Services*, AM. GREEN ZONE ALL. https://www.agza.net/services [https://perma.cc/3JFS-RXHW] (last viewed Oct. 3, 2020) (empowering their clients to confidently transition to electric lawn and garden tools through informed decision-making).

[127] *See* David E. Adelman & Kirsten H. Engel, *Adaptive Federalism: The Case Against Reallocating Environmental Regulatory Authority*, 92 MINN. L. REV. 1796, 1803 (2008).

costs of pollution within a given area.[128] Consistent with this idea, much of the nation's environmental regulation has historically resided at the federal level, with some limited overlap between individual states and the federal government.[129]

More recently, many states and local governments have taken on more active roles in governing national or even international scale environmental challenges, such as climate change.[130] This trend is consistent with an increasingly "adaptive" federalism approach considering each state's distinct socioeconomic, political, and environmental characteristics to help orchestrate more optimal use of multiple levels of government to address environmental issues.[131] It also reflects what some scholars have called "dynamic federalism," which can help states to innovate in environmental policy within certain constraints by providing a clearer framework for the interplay between federal and state actors.[132]

Based on the federalism concepts discussed above, the federal government is likely best suited to help address national and global externality problems associated with gas-powered LGE through federal-level policies, such as income tax credits. The federal government is also better situated to establish and enforce nationwide LGE manufacturing standards capable of preventing an unworkable patchwork of state standards.[133]

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[128] *See id.* at 1802; Henry R. Butler & Jonathan R. Macey, *Externalities and The Matching Principle: The Case for Reallocating Environmental Regulatory Authority*, 14 YALE L. & POL'Y REV. 23, 36 (1996).

[129] *See* Benjamin K. Sovacool, *The Best of Both Worlds: Environmental Federalism and the Need for Federal Action on Renewable Energy and Climate Change*, 27 STAN. ENVTL. L.J. 397, 409 (2008) (characterizing environmental policy beginning post-World War II era as a time of "creeping federalization").

[130] *See* Adelman & Engel, *supra* note 127, at 1799 (adopting the "adaptive" environmentalism approach because environmental problems are multifaceted and originate from more than one level of government); *see also* Kirsten H. Engel, *Democratic Environmental Experimentalism*, 35 UCLA J. ENV'T L. & POL'Y 57, 57–63 (2017) (recognizing regulatory gaps as a result of the downfalls static, traditional environmentalism federalism and its potential to stifle innovation at state and local levels).

[131] *See generally id.*

[132] *See* Kirsten H. Engel, *Harnessing the Benefits of Dynamic Federalism in Environmental Law*, 56 EMORY L.J. 159, 162 (2006).

[133] *See, e.g.*, E. Donald Elliott et al., *Toward a Theory of Statutory Evolution: The Federalization of Environmental Law*, 1 J.L. ECON. & ORG. 313, 330-31 (1985) (explaining federal air quality legislation is the result in part of industry efforts to replace inconsistent state laws with a uniform federal law); Andrew P. Morris & Susan E. Dudley, *Defining What to Regulate: Silica and the Problem of Regulatory Categorization*, 58 ADMIN. L. REV. 269, 324 (2006) (referring to same phenomenon with respect to worker safety rules); Baher Azmy, *Squaring the Predatory Lending Circle: A Case for States as*

States and local governments are well-positioned to play other vital roles in LGE-related policy, helping to tailor approaches to account for wide variations in economic, political, and geographic characteristics across jurisdictions. State and local governments can also be effective at advancing policy goals when the federal government encounters political gridlock.[134] For instance, in states and municipalities where local air quality issues are of particular concern, state or local rebate and voucher programs for electric LGE could be an appropriate and effective means of supplementing federal incentive policies. Many states and local governments may likewise be well-positioned to work with utility companies to better educate citizens and to combat path dependence problems otherwise slowing the transition to electric LGE. The materials that follow describe those potential policy strategies for promoting electric LGE suitable at each primary government level.

A. Potential Federal LGE Electrification Strategies

Stronger federal-level policies could do much to accelerate the electrification of LGE in the U.S. The following subsections describe two possible federal-level policy strategies capable of catalyzing widespread adoption of electric LGE: increasingly stricter nationwide LGE emissions standards and new federal tax credits for electric LGE purchasers.

i. New EPA "Phase 4" Emissions Standards for LGE

The most direct way the federal government could facilitate a faster transition to electric LGE would be to impose increasingly stringent federal manufacturing standards. Specifically, the EPA could impose new "Phase 4" emission manufacturing standards requiring manufacturers to gradually phase out their manufacture and sale of gas-powered LGE, and to steadily replace their existing gas-powered product lines with electric LGE products.

Laboratories of Experimentation, 57 FLA. L. REV. 295, 401 n.545 (2005) (same with respect to predatory lending laws).

[134] *See* NATIONAL CONFERENCE OF STATE LEGISLATURES, *State Legislative Policymaking in an Age of Political Polarization*, https://www.ncsl.org/Portals/1/HTML_LargeReports/Partisanship_1.htm [https://perma.cc/3NGM-NJCG] (last viewed Jan. 20, 2021).

Federal manufacturing standards are a sensible means of reducing nationwide emissions from LGE. For example, uniform federal standards prevent manufacturers from attempting to comply with a patchwork of different standards across state or local jurisdictions.[135] By structuring such emission standards to become increasingly stringent over time, the EPA could give manufacturers sufficient time and flexibility to transition their products lines. For many manufacturers, it will be less costly to respond to such new regulations by investing in and expanding electric fleets since electricity-based technologies are often already commercially available.[136] At the same time, imposing emissions standards that ratchet up over time gives manufacturers some flexibility by allowing them to continue producing some gas-powered products when they cannot immediately switch particular product lines to electric designs.[137]

The structure of such new nationwide LGE emissions standards could resemble standards used in the Energy Independence and Security Act of 2007 ("EISA"), which phased out incandescent lightbulbs in the U.S.[138] The EISA did not flatly ban the manufacture, sale, use, or purchase of incandescent bulbs.[139] Instead, the EISA required approximately twenty-five percent greater efficiency for household light bulbs over time.[140] In a similar way, the proposed "Phase 4" standards for LGE could be structured to ensure manufacturers are incentivized to invest in electric LGE technologies but could still sell some gas-powered products, so long as their aggregate product lines comply with new standards. These emission manufacturing standards will also promote local clean air goals within communities because they will compel the LGE industry to spend the necessary time and resources to develop innovative technology for electric LGE technology.[141]

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[135] *See* Joshua D. Sarnoff, *The Continuing Imperative (But Only from a National Perspective) For Federal Environmental Protection*, 7 DUKE ENV'T L. & POL'Y F. 225, 252–53 (1997).

[136] *See id.* at 252.

[137] *See* Ashley Morris Bale, *The Newest Frontier in Motor Vehicle Emission Control: The Clean Fuel Vehicle*, 15 VA. ENV'T L.J. 213, 219 (1996).

[138] *See* United States Environmental Protection Agency, *How the Energy Independence and Security Act of 2007 Affects Light Bulbs*, U.S. ENV'T PROT. AGENCY, https://www.epa.gov/cfl/how-energy-independence-and-security-act-2007-affects-light-bulbs [https://perma.cc/8FD3-XPES] (last viewed Jan. 20, 2021).

[139] *Id.*

[140] *Id.*

[141] *See* Sarnoff, *supra* note 135, at 298, 302 (setting motor vehicle emission

ii. Federal Tax Credit

While stricter manufacturing standards could help drive electrification on the supply side of the LGE market, federal tax credits could increase consumer demand for those new electric products. In 2009, the United States House of Representatives proposed the "Greener Gardens Act," which would have offered Americans a twenty-five percent tax credit on purchases of LGE powered by electricity or other qualifying alternative fuels.[142] Although the "Greener Gardens Act" never became law,[143] the potential benefits of such a tax credit program have arguably never been greater.

A federal tax credit for purchases of electric LGE is an appealing policy strategy in part because of the nation's growing reliance on clean and renewable energy sources.[144] Tax credits have historically been successful in fostering adoption and innovation for clean energy technologies.[145] Furthermore, tax credits for electric LGE purchases are likely to have comparable success because the technologies they would promote have similarly already been commercialized but have yet to be widely adopted and are thus poised to benefit greatly from further innovation and production economies of scale.[146]

Ideally, any such new federal tax credit for electric LGE would be structured to be transferrable between buyer and seller so retail consumers reap immediate price discounts.[147] A tax structure whereby purchasers can transfer their tax credit to their LGE dealers at the time of purchase effectively makes the tax credit a point-of-sale rebate for the purchaser.[148] Under this

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control policies at currently unattainable levels but allowing manufacturers to comply through a lead-in time period).

[142] *See* Greener Gardens Act 5 of 2009, H.R. 3530, 111th Cong. (2009).

[143] *Id.*

[144] *See* Troy A. Rule, RENEWABLE ENERGY LAW, POLICY, AND PRACTICE 64 (West 2018).

[145] *See* David Hart & Elizabeth Noll, *Less Certain Than Death: Using Tax Incentives to Drive Clean Energy Innovation*, INFORMATION TECHNOLOGY & INNOVATION FOUNDATION (2019), https://itif.org/publications/2019/12/02/less-certain-death-using-tax-incentives-drive-clean-energy-innovation [https://perma.cc/J6MD-N9R2].

[146] *Id.*

[147] *See* Electric Vehicle Deployment Act of 2010, S. 3442, 111th Cong. § 4 (2010) (proposing to enact a transferrable tax credit to national deployment communities for electric vehicles).

[148] *See* Electrification Coalition, *The Role of Tax Credits in the Electric Vehicle*

scheme, consumers do not have to wait to file annual tax returns to receive the direct financial benefits of participating in the tax credit program. Consumers tend to respond more strongly to instant cash discounts instead of delayed tax returns.[149]

Adopting stricter federal emissions standards and creating a new federal tax credit program would be a powerful means of accelerating the nationwide transition to electric LGE, yielding benefits likely outweighing the costs. Such policy approaches would likely be superior to alternatives, such as federal bans on gas-powered LGE, federally funded research grants, or tax incentives for private research.

Among other things, the EPA's longstanding approach to emissions standards for light-duty vehicles has been to impose them based on fleet-wide averages, so extending this approach to LGE would likely be similarly feasible and would not create enormous new administrative burdens.[150] A policy of gradually-increasing emissions standards would also minimize the adverse impacts of phasing out gas-powered LGE for industry stakeholders and disadvantaged communities, both of which will have to overcome heavy path-dependence after decades of under-regulation.[151] Moreover, the federal government's prior successes in funded renewable energy, energy storage, energy efficiency, and other sustainable energy innovations may help create spillover effects further supporting the more rapid development of an electric LGE industry.

Deployment Act (2018), https://www.electrificationcoalition.org/wp-content/uploads/2018/07/Need_for_Transferable_Credits.pdf. [https://perma.cc/DWL2-Y79G].

[149] *See* Kelly Gallagher, Erich Muehlegger, Giving Green to Get Green: Incentives and Consumer Adoption of Hybrid Electric Vehicle Technology, Harv. John F. Kennedy School of Gov't, (Feb. 1, 2008) (Faculty Working Paper) (copyright belongs to the author(s)).

[150] *See* U.S. EPA, *supra* note 82.

[151] *See* Christopher David Ruiz Cameron, *The Rakes of Wrath: Urban Agricultural Workers and the Struggle Against Los Angeles's Ban on Gas-Powered Leaf Blowers*, 33 U.C. DAVIS L. REV. 1087, 1089–90 (2000) (describing how Los Angeles's ban on leaf blowers oppressed Latino gardeners); *see also* Butler & Macey *supra* note 129, at 426 (supporting the idea that national emission manufacturing standards can assist in guaranteeing a minimum standard of environmental quality for *all* Americans) (italics added).

iii. State and Local Policy Options

In addition to federal government strategies, state and local governments could also play a key role in accelerating the nation's transition to electric LGE. Although federal laws have historically been a driving force behind environmental policy in the U.S., state and local government officials are better informed about the unique characteristics and needs of citizens within their jurisdictions. States and municipalities, based on their familiarity and locality, can likely disseminate information efficiently to citizens about electric LGE and the incentives available.[152] Thus, local government can be helpful in better tailoring LGE-related policies to local needs.[153]

iv. Rebate and Voucher Programs

In states such as Arizona, where gas-powered LGE can uniquely harm air quality, rebate or voucher programs, like those offered in parts of Arizona, can be powerful means for state or local governments to further motivate citizens to purchase electric LGE products.[154] Such layering of incentives at the federal and local levels is consistent with adaptive environmental federalism, which calls for greater local involvement when localized information and tailoring is important to achieving an efficient solution.[155]

A few municipalities around the country have previously implemented rebate or voucher programs for electric LGE, but often only for a limited time or with small amounts of available inventory.[156] If such programs were expanded and subsidized with state funds, they could potentially have transformative

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[152] *See generally id.*

[153] *See* Katrina F. Kuh, *Using Local Knowledge to Shrink the Individual Carbon Footprint*, 37 HOFSTRA. L. REV. 923 (2009) (noting that local governments are "uniquely positioned to influence citizen behaviors—their transportation options, energy consumption patterns and general consumer decisions").

[154] *See* Norem III, *supra* note 103.

[155] *See* Kuh, *supra* note 153, at 930–31 (describing the need for local involvement to capture as many costs and benefits of an environmental problem within a particular geographic area).

[156] *See* Utah Dept. of Envtl Quality, *CARROT Program,* Utah Division of Air Quality, (last updated Sept. 9, 2020, 9:33 AM) (describing a temporary state initiative in Utah to reduce emissions through an exchange of lawn equipment for rebates).

effects in states where electric LGE offer the greatest benefits. Properly structured incentive programs can also effectively assist the removal of older, dirtier, and environmentally harmful equipment. To drive greater citizen participation, such programs should be year-round rather than weekend-only events and all buyers and sellers of electric LGE within the jurisdiction should be eligible to participate.[157]

State and local programs promoting electric LGE may also be more effective at connecting with citizens and educating them on the advantages of electric LGE. Policies aimed at incentivizing retail consumers to transition from gas to electric LGE are effective only to the extent consumers know about the existence of such policies. There is widespread evidence members of the public want more information about environmental conditions and want more and earlier opportunities to participate in environmental decisions.[158] Local governments often play vital roles in this process, connecting market stakeholders with environmental stakeholders and citizens.[159]

v. Utility-Sponsored Partnerships

Some state and local governments may also benefit from partnering with electric utilities in LGE electrification efforts. From a utility's perspective, working with governmental officials to promote the adoption of electric LGE may provide a useful means of improving relationships with retail customers and involve them in environment-related decisions.[160] Because utilities have regular contact with virtually every household in their territories, they are also often capable of distributing information through mail or online platforms alongside monthly

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[157] Maricopa Cnty. Air Quality Dep't, *supra* note 110 (describing a voucher program in Maricopa County (Arizona) that can only be claimed at local Home Depot locations).

