Session 1.5

Breathless: How urban forests and trees can contribute to the reduction of air, water and soil pollution

Chair: Yujuan Chen

World Forum on Urban Forests

2nd World Forum on Urban Forests

Washington DC, 2023

Forgotten Places: greening coastal towns and cities in the UK

How trees are breathing new life into Bexhill-on-Sea

TREES FOR CITIES

Presented by

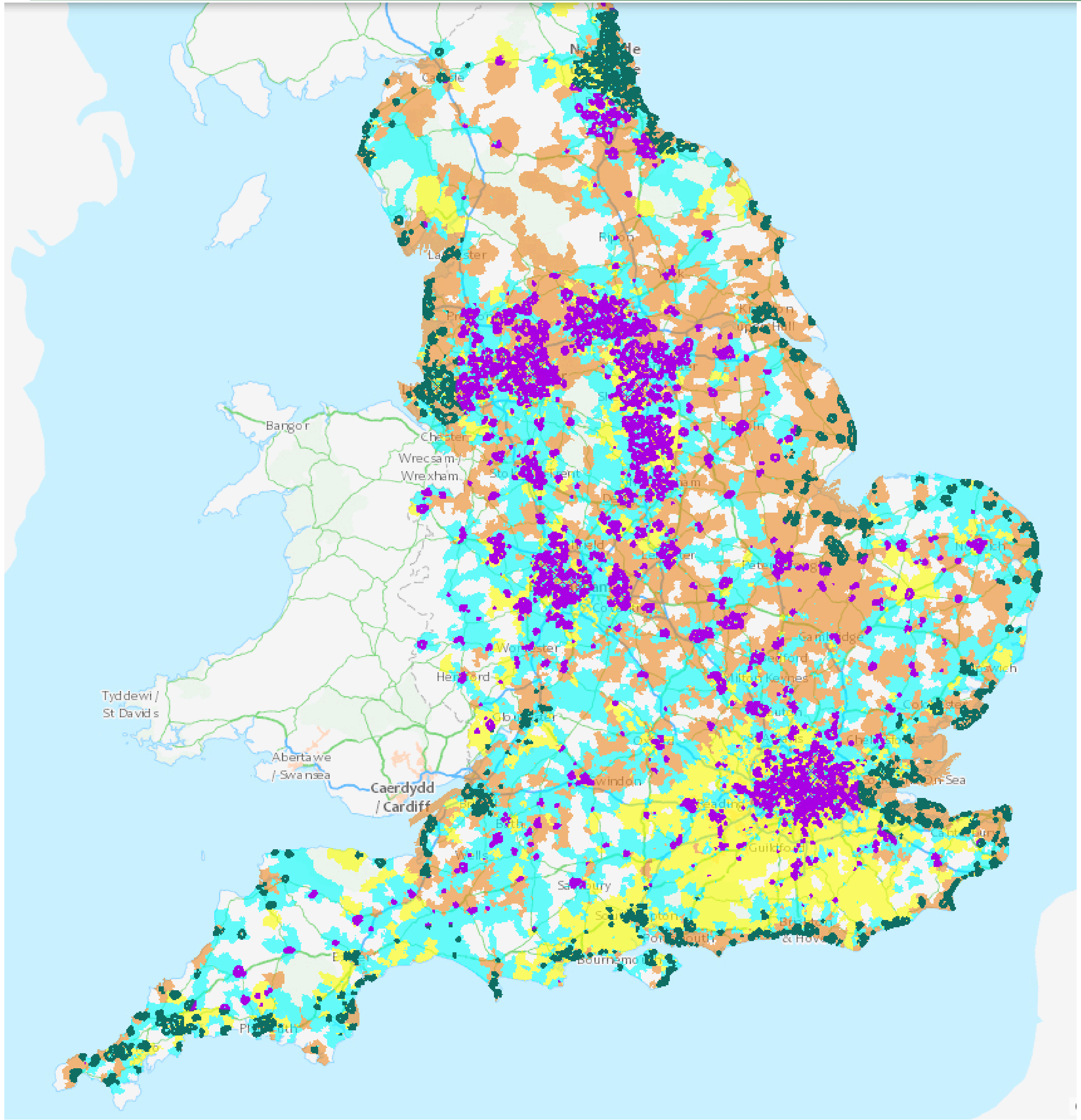
Kate Sheldon

Chief Executive, Trees for Cities

16 October 2023

TREE CITIES OF THE WORLD

TREES FOR CITIES


Bangor
Chester
Wrecsam
Wrexham
Tyddewi /
St Davids
Abertawe
/ Swansea
Caerdydd
/ Cardiff
Salisbury


Blackpool From the North Pier.
Chief Medical Officer's Annual Report 2021
Health in Coastal Communities
Map showing prevalence of coronary heart disease in England.
HOUSE OF LORDS
Select Committee on Regenerating Seaside Towns and Communities
Report of Session 2017–19
The future of seaside towns
Ordered to be printed 19 March 2019 and published 4 April 2019
Published by the Authority of the House of Lords
HL Paper 320