[158] *See* LeRoy Paddock, *Green Governance: Building the Competencies Necessary for Effective Management*, 38 ENVTL. L.R. 10609, 10639-40 (2008).

[159] *See* Melissa Birchard, *What is Grid Modernization? An Explainer*, CONSERVATIVE LAW FOUNDATION (Oct. 27, 2017), https://www.clf.org/blog/what-is-grid-modernization/ [https://perma.cc/EWV9-MHPC] (discussing 21st century trends and local roles in the future of electricity markets).

[160] *See* Shelley Welton, *Clean Electrification*, 88 U. COLO. L. REV. 571, 642 (2017); *See also*, Angelina Lian, *Shedding Light: The Role of Public Utility Commissions in Encouraging Adoption of Energy Efficient Lighting by Low-Income Households*, 38 COLUM. J. ENVTL. L. 333, 360 (2013) (recognizing that utilities can use their "gatekeeper" role to induce widespread adoption of new practices and more efficient equipment).

electric bill information at a very low cost. Partnering with governments to distribute information about electric LGE benefits may likewise help some utilities to build goodwill with customers by demonstrating a commitment to environmental protection.

Utilities may likewise view more widespread adoption of electric LGE as economically beneficial because of its potential to increase the demand for retail electricity in an era when distributed renewable energy technologies are gradually reducing aggregate demand for grid-delivered electric power.[161] As the nation's century-old public utility regulatory model faces growing challenges from this decrease in demand, the transition to electric LGE presents an opportunity to slow the trend.[162] Altogether, utility partnerships can have a major impact on consumers' knowledge, access, and opportunity to participate in local programs.

CONCLUSION

In today's age of sleek and powerful electric vehicles, it is no longer justifiable for low-tech, gas-powered lawn and garden tools to continue polluting the atmosphere. Modern, electric LGE technologies are cost-effective, efficient, and often as powerful as their gas-powered counterparts yet produce no direct emissions in American backyards.[163] And as the nation's electric energy mix grows ever cleaner and more renewable, the case for electrifying LGE only becomes stronger.[164]

Most existing policies are not designed to fully address the externality problems associated with modern uses of gas-powered LGE.[165] Purchasers and users of gas-powered LGE do not

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[161] *See* Jim Rossi & Michael Vandenbergh, *Good for You, Bad for Us: The Financial Disincentive for Net Demand Reduction*, 65 VAND. L. REV. 1527 (2012) (asserting that the use of information and other nonintrusive interventions could lead to reduced carbon emissions at the household level because retail electricity distributors regularly interact with customers, and control much of the flow of information to and from households).

[162] *See* Alexandra B. Klass, *Public Utilities and Transportation Electrification*, 104 IOWA L. REV. 545, 569–71 (2019) (explaining how energy efficiency investments and distributed energy systems have imposed downward pressure on utility revenues and that mass adoption of electric vehicles can significantly increase demand for electricity).

[163] Hope, *supra* note 31; Pincher, *supra* note 73.

[164] Nat'l Renewable Energy Lab'y, *supra* note 59.

[165] Dekeyan, *supra* note 61; Silverstein, *supra* note 53; ENV'T LINK, *supra* note 120.

internalize all of the costs of their actions, and those who invest in electric LGE likewise do not internalize all of the broader social benefits of their actions.[166] In light of these market failures, more aggressive policies are needed to promote optimal levels of electric LGE investment and use.

Fortunately, there are policy strategies available at all levels of government capable of accelerating the nation's transition to electric LGE.[167] At the federal level, a new set of "Phase 4" EPA regulations imposing increasingly strict emissions standards for LGE over time would compel manufacturers to steadily reduce emissions on gas-powered LGE models or rapidly switch to manufacturing electric equipment. A new federal tax credit for purchases of electric LGE paired with those standards would correspondingly help to drive increases in retail demand for new electric LGE products, mitigating some of the positive externality problems associated with electric LGE.

In states and municipalities with the most severe air quality challenges due to gas-powered LGE, new or expanded rebate or voucher programs could supplement federal incentives and drive even more rapid transitions to electric LGE products.[168] Working with utilities that are also eager to build goodwill with customers and increase electricity demand within their territories, state and local governments are well-situated to educate the public about the environmental and health costs of gas-powered LGE as well as the potential benefits of going electric.[169]

By leveraging readily available technologies, it is entirely possible for Americans to enjoy neatly-trimmed lawns while breathing clean, neighborhood air. Policymakers at all levels of government must adopt this vision and take simple steps to help the country build a fleet of lawn and garden tools powered mostly by wind and sun.

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[166] *See* California Air Resources Board, *supra* note 56; *see also* ENV'T LINK, *supra* note 120.

[167] Engel, *supra* note 98.

[168] Norem III, *supra* note 103.

[169] Birchard, *supra* note 159.

Riya Anand
Project: Electrifying Lawn Care

Electrifying Lawn Care Narrative

The majority of the population of the United States reside in suburban settings. Real estate in suburbia is often characterized by the presence of a large grass surrounding the property. With the presence of lawns and widespread norm to sustain an aesthetically-pleasing yard, comes extensive levels of lawn care and equipment, the most prevalent of which is the lawn mower. A staple of the American household for many decades, lawn mowers are traditionally powered by gas. In more recent years, electric lawn mowers have made their way forward, leading to the pressing question of gas VS electric.

Emissions & Air Pollution

"Gasoline-powered lawn mowers and garden equipment are emitting 30 million tons of pollutants yearly in the USA, accounting for a quarter of all non-road gasoline emissions' ' [Saidani, Michael, and Harrison Kim (2021)]. While gas lawn mowers have proven to be an effective grass-trimming device year-after-year, it is important to acknowledge some of its environmental and health effects.

A 2021 study observed that a common household two-stroke leaf blower emitted, into the air, twice the amount of nitrogen oxide, 23 times as much carbon monoxide, and 299 times as many non-methane hydrocarbons as a Ford Raptor, a large, 6000 pound truck. The truck would have to travel thousands of miles to even come close to matching the mower's level of emissions [Electrifying (2021)]. Other studies follow suit. They quantify, in various settings and contexts, the extensive level of emissions that result from lawn mowers [Banks]. Two-stroke and six four-stroke lawn-mowers presently in-use in Australia contributed to 5.2 and 11.6% of CO and NMHC emissions, respectively [Priest, M. W., et al (2000)]. It is important to note that these emissions can be directly attributed specifically to the use of the gas-powered lawn care, anthropogenic causes, rather than biogenic causes such as changes in soil respiration due to the act of cutting the lawn [Lawn Mowing Frequency].

Air pollution not only has a great effect on the environment acting as a catalyst for climate change, but also a huge effect on human health. In 2019, 99% of the world's population lived in places that did not fit WHO criteria for "clean air." Statistics show that air pollution is a huge public health threat that accounts for over 7 million premature deaths annually [Air Pollution Note], giving the significance of the emissions released every day world-wide by societal use of gas-powered lawn care.

Compared to gas-powered mowers, electric and battery powered mowers have shown to release approximately 1,500 times less carbon monoxide, 31 times less hydrocarbons and nitrogen oxides, and 18 less more carbon dioxide into the atmosphere, when used at a similar rate [Sivaraman, Deepak, and Angela S. Lindner (2021)]. This data was backed up, independently, by research conducted by the Electric Power Research Institute IncThe EPA, the Edison Electric Institute [Lamarre, Leslie (1996)]. Reduction in emissions via the transition to electric-powered equipment is not limited to lawn care. When analyzing the 25 most gas-consuming countries in the world, an Advancing Earth and Space Science article found that if all gas-powered appliances were replaced with electric appliances, there would be a reduction of 87% of total carbon emissions from energy consumption [Dietrich, Florian, et al (2023)].

This data gives evidence that the transition from gas-powered lawn care to electric and battery-powered lawn care reduces global level of emissions and has the potential to improve human health and levels of mortality.

Noise Pollution

Violation of Noise Pollution Guidelines

Air pollution is not the only way in which gas-powered mowers have proven to affect the well-being of society. Gas-powered mowers are well-known to contribute to local noise pollution, detrimental to human health. Extensive analysis and various dB metrics in a recent study determined that the noise emitted by gas powered leaf blowers violates WHO outdoor daytime standards (emitting 55 dB of noise up to 800 feet away from the point of operation), posing auditory and non-auditory health risks to those residing in communities where the blowers are being used [Walker and Banks (2017); Berglund, Birgitta, et al. (1999)].

Transition to Electric Sources

Once again, the transition to electric lawn care has proven useful for improvement in this area. An initiative called "Buy Quiet" describes a strategy implemented for improvement in this area, following the idea that the transition to electric leaf lawn care in community spaces acts as an effective parallel to reducing noise exposure to the general public [Tickle (2012)]. On the topic of lawn blowers, specifically, a battery-powered blower created by Blount International showed to have the same lawn-care capabilities as gas-powered two-leaf engine blowers while meeting or exceeding industry noise emission guidelines and attaining best in class sound quality [Nelson (2017)].

More generally, a 2017 study looked at 500 lawn mowers over 13 years and found that newer, electric lawn mowers are almost 1 decibel quieter than old, gas-powered mowers [Blomberg, Leslie D., et al (2017)]. In support, a similar, independent, study looked at 600 mowers between 2004 and 2021 to find that the transition to electric lawn mowers have been the most effective and impactful solution to the reduction of noise pollution caused by lawn care during this time period [Blomberg, Leslie, and Dave Trezza (2021)]. As a whole, both studies agree that noise pollution is an overlooked consequence of gas-powered lawn care in both areas of law and health, yet significantly impact both.

Health Effects

Directly contributing to chronic sleep deprivation, loss of hearing, and various other conditions, the effects of noise pollution on human health are severe but overlooked [Domina]. There are various auditory and non-auditory effects of chronic noise pollution. While auditory health effects are more commonly acknowledged, people are often unaware of non-auditory effects such as annoyance, irregular/disturbed sleep, daytime sleepiness, poor performance in the workplace, increased occurrence of hypertension and cardiovascular disease, and impaired cognitive performance in school children [Basner, et al. (2014)]. These non-auditory effects were found to occur when the population is exposed to low frequency noise, between 10 Hz and 200 Hz. For 97.5% of the population, chronic exposure to low frequency noise is associated with annoyance and stress [Leventhall (2004)] and has been shown to equally affect those with high noise sensitivity and "normal" levels of sensitivity [Stansfeld (1992)], showing how widespread this issue has become. CDC findings show that it only takes 2-5 minutes of exposure to cause permanent damage to the ear and hearing abilities of the user, even when exposed to solely low-frequency noise [Leaf Blowers Are Not Only Annoying].

This is further exemplified by the findings of other studies, including New York Times' article *"Noise Could Take Years Off Your Life. Here's How"* that a professional sound meter measures chronic sound exposure, the average level of sound an average individual is exposed to each day. The study found that chronic noise exposure is a health threat, actively increasing the risk of hypertension, stroke, and heart attacks for more than 100 million Americans, almost a fourth of the population, equally affecting those in urban, suburban, and rural areas [Baumgaertner, et al. (2023)].

Numerous sources and disadvocates for electrifying lawn care have argued that there are numerous other solutions that can mimic the reduction of noise pollution that do not involve forgoing gas-powered equipment. *"Are You Exposed to Too Much Noise? Here's How to Check,"* specifically, found that sleeping further away from the source of noise, installing thicker windows, and other measures of reducing exposure to noise pollution were found to be partially effective at best and urges for policy change at the municipal level.

These health risks are often non-reversible and many times fatal, which brings urgency and importance to this area.

Environmental Effect

Soil is an essential component of the environment. Its well being is essential to the wellbeing of various other organisms, including humans. The health of soil directly affects matters such as food security and water security, which are extremely prevalent and become of concern as the population continues to grow. The actions of humans must be carefully monitored and the potential consequences of their actions on the health of soil must be recognized, as soil is unable to renew itself quickly, so its destruction can have a long-term impact.

"Fuel Reduction Practices and Their Effects on Soil Quality" acknowledges the effect that gas-powered mechanics can have on soil quality. The article notes the various effects of fuel-driven practices and evidence supporting their negative effects on soil health [Busse, et al. (2014)]. This goes to show the indirect impact on human health via environmental changes that may be seen as a result of the continued use of gas-powered equipment.

Economic, Policy, & Technology

Apart from the more evident consequences of the transition to electric powered lawn care, it is important to note the less emphasized benefits and debunk some of the commonly misunderstood aspects of the transition.

The economic impact of the transition has been discussed to a great extent. The biggest and most commonly arising question is whether we, as a society, are able to handle the electric and economic burden of the transition to electric lawn care equipment. A study conducted by the Florida Energy Extension Service examines the impact of moving all of society's gas-powered appliances to electric-powered appliances, including refrigerators, lights, cars, etc. The study provides evidence that our electric grid, in the United States, is sufficient to accommodate the electricity needs of electric lawn care [West, Mike (1994)]. In fact, using an electric lawn mower all year would cost less than $4 in electricity, a relatively small cost [Pos-Rio].

With electric lawn care has come a myriad of research and development in this area, generally. For the first time in numerous decades of societal use of lawn care, various technological developments are making their way forward, including electric automatic lawn mower "robots" that can mow lawns for those with disabilities and who are generally unable, or unwilling, to do so themselves [*Lawn Care for the Lazy;* Aponte-Roa (2019); Okafor, Basil (2013)]. Developments such as these arise as the transition to electric lawn care continues to occur, specifically, in electric-powered lawn care vehicles, foreshadowing the breadth of developments which can potentially occur in the future.

For those questioning why this development is being made now, it is evidently due to the attention being brought to a highly ignored issue. There is an evident lack of government law regarding environmental policy at the federal and local levels. Despite its implementation being under jurisdiction of law-making bodies at all levels, environmental law has one of the biggest direct impacts on the health and well-being of our society, yet it is not once mentioned in major documents [Farquhar, Doug, et al (2021)]. Due to this, the attention and regulations surrounding the use of equipment such as gas-powered lawn care, etc. is often absent and overlooked; therefore, people are not aware of the magnitude of the issue and are less likely to find solutions to the problem.

Take-Aways

While there are numerous advantages and disadvantages to both gas and electric lawn-care equipment, it is important to acknowledge the environmental, technological, health, and political revolution which a transition to electric lawn care can provide for present US society [Enroth].

Overall, this works into the bigger picture, the true cost of a lawn and why it is such a highly valued component of the American household [Morton, Timothy (2009)]. Lawn mowers, whether gas or electric, have the potential to negatively impact human health, both through emissions and as serving as one of the major sources of child injury related to household appliances [Extremity Lawn-Mower Injuries]. While lawns are certain to remain a part of societal norms, it is vital to take a step back and acknowledge how to reduce the impact of maintaining this American commodity. The answer may be evident: electrifying lawn care.

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RESEARCH ARTICLE

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Lawn and Garden Equipment Sound: A Comparison of Gas and Battery Electric Equipment

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Abstract

Noise from gas-powered leaf blowers (GLBs) has become a source of distress for communities in North America and around the world. To date, approximately 170 communities in the United States have enacted regulations aimed at restricting their use. Battery electric leaf blowers (BLBs) have been suggested as a quieter alternative, but there are no published scientific studies comparing their sound to GLBs. This study compares directly the operating characteristics of measured sound (L_{90}) from leading models of commercial GLBs and BLBs and includes a GLB with the same manufacturer sound rating as two of the BLBs (~ 65 dBA at 50 feet). L_{90} levels at five feet ranged from 72 to 90 dBA for the GLBs and from 70 to 85 dBA for the BLBs. Sound levels at 50 feet were consistent with manufacturer ratings. At distances of 100 to 400 feet, L_{90} levels were 4-22 dBA higher for GLBs than for BLBs. The measured GLB sound spectrum had a markedly greater low frequency component compared with the BLB sound spectrum allowing it to transmit and remain audible over longer distances and have greater adverse impact on the surrounding community. Further, the low frequency component of GLBs enabled their sound to transmit more readily through windows and glass doors of homes. Application of a measure of loudness as perceived by the human ear suggests that GLBs can often be heard up to several times louder than BLBs in outdoor and indoor settings. In actual settings, the routine use of multiple GLBs and other noisy equipment for hours a day exposes not only workers but large numbers of people in the community to harmful levels of noise and threatens not only work health, but public health, particularly of children, seniors, and other vulnerable populations. Policy makers and industry should adopt new technologies and good practices that place the health and well-being of workers and the public first.

Keywords: Noise; Lawn and garden equipment; Leaf blower; Community; Low frequency; Occupational health; Health effects

Introduction

Noise from commercial gas-powered leaf blowers (GLBs) is adversely affecting the lives of workers and citizens in communities in North America and other parts of the world. Approximately 170 communities in the United States have enacted some form of restriction on this specific piece of equipment. Originally developed to spray insecticide, GLBs today are used for a wide variety of outdoor tasks ranging from the actual blowing of leaves to hardscape cleaning, gutter cleaning, and even snow removal. The current dependence of the commercial land care industry on GLBs to perform tasks large and small has resulted in their ubiquitous presence in neighborhoods, parks, schools, and other public spaces.

Advances in electric battery technology are enabling a transition away from GLBs as well as other gas-powered equipment, including mowers, trimmers, and chain saws. Policy makers considering battery electric powered leaf blowers (BLBs) as possible alternatives presume them to be less harmful because of the elimination of emissions and less noise. However, there is a scarcity of objective data directly comparing the measured sound levels and spectra of operational GLBs and BLBs.

The objectives of this study are to: 1) compare in a head-to-head study the characteristics of sound from of commercial grade GLBs and BLBs in outdoor and indoor settings; 2) compare the impacts of GLB and BLB sound on communities; and 3) determine if GLBs and BLBs with the same manufacturer sound rating affect communities in the same way.

Materials and Methods

Area and conditions of study

Outdoor field work for this study was carried out on Sunday, June 18, 2018, between the hours of 10 am and 3 pm at the Department of Public Works, Lincoln, MA. The date was intentionally chosen for optimal weather (fair, little wind) and ambient sound conditions (less traffic, fewer trains). Lincoln is a suburb located approximately 20 miles from the City of Boston with a population of 8,600 (including residents of an air force base) and a land area approximating 15 square miles. The blowers were operated at a single location on pavement (the origin, blue asterisk on Outdoor Study Map-Figure 1) at more than 100 feet from any building, within 10 feet of a grassy area, and more than 400 feet from main town roads, as recommended by the American National Standards Institute (ANSI) [1]. Indoor measurements were taken at a nearby residential property (0.6 acre) with modern double pane insulated glass windows.

Lawn and garden equipment

Three models of commercial grade backpack GLBs and four models of the most powerful commercial grade backpack BLBs on the market were tested (Table 1). Two of the gas models were powerful, top-rated models used routinely in commercial landscape use [2]; the third (Echo PB760) was chosen because it is among those touted as "quiet GLBs" with the same manufacturer sound rating (A-weighted decibels [dBA] at 50 feet) as two of the BLBs. The ages of the machines ranged from new to three years. The fuel levels of the three GLBs were approximately 48 ounces at the start of the study. Each GLB and BLB was operated by the same person, an experienced lawn care/landscaping professional.

Sound measurement

Sound measurements were made using a calibrated Type 1 professional sound level meter (Bruel and Kjaer type 2250 with windscreen and tripod mounted) capable of recording up to 140 dBA or 143 C-weighted decibels (dBC) across each of the 1/3 octave band filters. A Type 1 meter ensures a high level of accuracy and repeatability.

Sound metrics

The primary metric was the L_{90}, measured as an average and by 1/3 octave band center frequency. An L_{90} is the sound energy (measured in dBA) which is exceeded more than 90% of the time. Other metrics included: the L_{EQ} which is the average equivalent dBA level and minimum (L_{min}) and maximum (L_{max}) sound levels taken on fast and slow settings. Compared with unweighted decibels (dB), the dBA under weights the contribution of lower frequency sound. Compared with the L_{EQ} which is an average, the L_{90} is a more conservative measure of sound level representing a lower threshold that more confidently captures the GLB/BLB sound rather than traffic sound. The L_{90} metric, enables the measurements to confidently represent the GLB/BLB noise when there may also be fluctuating ambient noise levels present.

Outdoor measurements

The machines were tested at distance intervals of 5, 50, 100, 200, 400, and 800 feet in a straight line from the origin as shown in figure 1. ANSI's Safety Requirements and Performance Testing Procedures for blowers [3] were used to guide sound testing at the origin and at 50 feet. At all distances, the microphone was positioned four feet above the ground. In every case, operators brought the blowers immediately to full power once started. At each distance interval, a thirty second ambient sound measurement was taken to account for background noise, e.g., road traffic. In instances in which loud sound from external sources (e.g. train, plane, siren) interfered, measurements were repeated.

Measurements at the origin and at fifty feet: Sound at the origin was measured five feet from the operator for 30 seconds. At 50 feet, the operators ran the blowers at eight positions (0°, 45°, 90°, 135°, 180°, 225°, 270°, and 315° to the axis), rotating in a circle in a clockwise direction in accordance with ANSI standards [3]. The operator held the blower tube in normal operating position with the end of the blower tube (nozzle) at least 2 inches from the surface and maintained a consistent blower tube position throughout the rotation. At each position, the sound was measured for 30 seconds. For comparison with pavement, a 30 second measurement was taken with the operator standing on a grass surface, using the blower as they would for routine maintenance work while rotating through 360 degrees.

Measurements at distances beyond 50 feet: For measurements at all further distances, the operator ran the blowers as if using them in routine maintenance while rotating through 360° with sound measurements taken for one minute.

Indoor sound measurements

At the residential property, blowers were operated at full power in the backyard 50 feet from an insulated, double pane glass window. The operator stood on natural ground cover (grass, ivy) and operated the blower at full power and as they would for routine maintenance while rotating through 360°. Sound measurements were taken for one minute indoors within five feet of the closed window. All windows and doors of the home were closed while sound measurements were taken.

Analyses

All analyses were performed using descriptive statistics. At 50 feet, an average of the L_{90} was derived from the L_{90} at each of the eight positions of the circle. The minimum difference in L_{90} between GLBs and BLBs was calculated as the smallest difference between values from each type; the maximum difference was calculated as the greatest difference between values from each type. The relative loudness of sound from GLBs and BLBs as perceived by the human ear was calculated using the following standards: A 3 dB difference is noticeable to the human ear; a difference of 10 dB less reduces the perceived sound by 50% and a difference of 10 dB more doubles the perceived sound. In a nested comparison, the loudness of sound over distance for the Echo GLB (manufacturer-rated at 65 dBA) was compared with the BLBs that were manufacturer-rated at 64-65 dBA.

Results

Outdoors: Sound energy and perceived loudness

At 5 feet and 50 feet, the observed sound levels from the GLBs were consistent with available manufacturer noise ratings using ANSI standards (Table 2). The L_{90} of the quietest GLB, the Echo PB760, at 5 and 50 feet were comparable to three of the BLBs. At both distances, the L_{90} of the two louder GLBs (Redmax, Stihl) were 8-20 dBA higher than those of the BLBs, indicating that the perceived loudness was approximately double that of the GLBs.

At distances of 100, 200, and 400 feet, the measured sound level is higher for the GLBs compared with the BLBs (Table 3). The two more powerful GLBs (Redmax, Stihl) were 7-22 dBA higher than the BLBs, meaning the perceived loudness was two to more than 4 times higher. The quieter GLB (Echo) was 3-13 dBA higher compared with the BLBs, meaning the difference in sound level was noticeable to more than twice as loud. At 800 feet, the differences in audible sound profile narrowed considerably. However, it was observed that the three GLB were still audible, two being clearly audible and the third being less audible, but still noticeable.

Outdoors: Sound energy and frequency

The loudness and frequency profiles of GLBs and BLBs at all distances are shown in figures 2-7. Most outdoor measurements in

Table 1: Summary of Equipment.

Make/Model	Power Source	Max Air Flow (CFM)*	Max Air Speed (MPH)*	ANSI Manufacturer Sound Rating at 50 feet (dBA)[3]
Redmax EBZ8500	Gasoline	908	206	77
Stihl BR 700x	Gasoline	901	193	75
Echo PB760	Gasoline	535	214	65
Greenworks GBB 700	Lithium battery	640-700	160-170	N/A
Greenworks GBB 600	Lithium battery	600	150	64
Chervon EGO 600	Lithium battery	580	168	65
Stihl BGA 100	Lithium battery	494	168	56

ANSI: American National Standards Institute; CFM: cubic feet per minute; dBA: A-weighted decibels; MPH: miles per hour.
Note: CFM and MPH are common measures used to denote power.

Table 2: Measured Operational Sound Levels of Equipment at 5 Feet and 50 Feet (Outdoors).

Make/Model	Type	ANSI Manufacturer Sound Rating at 50 Feet (dBA)[3]	Measured L_{90} dBA	
			At 5 Feet	At 50 Feet
Redmax EBZ8500	GLB	77	93**	77
Stihl BR 700x	GLB	75	90	77
Echo PB760	GLB	65	82	67
Greenworks GBB 700	BLB	N/A	85	67
Greenworks GBB 600	BLB	64	83	64
Chervon EGO 600	BLB	65	77	64
Stihl BGA 100	BLB	56	70	57
Range of difference in sound pressure levels (dBA): GLB *vs* BLB		0 to 21	1 to 23	0 to 20
Relative difference in perceived loudness: GLB *vs* BLB		0 to 4 times louder	0 to 4 times louder	0 to 4 times louder

BLB: Battery-powered leaf blower; GLB: Gas-powered leaf blower; N/A: not available
ANSI: American National Standards Institute; **L_{EQ} was used instead of L_{90} due to an elongated measurement period in which the blower was idling and affecting the L_{90} result.

Table 3: Measured Operational Sound Levels of Equipment at 100, 200, 400, and 800 Feet (Outdoors).

Make/Model	Type	Measured L_{90} dBA			
		At 100 Feet	At 200 Feet	At 400 Feet	At 800 Feet
Redmax EBZ8500	GLB	71	66	55	39
Stihl BR 700x	GLB	72	65	58	39
Echo PB760	GLB	63	56	48	37
Greenworks GBB 700	BLB	59	52	44	36
Greenworks GBB 600	BLB	57	46	41	39
Chervon EGO 600	BLB	57	49	45	41
Stihl BGA 100	BLB	50	44	38	34
Range of difference in sound pressure levels (dBA): GLB *vs* BLB		4 to 22	4 to 22	3 to 20	-4 to 5
Relative difference in perceived loudness: GLB *vs* BLB		Noticeably louder to 4 times louder	Noticeably louder to 4 times louder	Noticeably louder to 4 times louder	Noticeably above ambient *vs*. not audible

BLB: Battery-powered leaf blower; GLB: Gas-powered leaf blower

Figure 1: Map of Area for Outdoor Measurements.

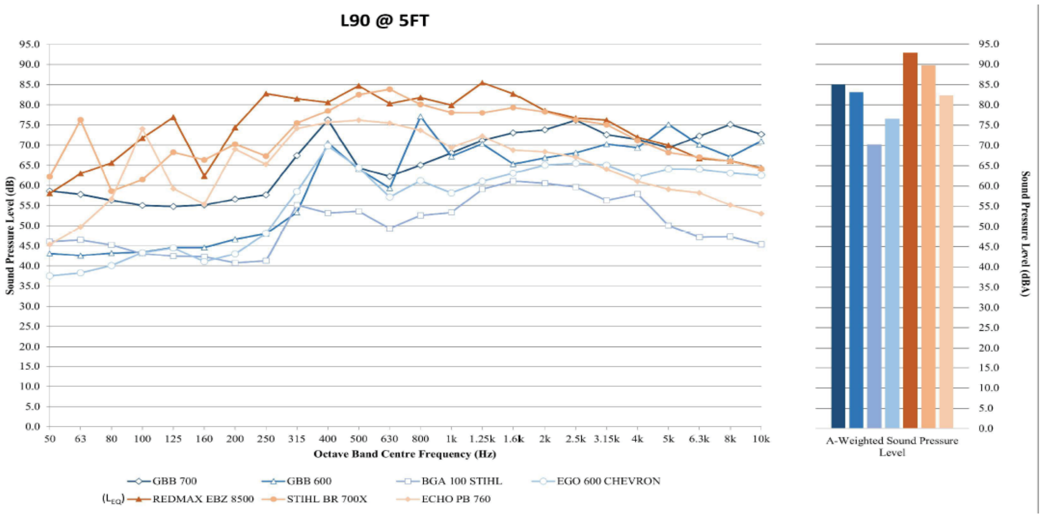

Figure 2: L_{90} Measurements for GLB and BLB Models at 5 Feet.

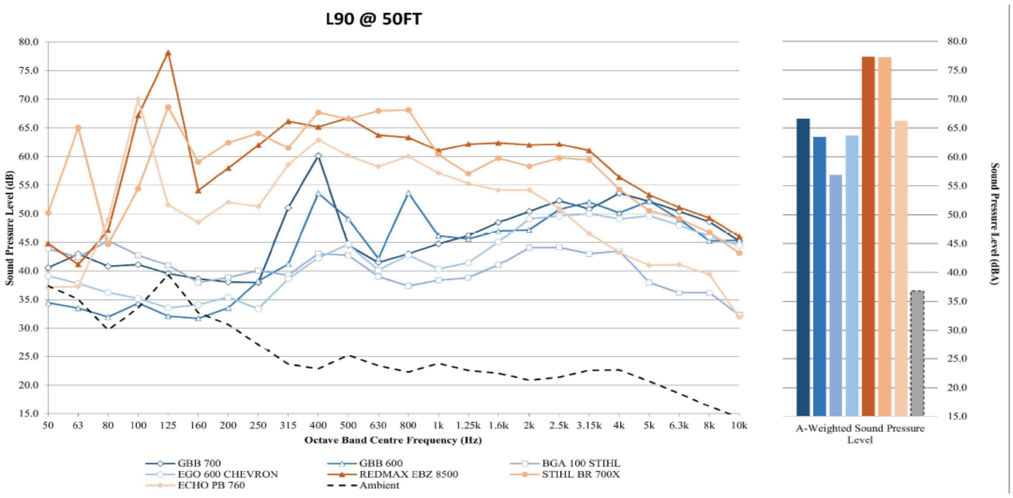

Figure 3: L_{90} Measurements for GLB and BLB Models at 50 Feet.

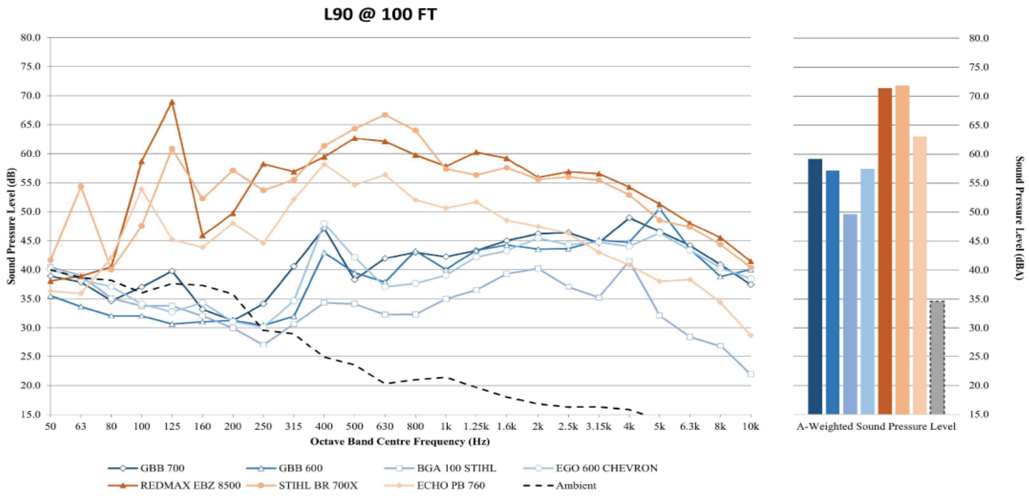

Figure 4: L_{90} Measurements for GLB and BLB Models at 100 Feet.

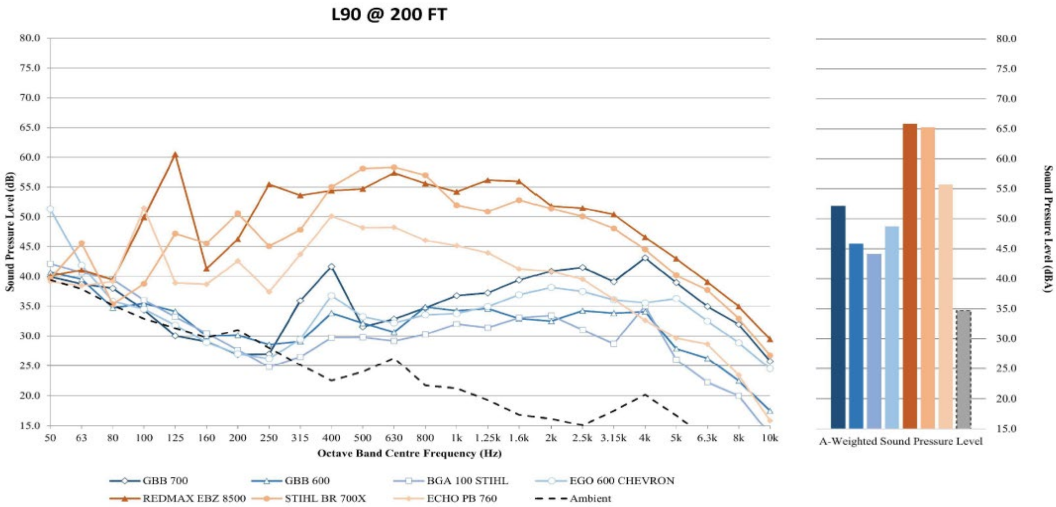

Figure 5: L_{90} Measurements for GLB and BLB Models at 200 Feet.

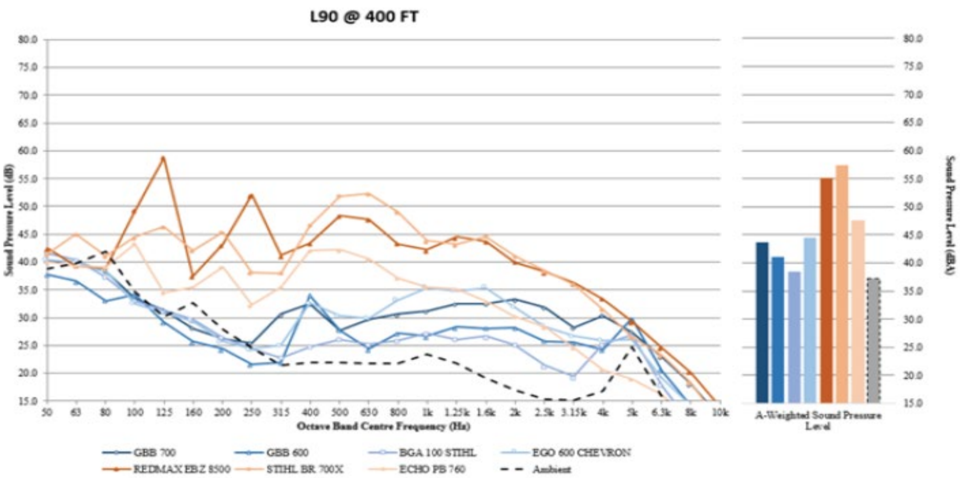

Figure 6: L_{90} Measurements for GLB and BLB Models at 400 Feet.

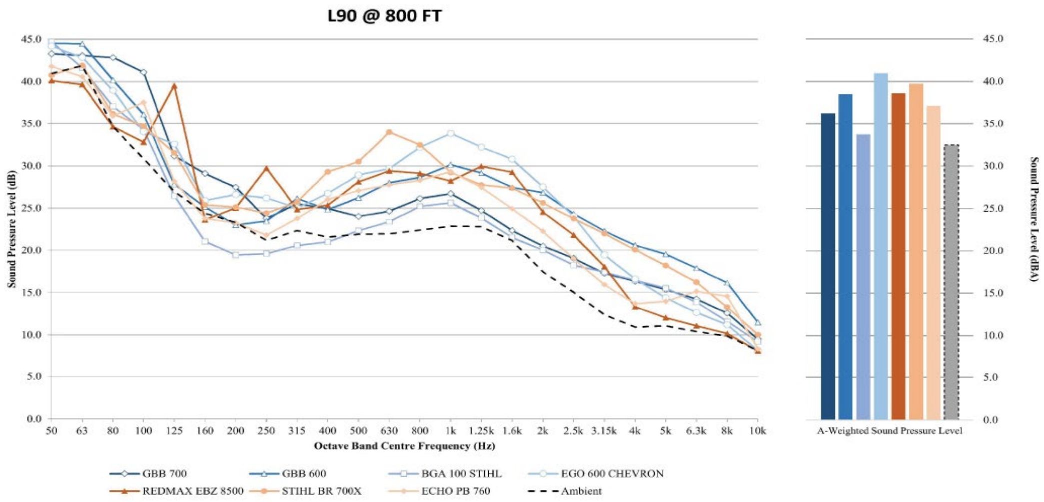

Figure 7: L_{90} Measurements for GLB and BLB Models at 800 Feet.

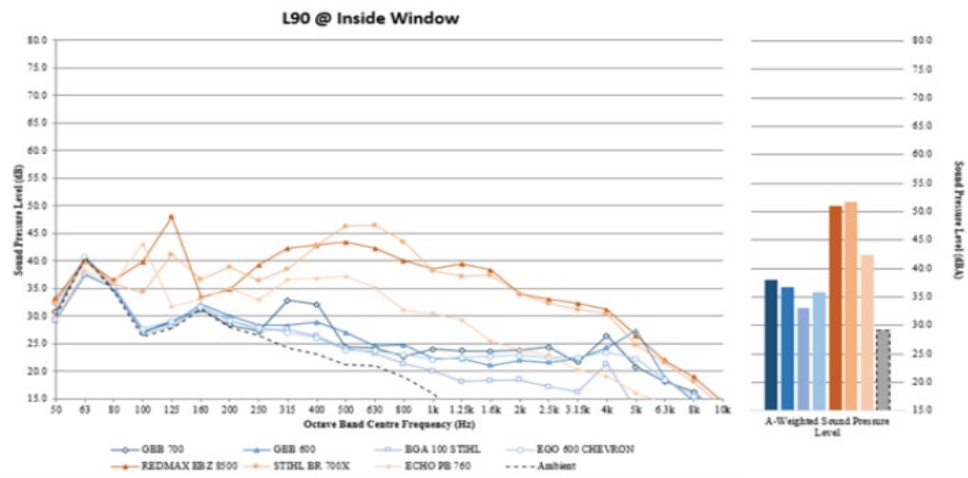

Figure 8: L_{90} Measurements for GLB and BLB Models inside Window.

locations with any distant traffic will have more low frequency than high frequency noise, and the ambient sound in this study was also of this character. At distances of more than 5 feet and less than 800 feet, the frequency profiles of GLBs and BLBs are markedly divergent. The GLBs (shaded in orange) produced much higher levels of sound energy in the low frequency bands at all distances compared with the BLBs. In a number of cases, this sound peaked at 100 to 125 Hz. These differences became most marked at distances of 100 to 400 feet.

Although at 800 feet, there were negligible differences in L_{90} between the GLBs and BLBs, it was observed that the three GLB were still audible, two being clearly audible and the third being noticeable. In contrast, the sound energies from the BLBs were indistinguishable from the ambient sound level at that distance. Only the peaks of low frequency sound from the GLBs were prominently audible above the ambient noise. Because these low frequency peaks do not occur with the BLBs, it is this low frequency component that is likely to account for the audibility of the GLBs over long distances.

Indoor measurements

Table 4 shows that differences in sound measured indoors ranged from 5-19 dBA higher for GLB compared with BLB, meaning that in most cases the perceived sound from the GLBs compared with the BLBs was clearly noticeably louder, and in some cases, up to four times as loud. As seen in figure 8, the low frequency sound (100-125 Hz as well as frequencies up to around 500 Hz) from GLBs, as measured inside the house, were significantly above those of the BLBs.

Nested comparison of GLB and BLB with comparable manufacturer noise ratings

Outdoor measurements (Table 5) showed differences in sound levels from the GLB (Echo PB 760) and two BLBs (with similar manufacturer noise ratings of 64-65 dBA at 50 feet) over distances up to 400 feet. Human perceived loudness was up to two to four times greater for the GLB at distances up to 400 feet.

Indoor measurements (Table 6) showed differences in sound levels that would be perceived as noticeably louder to twice as loud for the GLB compared with the BLBs.

Discussion

This is the first published study to directly compare the measured characteristics of commercial grade GLB and BLB sound over distance, in outdoor and indoor community settings. It found that a strong low frequency component is responsible for transmitting more audible GLB sound over long distances and into homes, consistent with the findings of previous studies [4,5] and with what is generally known about internal combustion engine sound [6,7]. The study also determined that people experience GLBs as much louder than BLBs at distances up to at least 400 feet outdoors, and indoors as well, even when the GLB and BLB have the same manufacturer noise rating.

Commercial landscape maintenance activities have become a major source of air pollution as well as of environmental noise. The GLB is often cited as the most egregious source of harmful noise [8-10].

At the ear of the operator, GLB sound exceeds the 85 dBA occupational safety standard set by NIOSH (National Institute of Occupational Safety and Health) by 10-to 100-fold [2,11]. At 50 feet, it far exceeds the World Health Organization's 55 dBA outdoor noise guideline and 35-45 dBA indoor noise guideline to protect the health of the public [12-14]. With GLBs, the low frequency sound component is what is most easily transmitted and is what accounts for its audibility over long distances as well as inside homes and structures. One of the challenges with low frequency noise is that it requires heavy construction or materials to reduce the sound transmitting. This is very clear when it comes to windows and glass doors in houses. The heavy drywall or brick walls of a house may do a good job at blocking noise from outside, but low frequency sound transmits more easily through the lighter weight windows. This is a common issue with the drone of road traffic or aircraft overhead, and several states and federal programs (e.g., the FAA Airport Noise Program/Residential Sound Insulation Program administered by the US CDC) provide funding to upgrade housing in impacted areas.

Regular exposure to loud and/or persistent noise contributes to hearing impairment, hypertension, ischemic heart disease, annoyance, sleep disturbance, cognitive impairment, and diminished school performance [15-17]. Noise over 60 decibels increases the risk of cardiovascular disease [15]. Low frequency noise is a special health concern because it may "increase adverse effects considerably" [12,18]. Studies in animals show that exposure to low frequency noise causes fibrosis and thickening of cardiovascular vessels [19,20]. Populations most vulnerable to these effects include not only the equipment operators, but also children, seniors, people with hearing disorders and neurological conditions like autism and sensory deficit disorders [21].

Table 4: Measured Operational Sound Levels of Equipment Indoors.

Make/Model	Type	Measured L_{90} dBA
Redmax EBZ8500	GLB	51
Stihl BR 700x	GLB	52
Echo PB760	GLB	43
Greenworks GBB 700	BLB	38
Greenworks GBB 600	BLB	37
Chervon EGO 600	BLB	36
Stihl BGA 100	BLB	33
Range of difference in sound pressure levels (dBA): GLB *vs* BLB		5 to 19
Relative difference in perceived loudness: GLB *vs* BLB		Noticeably louder to 4 times louder
BLB: Battery-powered leaf blower; GLB: Gas-powered leaf blower		

Use of GLBs and other noisy landscape maintenance equipment is unregulated. Industry guidelines (e.g., only one GLB in use at a time, never operated at full throttle in residential settings, never operated within fifty feet of people) are routinely disregarded by operators and business owners. Rather, these blowers are often part of a stable of equipment used for maintenance that may include mowers, edgers, trimmers, and saws. The combination of all this equipment and their distribution around a property can produce sound that has a much greater impact on a community than a single piece of equipment. Although not considered here, it must be mentioned that these machines are not only a source of harmful noise, but also of emissions, including ozone - forming chemicals, carbon monoxide, and fine particulates.

The number of households affected by harmful levels of noise depends on several factors. Ameliorating factors include high levels of ambient noise, structures and natural barriers. Exacerbating factors may include the combined use of multiple pieces of equipment. In quieter neighborhoods where GLB sound is not masked by other sources, the degree of community impact will rely largely on the distance over which harmful noise levels are transmitted. The area of impact is a function of the square of this distance, meaning that even a small increase in the distance over which harmful levels of sound are transmitted can have a large adverse impact on the community.

The results of this study provide a conservative estimate of harmful noise exposure from gas-powered landscape maintenance practices. They do not represent common situations in which people living in densely populated neighborhoods are exposed to the sound from several GLBs and other equipment operating on a single property and/or multiple properties for hours at a time several days each week. In this situation, harmful levels of protracted noise may carry out to 400 or more and may affect more than 90 households.

Good landscape maintenance practices should be as much about health and quality of life, as they are about aesthetics. Policy makers and industry players - manufacturers and service providers - need to recognize that the unbridled use of GLBs and other noisy equipment has become a public health problem in some communities, threatening the health and well-being of the public, particularly children, seniors, and other vulnerable populations. While BLBs are not perfect with regard to noise, they constitute a major improvement and are now powered so that they can be used for all routine commercial tasks. Transitioning to BLBs as well as other battery electric equipment would reduce health risks for operators from noise (and from toxic emissions) and improve the health and well-being of entire neighborhoods.

Lastly, it should be noted that the ANSI dBA standard at 50 feet does not adequately evaluate community impact or allow comparisons of gas-and battery-powered equipment sound and has been widely criticized in its application to internal combustion engines [12,18, 22-25]. Because it underweights the contribution of low frequency sound, it does not provide information sufficient to evaluate how sound energy transmits over distance or on its related health risks. More appropriate measures are needed.

Table 5: Measured Operational Sound Levels of Equipment with Equivalent Manufacturer Sound Ratings at Distances of 5 Feet to 800 Feet (Outdoors).

Make/Model	Type	Measured L_{90} dBA					
		5 ft	50 ft	100 ft	200 ft	400 ft	800 ft
Echo PB760	GLB	82	67	63	56	48	37
Greenworks GBB 600	BLB	83	64	57	46	41	38
Chervon EGO 600	BLB	77	64	57	49	45	41
Range of difference in sound pressure levels (dBA): GLB vs BLB		-1 to 5	3	6	7 to 10	3 to 7	-1 to -4
Relative difference in perceived loudness: GLB vs BLB		Similar to Noticeably louder	Noticeably louder	Noticeably louder	~ 2 times louder	Noticeably louder	Similar
BLB: Battery-powered leaf blower; GLB: Gas-powered leaf blower							

Table 6: Measured Sound Levels of Equipment with Equivalent Manufacturer Sound Ratings (Indoors).

Make/Model	Type	Measured L_{90} dBA
Echo PB 760	GLB	43
Greenworks GBB 600	BLB	37
Chervon EGO 600	BLB	36
Range of difference in sound pressure levels (dBA): GLB *vs* BLB		6-7
Relative difference in perceived loudness: GLB *vs* BLB		Noticeably louder to 2 times louder
BLB: Battery-powered leaf blower; GLB: Gas-powered leaf blower		

Conclusions

GLBs affect many people with harmful levels of noise, known to cause serious health problems. The proliferation of GLBs along with other noisy pieces of gas-powered equipment are creating a public health problem in communities, exposing large numbers of people to harmful noise, including children and others who are especially vulnerable. Policy makers should raise public awareness of GLB and other gas-powered landscape equipment as local sources of harmful noise, as well as toxic emissions. Industry-manufacturers and service providers-should adopt equipment and practices that place the highest priority on the health of workers and the public.

Acknowledgements

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Conflicts of Interest

The authors declare no conflict of interests.

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ENVIRONMENTAL
Fact Sheet

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

29 Hazen Drive, Concord, New Hampshire 03301 • (603) 271-3503 • www.des.nh.gov

ARD-22 2020

Take Steps to Limit Air Emissions When Using Garden Equipment

Did you know that every time you mow your lawn, you are contributing to air pollution? According to the U.S. Environmental Protection Agency (EPA), one hour operating a new gasoline lawn mower emits the same amount of volatile organic compounds and nitrogen oxide driving a new car 45 miles. Garden equipment engines produce up to 5% of the nation's air pollution. Gasoline-powered lawn and garden equipment emit air pollutants such as carbon dioxide, carbon monoxide, hydrocarbons, volatile organic compounds, nitrogen oxides and particulate matter.

Some of these air pollutants contribute to the formation of ground-level ozone and haze. While ozone occurs naturally in the upper atmosphere and shields the earth from harmful radiation, ozone at ground level is a harmful pollutant.

Ground level ozone affects your health, your neighbor's health, and the environment. Ground level ozone is especially harmful to sensitive receptors such as children, the elderly and people with respiratory ailments like asthma.

Exhaust emissions from gasoline-powered engines can lead to health problems such as respiratory disease, cancer, cardiovascular disease, neurological conditions and premature death.

Every time you fill your gas can and mower, you are emitting volatile organic compounds into the air and risk releasing gasoline to the environment through an accidental spill. EPA estimates that over 17 million gallons of gasoline is spilled as garden equipment is refueled each year. This can migrate through the ground and impact your drinking water.

Tips for Reducing Emissions from Lawn and Garden Equipment

Switch to Electric Operated Equipment.

Electric corded or battery -powered lawn and garden equipment produce no emissions and require no gas or oil to operate, hence no annual maintenance. An added bonus is electric garden equipment is significantly quieter than the gasoline fueled equipment.

Purchase Newer Equipment.

If you still want to use a gasoline powered lawn and garden equipment, purchase new and avoid using older equipment. Phase 3 engines, which reduce air pollution up to 70%, have been included in all small non-road equipment since 2012.

Maintain your equipment.

Like cars, properly maintained lawn and garden equipment are less likely to pollute and will perform better and last longer. Perform maintenance as recommended in your user's manual.

Avoid spilling gasoline or allowing it to evaporate.

Because even small gasoline spills evaporate and pollute the air and water, preventing spills and over-fills is an easy and effective way for power equipment owners to prevent pollution. Use a spill-proof gasoline container in a size you can handle easily and hold securely.

Shrink your lawn.

Consider shrinking your lawn or getting rid of it completely. You can plant native grasses and wild flowers instead that may attract pollinating bees and butterflies. If you have less lawn you need to use your garden equipment less which will reduce fossil fuel use and air pollution. A smaller lawn may reduce your water usage too, somewhere between a third and one half of residential water use is for lawn and garden irrigation. Finally, think of all that time you can spend in the hammock looking at your wild flowers rather than mowing the lawn.

BIRMINGHAM
A WALKABLE CITY

MEMORANDUM

Planning Department

DATE: June 23, 2025

TO: Environmental Sustainability Committee

FROM: Summer Aldred-Arens, City Planner

SUBJECT: Community Engagement Plan Draft

Attached is the draft Community Engagement Plan developed to support implementation of the Birmingham Green Healthy Climate Plan. This document outlines a structured framework for planning, executing, and evaluating public engagement activities that advance the Plan's goals, including carbon neutrality by 2050 and a 25% reduction in greenhouse gas emissions by 2035.

The engagement strategy emphasizes equity, transparency, and adaptability, and incorporates a variety of methods including in-person outreach, digital tools, printed materials, and regional collaboration. Roles and responsibilities are clearly defined, a phased timeline provides structure, and key performance metrics are included to measure progress and impact.

A demographics page is anticipated in a future draft to help ensure that outreach strategies are inclusive and reflective of Birmingham's population characteristics.

Feedback from the Committee is encouraged to refine this plan and ensure alignment with the City's climate and community engagement objectives.

CONNECT. ENGAGE. LISTEN. BUILD.

Birmingham Green Healthy Climate Plan

Community Engagement Plan

Table of Contents

GREEN

Introduction

Purpose

The purpose of this document is to provide a comprehensive framework for planning, executing, and monitoring community engagement activities for the Birmingham Green Healthy Climate Plan. The Plan aims to achieve carbon neutrality by 2050 while fostering community ownership and actionable participation to achieve the plan's key targets by 2035. This engagement plan emphasizes meaningful two-way communication, inclusivity, and adaptability to ensure alignment with community needs and priorities.

A core component of this effort is a commitment to environmental justice, prioritizing historically underserved and frontline communities who are most vulnerable to the impacts of climate change. By centering equity in outreach and decision-making, the City seeks to ensure that all residents, regardless of background or neighborhood, have a voice in shaping a healthier and more resilient Birmingham.

Carbon Neutrality Goals

Reduce carbon emissions by

25%

by 2035

Carbon Neutral by

2050

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Goals for Engagement

Connect 1

Foster trust and transparency among stakeholders and residents.

Engage 2

Engage a diverse cross-section of the Birmingham community.

Listen 3

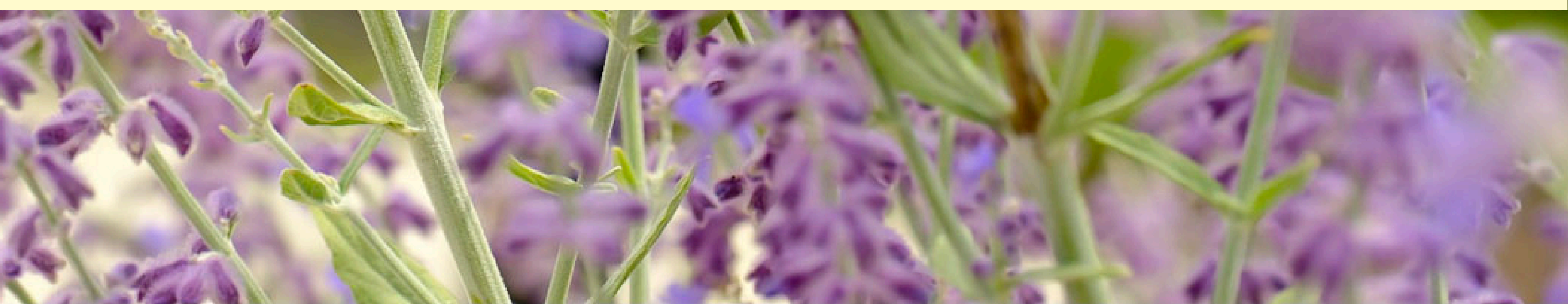
Ensure continuous feedback and iterative improvements to the Plan.

Build 4

Translate input into actionable projects and policies that support climate goals.

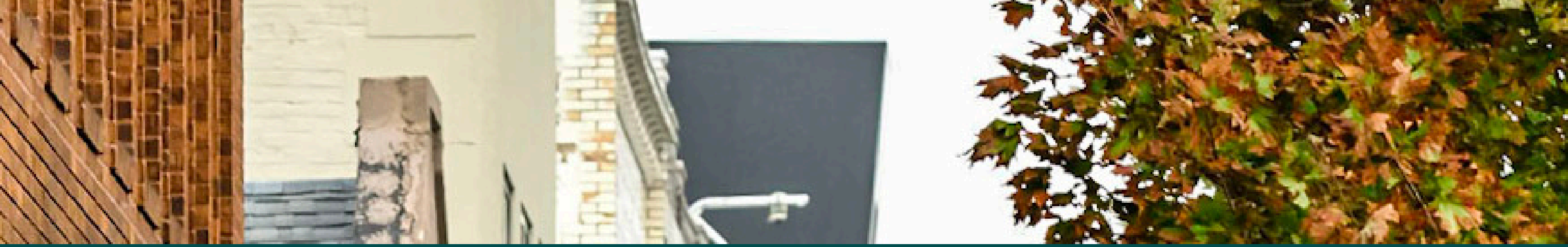
GREEN

Plan Overview



Plan Overview

The Birmingham Green Healthy Climate Plan is the City of Birmingham's comprehensive roadmap to achieve carbon neutrality by 2050, while improving environmental quality, public health, and long-term community resilience. Adopted in 2024, the Plan outlines targeted strategies across seven key areas: transportation, energy use in buildings and facilities, natural resource protection, water and stormwater management, waste reduction, municipal operations, and quality of life enhancements. It establishes near-term benchmarks, including a 25% reduction in greenhouse gas emissions by 2035, and provides a framework for integrating sustainability into everyday municipal decisions. Grounded in best practices and shaped by regional data and climate modeling, the Plan reflects Birmingham's commitment to responsible stewardship, economic vitality, and a livable, healthy future for all residents.



Engagement Framework

Engagement Objectives

1

INFORM

Share clear, accessible information about the Plan.

2

CONSULT

Seek input on priorities, concerns, and proposed solutions.

3

INVOLVE

Actively involve stakeholders in decision-making processes.

4

EMPOWER

Enable community members to be involved and take on leadership in climate initiatives.

Stakerholders

- Residents
- Local Businesses
- Community Organizations: Nonprofits, schools, and advocacy groups.
- Youth and Seniors: Ensuring engagement across age demographics.
- Underserved Communities: Including low-income households and individuals with disabilities

Engagement Approach

Proposed Engagement Strategies

To ensure inclusive, transparent, and effective community participation throughout the implementation of the Birmingham Green Healthy Climate Plan, we identified a range of engagement approaches designed to meet residents where they are—both physically and digitally. These strategies emerged from a review of best practices in equitable climate planning, feedback from previous city initiatives, and the unique characteristics of Birmingham's neighborhoods. Our approach balances in-person events, like public meetings and pop-up engagements, with digital tools such as an interactive website and online workshops to broaden accessibility. We also recognized the importance of printed materials for reaching all age groups and media preferences. Additionally, our commitment to intergovernmental collaboration ensures Birmingham remains a regional leader, with staff regularly engaging with local, state, and national networks such as the Catalyst Leaders Circle and SEMCOG's Healthy Climate Task Force—bringing back critical updates and aligning our efforts with broader sustainability goals.

1

In-Person Engagement

- Public Meetings and Open Houses: Provide updates, seek input, and share progress.
- Focus Groups: Address specific topics like energy efficiency or public transit.
- Pop-Up Events: Outreach at community hubs like farmers' markets or libraries.

2

Digital Engagement

- Interactive Website: Host resources, surveys, and feedback forms.
- Social Media: Regular updates and event promotions.
- Online Workshops: Virtual participation for broader accessibility.

3

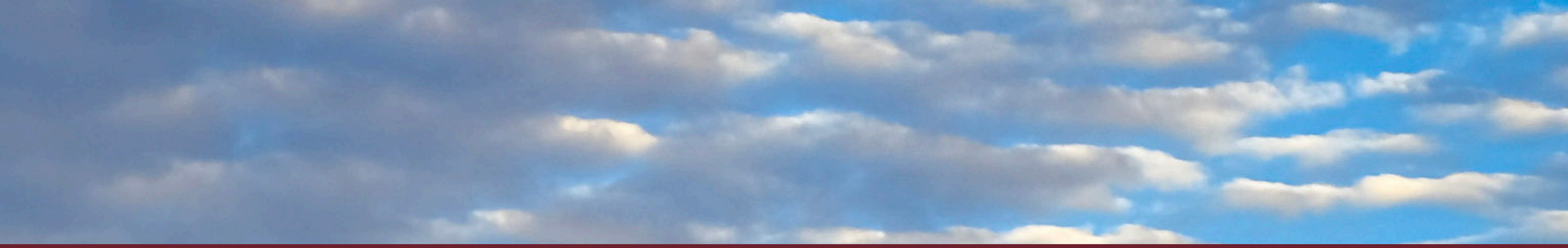
Printed Materials

- Flyers, brochures, posters, stickers, & other materials distributed at key locations.

4

Local/Regional/State/National Participation

- Groups like CLC, Healthy Climate Task Force, FOTR, CLWA etc.
- Bringing important info back to Birmingham residents
- Regional leader
- Recaps



Roles & Responsibilities

Roles & Responsibilities

Successful implementation of the Birmingham Green Healthy Climate Plan requires clearly defined roles and responsibilities across city departments, partner organizations, and community stakeholders. This section outlines who is accountable for advancing key actions, monitoring progress, and ensuring alignment with the plan's overarching goals. By clarifying leadership roles, support functions, and opportunities for collaboration, we aim to foster shared ownership, build internal capacity, and create accountability at every level. Establishing these responsibilities up front also helps streamline coordination, allocate resources effectively, and support long-term success across implementation phases.

Role	Responsibilities
Engagement Team	• Includes members of city staff, Environmental Sustainability Committee (ESC), and volunteers • Plan and execute engagement activities
City Staff	• Facilitate communication and promote activities locally.
Community Ambassadors	• Act as liaisons to the Birmingham community, including historically underrepresented groups (youth/seniors)
Stakeholders	• Provide feedback and advocate for community priorities.

GREEN

Engagement Methods

Engagement Methods

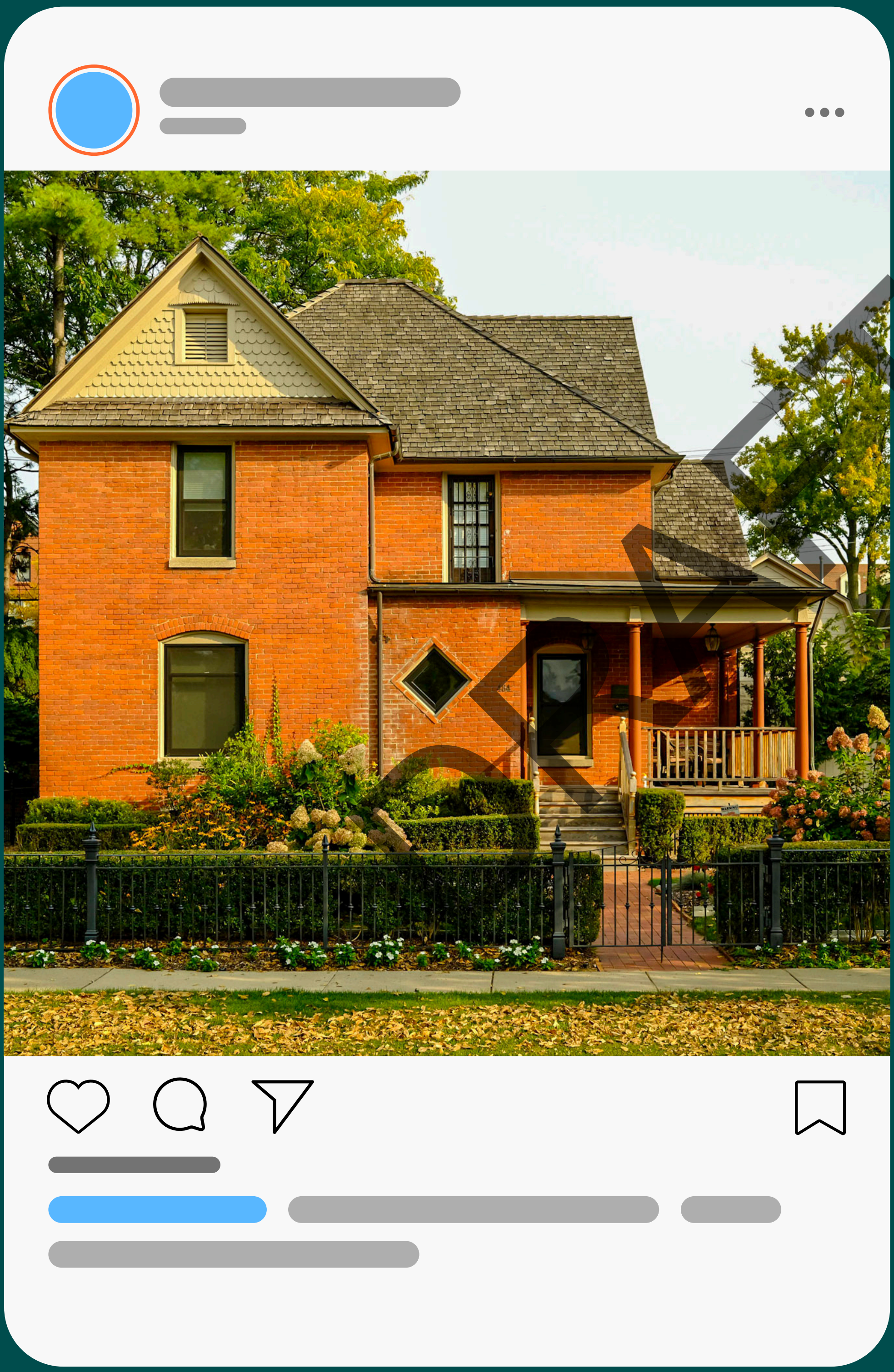
To support meaningful and ongoing participation throughout the implementation of the Birmingham Green Healthy Climate Plan, we are deploying a variety of engagement methods tailored to inform, involve, and empower community members. These tools and techniques are designed to ensure transparency, track progress, and facilitate two-way communication. From interactive surveys and focused workshops to accessible materials and digital content, our methods aim to engage a broad cross-section of residents. Regular monitoring and reporting—through quarterly updates, newsletters, and presentations to the Environmental Sustainability Committee and City Commission—will ensure that public input remains central to the plan's evolution and that progress is communicated clearly at every stage.

Tools & Techniques		
Progress Tracker	**Suverys & Polls**	**Workshops and Panels**
Live look on progress of action items	Collect quantitative and qualitative input.	Deep-dive discussions on Plan elements

Materials		
Hard-Copy Information	**Social Media**	**Online Reports**
ADA-compliant flyers and presentations.	Social media graphics and content.	Reports summarizing feedback and next steps.

Monitoring and Reporting		
Progress Updates	**Outcomes**	**Reports**
Publish quarterly progress updates.	Share engagement outcomes through newsletters and online portals.	Reports to ESC & annual report to City Commission.

Social Media Examples



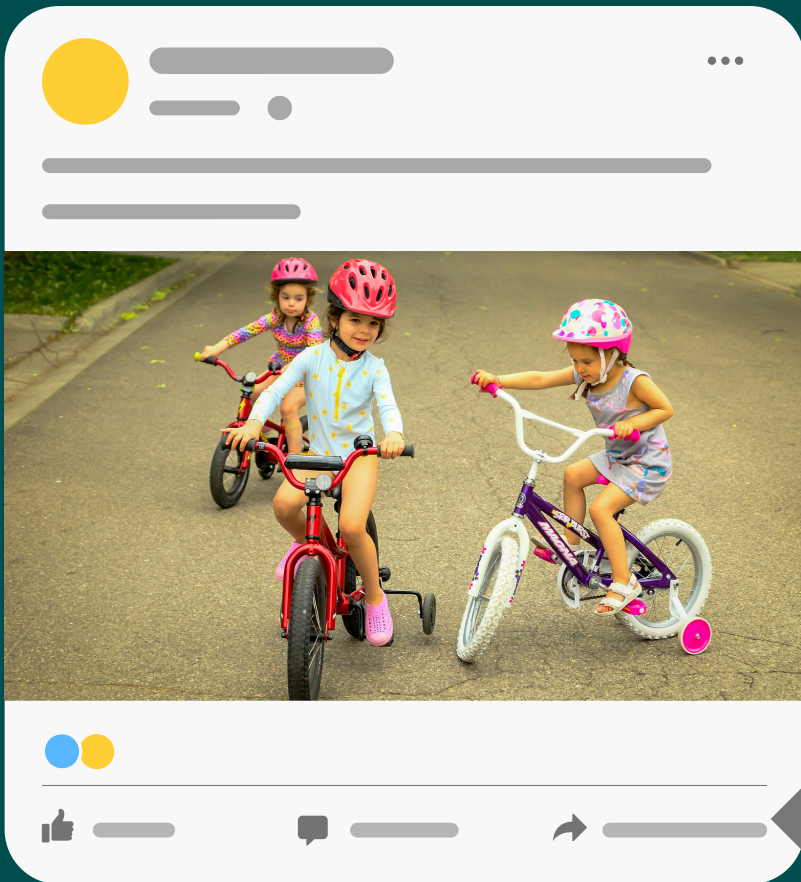
Instagram Post Example

Did you know? Buildings account for nearly 40% of energy use in the U.S. 💡

In Birmingham, small changes in your home can make a big impact – like switching to LED bulbs, sealing drafty windows, or setting your thermostat just 2° lower in winter.

Together, we can make Birmingham greener, one action at a time!

Follow us for more simple sustainability tips you can use every day. #GreenHealthyClimate #BirminghamMI #SustainableLiving #EnergySmart



Social Media Examples

Facebook Post Example:

What Does Sustainability Mean for Birmingham?

Sustainability isn't just about recycling or turning off lights – it's about making thoughtful choices that protect our environment and improve the quality of life for current and future generations.

In Birmingham, that means:

- Expanding clean energy use
- Supporting walkable neighborhoods
- Promoting bike-friendly infrastructure
- Protecting our trees and green spaces

We're building a future that balances environmental health, economic opportunity, and community well-being. Want to learn more about our Green Healthy Climate Plan and how you can get involved? Visit [insert link]!

#BirminghamMI #SustainabilityMatters #GreenHealthyClimate #ThinkGloballyActLocally #CommunityDrivenClimateAction

Metrics for Success

Metrics for Success

To ensure the Birmingham Green Healthy Climate Plan delivers meaningful results and remains accountable to the community, we have established a clear set of success metrics. These metrics will help us track progress, assess the effectiveness of our engagement strategies, and adjust our approach as needed. Centered on inclusivity, participation, and community empowerment, these benchmarks reflect our commitment to not only advancing sustainability goals, but also doing so in a way that is equitable and transparent. From tracking how many households we reach to measuring whether participants feel heard, each metric is designed to keep the plan grounded in real, measurable community impact.

Metric	Target
Participation	• Engage 30% of Birmingham households by Year 3.
Diversity of Input	• Ensure representation from all demographic groups
Community-Led Initiatives	• Launch 10 community-driven projects by 2029.
Satisfaction Rate	• 80% of participants feel heard and valued.

Timeline and Milestones

Timeline and Milestones

The successful rollout of the Birmingham Green Healthy Climate Plan requires a structured, phased approach to ensure steady progress, community alignment, and the ability to adapt over time. This timeline outlines key milestones from initial preparation through implementation and ongoing refinement. Each phase builds on the last, starting with internal planning, followed by broad public outreach, launching initiatives, and evaluating outcomes. By clearly defining these stages, we aim to provide transparency, manage expectations, and create space for continuous community input and improvement. This cycle will repeat as new goals emerge and as Birmingham's climate priorities evolve in alignment with our Plan. This phased approach will also serve as the standard procedure for each new action item that involves community engagement, ensuring consistency, responsiveness, and accountability throughout implementation.

Phase	Activity	Timeline
Participation	• Stakeholder mapping, resource allocation.	0-6 Months
Diversity of Input	• Public meetings, surveys, and focus groups.	6-12 Months
Community-Led Initiatives	• Launch pilot community initiatives and track engagement.	12-16 Months
Satisfaction Rate	• Evaluate outcomes and refine strategies.	12+ Months

Conclusion

Conclusion

The Birmingham Green Healthy Climate Plan's Community Engagement Plan provides a clear, strategic roadmap for fostering inclusive, transparent, and sustained participation as the city works toward carbon neutrality by 2050. Grounded in the principles of equity and collaboration, the plan outlines engagement goals to build trust, seek diverse input, and translate community feedback into actionable policy.

This document details a multi-faceted engagement framework that includes in-person, digital, and print strategies tailored to reach a wide range of audiences—residents, youth, seniors, businesses, and community organizations. Roles and responsibilities are clearly defined to ensure accountability, with city officials, community ambassadors, and stakeholders each playing a vital part. Engagement tools such as progress trackers, surveys, and accessible materials are supported by a monitoring and reporting structure to maintain transparency and responsiveness.

Success will be measured through defined metrics, including participation rates, diversity of input, and community-led initiatives, while a phased timeline ensures structured, adaptable implementation. Ultimately, this engagement plan empowers residents to be active participants in shaping Birmingham's climate future, reinforcing that a resilient and sustainable city must be built with its community at the center.

Thank you!

BIRMINGHAM GREEN

BIRMINGHAM
A WALKABLE CITY

MEMORANDUM

Planning Department

DATE: June 23, 2025

TO: Environmental Sustainability Committee

FROM: Summer Aldred-Arens, City Planner

SUBJECT: SCAP Gantt Chart

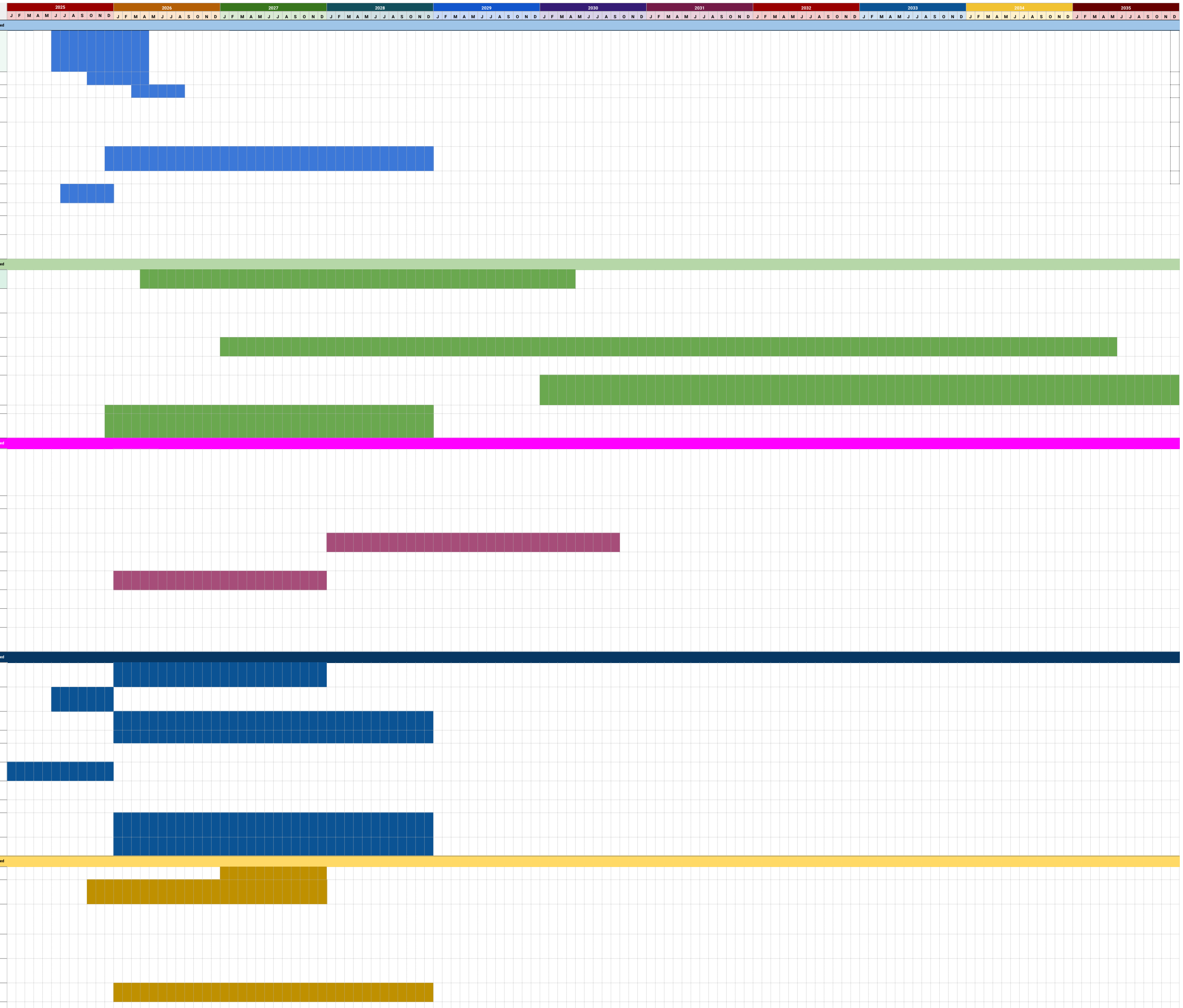
Below is the Gantt Chart outlining the anticipated timeline for implementation of the Birmingham Green Healthy Climate Plan (SCAP). This chart is intended to serve as a project management tool to support oversight, coordination, and evaluation of the plan's climate action items from 2025 through 2035.

The Gantt Chart visually organizes the schedule of action items across the Plan's seven key focus areas: Water & Stormwater, Natural Resources, Quality of Life, Buildings & Facilities, Waste, Transportation, and Municipal Operations. It includes anticipated start and end dates, lead departments, progress indicators, and completion percentages where available. This format is intended to support transparency and track progress in a clear and structured manner.

This tool also complements the broader Community Engagement Plan by identifying milestones and windows for public involvement aligned with implementation activities.

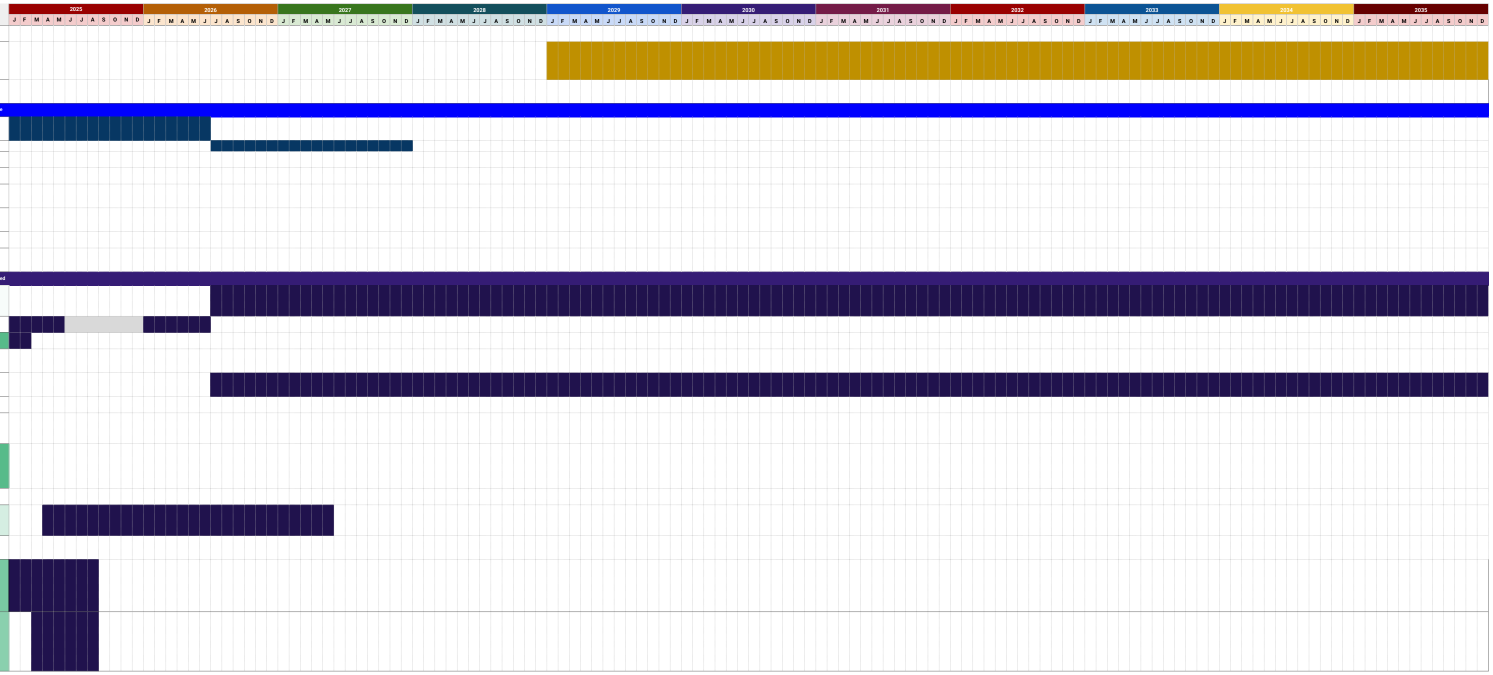
SCAP GANTT CHART

1	**Water and Stormwater**	**Department Lead**	**Date Started**	**Date Completed**	**Duration**	**Percent Completed**
WS-1*	Study the hydrology and topography of the City and produce recommendations toward targeting stormwater infrastructure improvements in areas that have the largest impact in reducing the negative effects of stormwater	Engineering Planning	6/11/25		-45161	10%
WS-2*	Adopt a residential rain garden program	Planning			0	0%
WS-3*	Develop a tracking system for green stormwater infrastructure	Planning			0	0%
WS-4	Form new alliances and improve existing alliances with municipalities and organizations that address stormwater runoff to the Rouge River				0	0%
WS-5	Require green infrastructure installations in every public infrastructure and development project				0	0%
WS-6	Require, through ordinance, green stormwater infrastructure installations on commercial properties	Planning			0	0%
WS-7	Reduce indoor & outdoor potable water usage city-wide				0	0%
WS-8*	Require stormwater retention or infiltration on all new single-family construction	Planning Engineering			0	0%
WS-9	Reduce barriers to local stormwater credit programs				0	0%
WS-10	Engage with the Clinton River Watershed Council and become a designated WaterTown				0	0%
WS-11	Produce a feasibility study for strategic use of public easements to manage stormwater and create naturalized areas				0	0%
2	**Natural Resrouces**	**Staff Lead**	**Date Started**	**Date Completed**	**Anticpated Duration**	**Percent Completed**
NR-1*	Protect and expand the tree canopy in each census tract of the City to at least 40%.	Planning			0	22%
NR-2	Promote the transition of private gardens and landscapes to native species and remove any barriers to such.				0	0%
NR-3	Study the issue of clear-cutting of lots in the City with special attention towards tree removal during construction projects.				0	0%
NR-4	Transition 100% of municipal plantings to native perennial plantings	Planning			0	0%
NR-5	Revisit streetscape standards to include better environments for street trees and plantings.				0	0%
NR-6	Prioritize the health of the Rouge River corridor and follow and support the recommendations of the Birmingham Plan 2040 related to the Rouge River.				0	0%
NR-7	Prohibit artificial turf as groundcover	Planning			0	0%
NR-8	Require, through ordinance, green roof's to be installed on all new commercial and mixed-use buildings in the City.	Planning			0	0%
3	**Quality of Life**	**Staff Lead**	**Date Started**	**Date Completed**	**Anticpated Duration**	**Percent Completed**
QL-1	Develop the newly acquired YMCA building and St. James Park into a nexus of intergenerational recreation opportunities including a resilience hub that will serve as a warming and/or cooling center as needed and better connect residents to city services.				0	0%
QL-2	Permit community gardens in select parks and public open space.				0	0%
QL-3	Include educational opportunities in sustainability and climate action projects that are accessible to everyone.				0	0%
QL-4*	Install one air quality monitoring station in the City and connect to the EGLE network.				0	0%
QL-5	Consider internal air quality monitoring systems in and around all municipal buildings.				0	0%
QL-6	Support and expand upon the sustainable land use decisions of the Birmingham Plan 2040.	Planning			0	0%
QL-7	Remove barriers to food production in residential zones and on residential properties.				0	0%
QL-8	Develop a green business certification program alongside the Birmingham Shopping District.				0	0%
QL-9	Maintain a regular flow of educational materials in newsletters, city publications, social media, and other outlets.				0	0%
4	**Buildings and Facilites**	**Staff Lead**	**Date Started**	**Date Completed**	**Anticpated Duration**	**Percent Completed**
BF-1*	Develop a plan to incentivize or require the transition from natural gas to electric in residential renovation and construction.	Planning			0	0%
BF-2*	Promote state and local energy efficiency programs and encourage homes and businesses to complete home energy audits and upgrades.	Planning			0	0%
BF-3	Remove any barriers to the use of geothermal energy strategies in the City.	Planning			0	0%
BF-4	Increase EV charging network city-wide.	Planning			0	0%
BF-5	Produce feasibility studies for solar photovoltaics on all city buildings and/or sites.				0	0%
BF-6	Expand the City's historic preservation program to protect existing buildings and character.	Planning	1/1/25		-45001	0%
BF-7	Develop a process for comprehensively monitoring energy usage for all city buildings.				0	0%
BF-8	Study the feasibility and placement of a community solar facility.				0	0%
BF-9	Promote green development in large commercial districts in Birmingham through improved Zoning Ordinance standards.	Planning			0	0%
BF-10*	Revise and expand ordinances related to solar photovoltaics and other alternative energy sources.	Planning			0	0%
5	**Waste**	**Staff Lead**	**Date Started**	**Date Completed**	**Anticpated Duration**	**Percent Completed**
W-1*	Develop a city-wide food waste composting program.	Planning			0	0%
W-2*	Study waste outside of the MSW program and work to improve data collection for commercial waste and other waste sources.	Planning			0	0%
W-3	Promote source reduction for waste to increase the practice of reducing or eliminating waste before it's created with a focus on plastics and food.				0	0%
W-4	Create a deconstruction ordinance to encourage the reuse and repurposing of building material during construction projects.				0	0%
W-5	Increase and improve quality of recyclables in curbside carts through direct education campaigns and audits.				0	0%
W-6	Require recycling opportunities in all new commercial and multifamily development projects.	Planning			0	0%
W-7	Develop bi-annual recycling events for hard to recycle materials.				0	0%



SCAP GANTT CHART

		Staff Lead	Date Started	Date Completed	Anticpated Duration	Percent Complete
W-8	Pilot a zero-waste policy for City-managed events.				0	0%
W-9	Invest in new local facilities and services for recycling food waste, electronics, textiles, hazardous materials and other specialty recycling.				0	0%
W-10	Engage with Oakland County on its Part 115 Solid Waste Management Plan				0	0%
6	**Transportation**	**Staff Lead**	**Date Started**	**Date Completed**	**Anticpated Duration**	**Percent Complete**
T-1	Continue to implement the City's current multi-modal transportation goals.	Planning			0	0%
T-2*	Update the City's multi-modal plan.	Planning			0	0%
T-3	Introduce bike sharing systems such as MoGo across the City.				0	0%
T-4	Advocate for more frequent and reliable transit service.				0	0%
T-5	Support the creation and maintenance of non-motorized transportation options in the City.				0	0%
T-6	Increase the maintenance of, and amenities within, all non-motorized facilities.				0	0%
T-7	Advocate for a Woodward Avenue road diet.				0	0%
T-8	Promote the use of mass transit in the City through enhanced transit stops.				0	0%
7	**Municipal Operations**	**Staff Lead**	**Date Started**	**Date Completed**	**Anticpated Duration**	**Percent Completed**
MO-1	Transition all administrative and light-duty municipal internal combustion engine vehicles and equipment to alternative fuels.	Planning			0	5%
MO-2*	Hire a full-time sustainability staff person and a stormwater specialist.	Planning			0	0%
MO-3*	Create a sustainability fund for use by multiple City Departments.	Planning	1/1/25	2/10/25	39	100%
MO-4	Establish a sustainable purchasing program and an internal administrative regulation.				0	0%
MO-5	Decrease vehicle miles traveled by municipal staff by 450,000 miles through incentive programs.	Planning			0	0%
MO-6	Adopt an anti-idling policy for all non-emergency City vehicles.				0	0%
MO-7	Identify and maintain a database of new and recurring grant opportunities geared towards sustainability and climate action.				0	0%
MO-8*	Create, by ordinance, an Environmental Sustainability Committee to oversee and make recommendations on a variety of issues related to sustainability and climate action.	Planning	9/23/24	10/7/24	14	100%
MO-9	Provide recycling opportunities in all public parks and other public spaces.				0	0%
MO-10	Phase out the use of all chemical pesticides, herbicides and fertilizers on city property and in park maintenance operations.	DPS			0	25%
MO-11	Increase or require specialized training for all workers who manage natural spaces.				0	0%
MO-12	Create a sustainability web page to act as a landing page for all city sustainability initiatives as well as to inform and educate residents on sustainable topics, best practices and relevant state and regional programs.	Planning			0	80%
MO-13*	Develop a comprehensive public engagement plan as early as possible to ensure that residents, businesses and other stakeholders in the City have the education and information necessary to meaningfully engage with the implementation of this plan.	Planning	3/24/25		-45084	70%



BIRMINGHAM
A WALKABLE CITY

MEMORANDUM

Planning Department

DATE: June 23, 2025

TO: Environmental Sustainability Committee

FROM: Summer Aldred-Arens, City Planner

SUBJECT: FloodWise Communities Cohort

The City of Birmingham is participating in the FloodWise Communities (FWC) cohort, a technical assistance program that supports municipalities in assessing the vulnerability of stormwater systems to climate-related flooding and other hazards. This effort is being led by the Planning Department, with collaboration from the Engineering Department and the Office of the City Manager.

Developed by the Great Lakes Integrated Sciences and Assessments (GLISA) team, the FWC process utilizes a web-based tool featuring localized climate and socioeconomic data. It guides communities through a step-by-step stormwater vulnerability assessment and generates a customized vulnerability matrix and report. These outputs can inform planning, capital improvements, hazard mitigation strategies, and grant applications.

Participation in this cohort will help further the City's goals of increasing community resilience, protecting public infrastructure, and proactively planning for the impacts of climate change, and start tackling recommendation WS-1 of the Birmingham Green Healthy Climate Plan which is, "Study the hydrology and topography of the City and produce recommendations toward targeting stormwater infrastructure improvements in areas that have the largest impact in reducing the negative effects of stormwater". The cohort kicked off in the beginning of June and will wrap up in the fall.

Questions or input related to the cohort may be directed to the Planning Department.

GLISA
A NOAA CAP/RISA TEAM

FloodWise Communities (FWC): Overview of Tool & Approach

Overview

- **Summary:** The FloodWise Communities (FWC) process guides practitioners through a municipal stormwater vulnerability assessment using a web-based tool with customized climate and socioeconomic information and a series of stepwise assessments.
- **Opportunity:** GLISA seeks partners to expand the reach of or improve the FWC process by conducting stormwater vulnerability assessments with partners in new locations and/or with different user groups.
- **To learn more:**

  FWC website

  Video tutorial

  City Outcomes & Testimonials summary

Applications: FWC was designed specifically to help communities assess the vulnerability and adaptive capacity of their stormwater systems to climate-related flooding and other hazards. The web-based tool offers communities a unique profile customized with local climate and socioeconomic information and the opportunity to select from 30 individual stormwater system components to assess (image 1). Additionally, multiple users can access the profile to work on the assessment collaboratively. Once the assessment is complete, results are automatically compiled into a vulnerability matrix (image 2) and corresponding reports that can be printed and shared with community leaders and other interested parties. Past participants have used the assessment to update stormwater design and fee structures, develop hazard mitigation plans, influence capital improvement planning, secure grants, and communicate risk to community leaders, among other applications (see City Outcomes & Testimonials summary).

Intended Audience: To date, the primary audience for FWC has been municipal practitioners (e.g., stormwater engineers, sustainability staff, public works officials). Moving forward, FWC will continue to be available to municipal users, however the process could be adapted to involve other types of participants (e.g., community groups or residents).

Data Sources: Localized weather and climate data come from existing, publicly available data sources that are detailed in the customized materials created for participating communities and determined to be credible by GLISA. Socioeconomic information is populated using the Neighborhoods at Risk (NaR) tool developed by Headwaters Economics as part of FWC (see next page).

> *“When we got invited to participate, it was sort of a no-brainer... it's really going to increase our capacity. The template is designed to provide individual communities, in this case around the Great Lakes region, essentially an overview in a written template of what the most likely climate impacts will be on their community.”*
>
> \- FWC user from Evanston (IL)

> *“It got a lot of our different divisions in the room together and discussing these things and seeing how climate change might impact something that Engineering Services is doing, but also sewers and streets. It was just really interesting to have all of us in the same room talking about these things.”*
>
> \- FWC user from Toledo (OH)

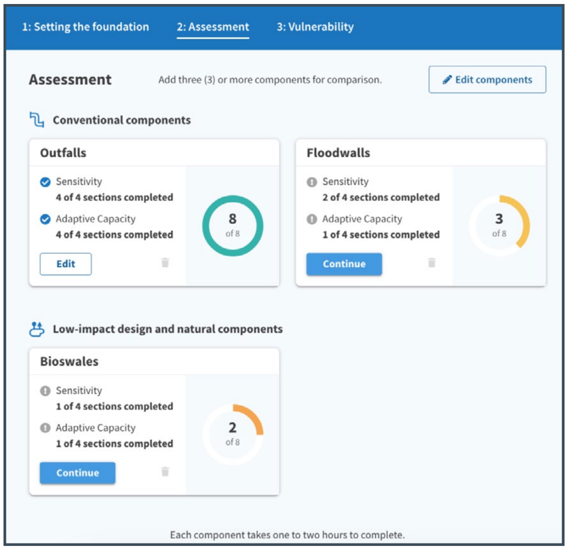


Image 1: Visual of the assessment dashboard including individual assessments for stormwater system components with prompts related to sensitivity and adaptive capacity.

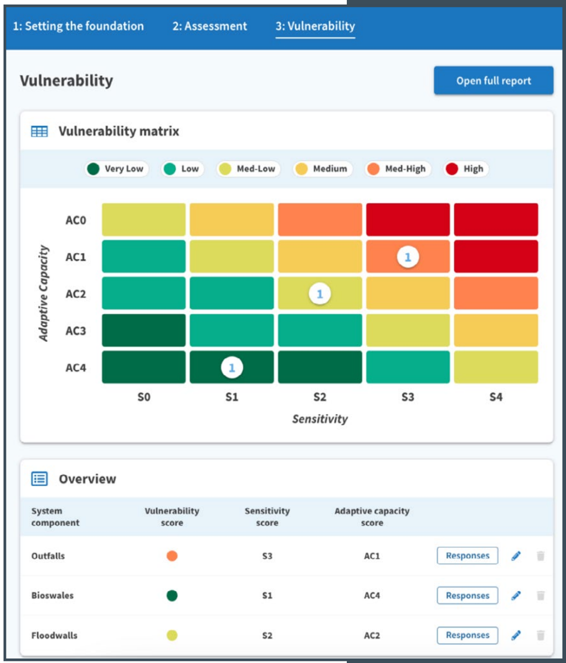


Image 2: Visual of the final vulnerability matrix with separate scores for individual stormwater system components.

Motivation & History: GLISA and partners have been building and refining the FWC tool and approach since 2017, making FWC one of GLISA's most developed tools and programs. It started as a collaborative project in 2017 with funding from the Urban Sustainability Directors Network, led by the Huron River Watershed Council with support from GLISA, Headwaters Economics, and the Great Lakes Climate Adaptation Network. In this phase I (2017-2018), the project team and practitioners worked together to create a framework that helped five small and mid-sized cities in the Great Lakes region mainstream climate and socioeconomic information into existing planning processes. The resulting Microsoft Excel template and Word document could be applied to city-wide or project-specific assessments and a pilot regional version of NaR was developed.

In phase II (2018-2019) with support from the NOAA Sectoral Applications Research Program, GLISA led the project team to adapt the template to stormwater management and implement it with 12 more Great Lakes cities to address the observed and projected increase in total and extreme precipitation. The team also started to explore different forms of engagement (i.e., in-person, remote via webinar, or self-guided) to see which methods would be most effective and efficient at reaching more communities while still delivering meaningful outcomes.

In phase III (2019-2023), GLISA led a new team to secure additional funding from the National Academy of Sciences Gulf Research Program to expand engagement and research in the U.S. Gulf region with the Southern Climate Impacts Planning Program (SCIPP), Adaptation International, Stanford University, and Headwaters Economics. The project team transferred the vulnerability assessment template into a formal web-based application, launched a national version of NaR, and completed vulnerability assessments with more than 50 communities across Alabama, Florida, Louisiana, Mississippi, and Texas, testing the same forms of engagement as in phase II. In all phases, each community received customized weather/climate and socioeconomic profiles to inform their assessments.

Contact: projectteam@floodwisecommunities.org

About GLISA

GLISA was established in 2010 and is a collaboration between the University of Michigan, Michigan State University, The College of Menominee Nation, and the University of Wisconsin. GLISA is the NOAA CAP (formerly RISA) team for the Great Lakes region. GLISA works at the boundary between climate science and decision-makers, striving to enhance Great Lakes communities' capacity to understand, plan for, and respond to climate impacts now and in the future.

Learn more at:
glisa.umich.edu

Contact us:
glisa-info@umich.edu

FloodWise Communities:
List of Available Stormwater Infrastructure Components to Assess

Boosting Local Capacity through Stormwater Vulnerability Assessments.

Conventional Components

- Above-ground storage
- Backwater gates
- Built environment
- Canals
- Catch basins or storm drains
- Channels
- Closed system components
- Combined sewers
- Control structures
- Conveyance
- CSO treatment basins
- Culverts
- Dams
- Detention basins
- Dikes
- Drainage ditches
- Effluent channels
- Flood gates
- Flood protection systems
- Flood walls
- Hydrodynamic separators
- Impervious cover
- Influent channels
- Inlet control structures
- Inlet filters
- Inlets
- Levees
- Lined channels
- Locks
- Main lines
- Oil-water separators
- Outfall interceptors
- Outfalls
- Outlet control structures
- Outlets
- Pavements
- Ports
- Pumps and pump stations
- Roadways and railroads
- Reservoirs
- Retaining walls
- Retention basins
- Sanitary sewers
- Sea walls
- Sediment traps
- Service lines
- Sewage overflow storage
- Sidewalks
- Spillways
- Storm sewers
- Stormwater pumps
- Subsurface pipes
- Sumps
- Treatment facilities
- Trunk lines
- Tunnels
- Underground pipes
- Underground storage
- Wastewater pumps
- Water and wastewater components
- Weirs

Natural / Low-Impact Components

- 100-year floodplains
- 500-year floodplains
- Bayous
- Beach-dune systems
- Bioswales
- Coastal barrier resource systems
- Dry basins
- Estuaries
- Flood sensors
- Floodplains
- Forests
- Groundwater
- Harbors and bays
- Infiltration basins
- Lakes
- Low-impact design components
- Monitoring stations
- Natural dikes
- Natural environment
- Natural levees
- Natural stream channels
- Open ditch drains
- Open system components
- Pervious cover
- Rivers and streams
- Stormwater wetlands
- Swales
- Unlined canals
- Unlined channels
- Urban green infrastructure
- Urban tree canopy
- Water quality sensors
- Wet basins
- Wetlands and marshes

FloodWise Communities:
Summary of Vulnerability Assessment Questions

Boosting Local Capacity through Stormwater Vulnerability Assessments.

STEP 1: Setting the Foundation	
GOAL: Assess Local Exposure	
Weather & Climate Conditions	• Which climate **conditions** & weather **events** affect your community now and in the future? • How could these conditions and events affect local **stormwater infrastructure**?
Weather & Climate Risk	• Which **areas** in your community are most impacted by climate hazards? • Which **community characteristics** could limit the ability for someone to prepare for and recover from these hazards? • Which **other local hazards** are present that may cause greater risk in your community?
Local Capacity	• What is your community's **local capacity** to fulfill stormwater management needs?
STEP 2: Stormwater Assessment *(completed for each stormwater infrastructure component assessed)*	
GOAL: Assess Infrastructure Sensitivity	
Infrastructure Stressors	• In the **past**, which stressors have impacted the component's performance? • In the **future**, which stressors may impact the component's performance?
Community Impacts	• In which **areas** of your community does this component perform less effectively? • Which **residents** are most likely impacted if this component is compromised? • Which **critical services** may be impacted if this component is compromised?
Sensitivity Score	• **Rank** how sensitive the component is to changing weather & climate conditions.

STEP 2: Stormwater Assessment *(completed for each stormwater infrastructure component assessed)*

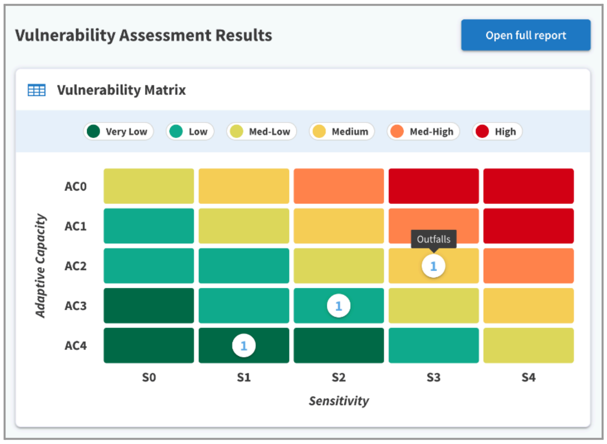
GOAL: Assess Infrastructure Adaptive Capacity

Assets	• Which assets are **available** to your community to maintain or improve the component's performance now and in the future? • Which assets are you **already using**? Which assets **could you be using**?
Needs	• What is needed to help this **component** adapt to changing conditions? • What is needed to limit **community impacts** if the component is compromised? • How feasible will it be to fulfill needs in key **management areas** for this component?
Constraints	• Which constraints limit the component's performance under **current** conditions? • Which constraints may limit the component's performance under **future** conditions?
Opportunities	• Which **opportunities** exist to adapt and take next steps?
Adaptive Capacity Score	• **Rank** how prepared the component is to adapt to changing weather & climate conditions.

STEP 3: Vulnerability Assessment Results

GOAL: Review Results & Plan Next Steps

At the end of the assessment, sensitivity and adaptive capacity scores for each component are displayed in a vulnerability matrix (right) to help communities prioritize next steps. Participants also receive a final report summarizing findings from the vulnerability assessment process. Participants own the outputs of the vulnerability assessment and can reference the matrix and full assessment at any time following the program in their custom account in the FloodWise Communities tool.



BIRMINGHAM

How do I dispose of...

socrra.org/waste-wizard

SOCRRA
Community Partners in Recycling & Waste