Forgotten Places Project 2021-23

- Delivery
- Research
- Modelling
- Campaign

Partnership and Collaboration

Green Recovery Challenge Fund

Department for Environment Food & Rural Affairs

The National Lottery Heritage Fund

Environment Agency

NATURAL ENGLAND

Brighton & Hove City Council

CPRE The countryside charity Sussex

FSC

GREAT YARMOUTH BOROUGH COUNCIL

Hull City Council

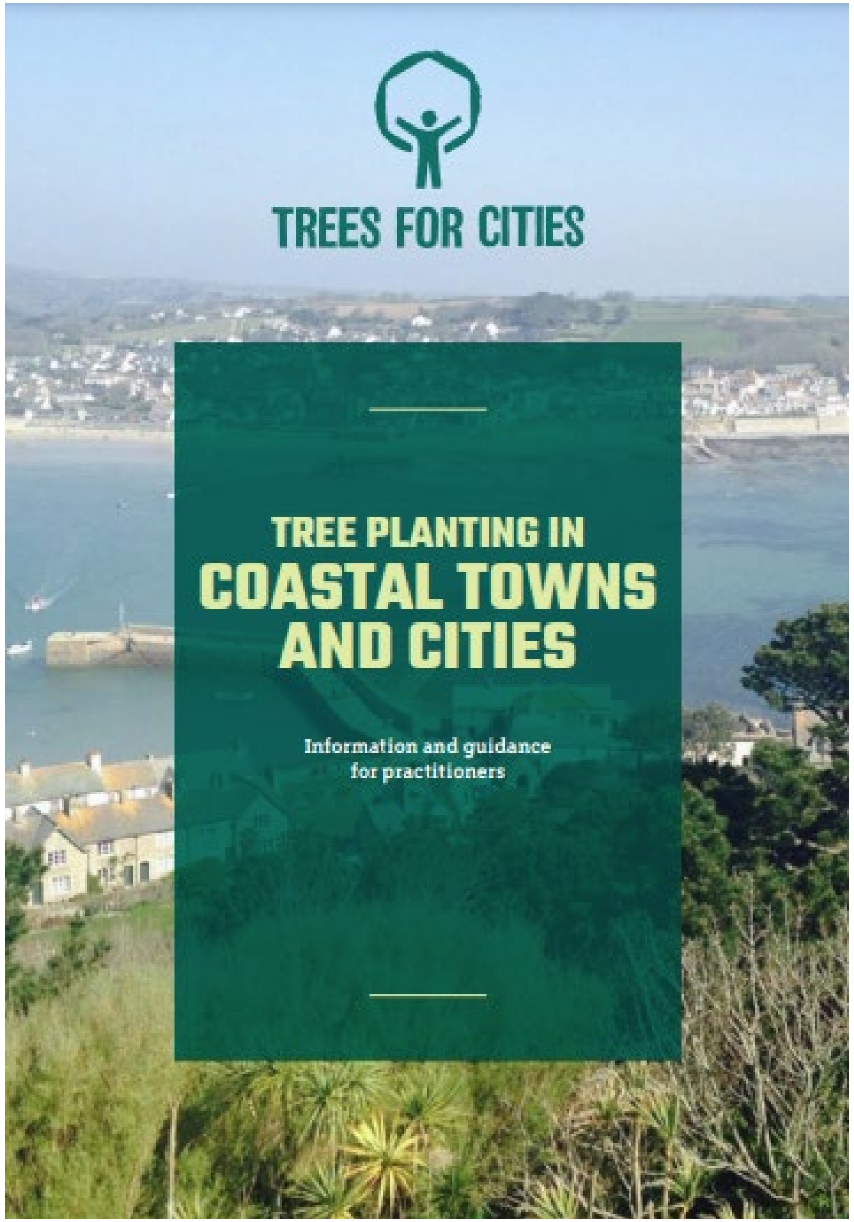
Portsmouth CITY COUNCIL

thanet district council

Rother District Council

Stockton-on-Tees BOROUGH COUNCIL

TREES FOR CITIES



A framework for Ecosystem Service improvement

- Improving place

- Increasing visits

- Growing goods and services

Forest Research

Technicalities of coastal planting

Practicalities of community engagement

Replicable model for strategic tree planting:

1) i-Tree Eco survey with local volunteers
2) Desktop opportunity mapping
3) Stakeholder consultation
4) Identify plantable spaces
5) Tree planting
6) Develop Tree Planting Strategy

TREES FOR CITIES

Treeconomics

Forest Research

Rother District Council


"IT WAS SUCH A LOVELY EVENT, SO CASUAL AND CHILLED WHICH MADE IT MORE ENJOYABLE. THE DEMONSTRATION WAS USEFUL AND THE TEAM WERE HELPFUL TOO MAKING SURE WE WERE ABLE TO DO IT. I REALLY ENJOYED THE DAY AND WOULD LOVE TO TAKE PART AGAIN!"
Stockton-On-Tees resident at a Trees for Cities community tree planting day


"I FELT LIKE I MADE A DIFFERENCE."
Hull resident at a Trees for Cities community tree planting day

Thank you

Kate Sheldon |Trees for Cities

[kate@ treesforcities.org](mailto:kate@treesforcities.org)
www.treesforcities.org

Food and Agriculture Organization of the United Nations
Arbor Day Foundation
POLITECNICO MILANO 1863
SISEF
ISA
Smithsonian
Forest Service U.S. Department of Agriculture

2nd
World Forum on Urban Forests

2023

World Forum on
Urban Forests

2nd World Forum on Urban Forests

Washington DC, 2023

Maximizing ecosystem services using phyto-recurrent selection for environmental applications

Presented by

Ryan A. Vinhal[1], Elizabeth R. Rogers[1,2], Ronald S. Zalesny[1]

[1] USDA Forest Service, Northern Research Station, Rhinelander, Wisconsin, USA

[2] University of Missouri, Center for Agroforestry, Columbia, Missouri, USA

Globally, 3.2 billion people are negatively impacted by land degradation*

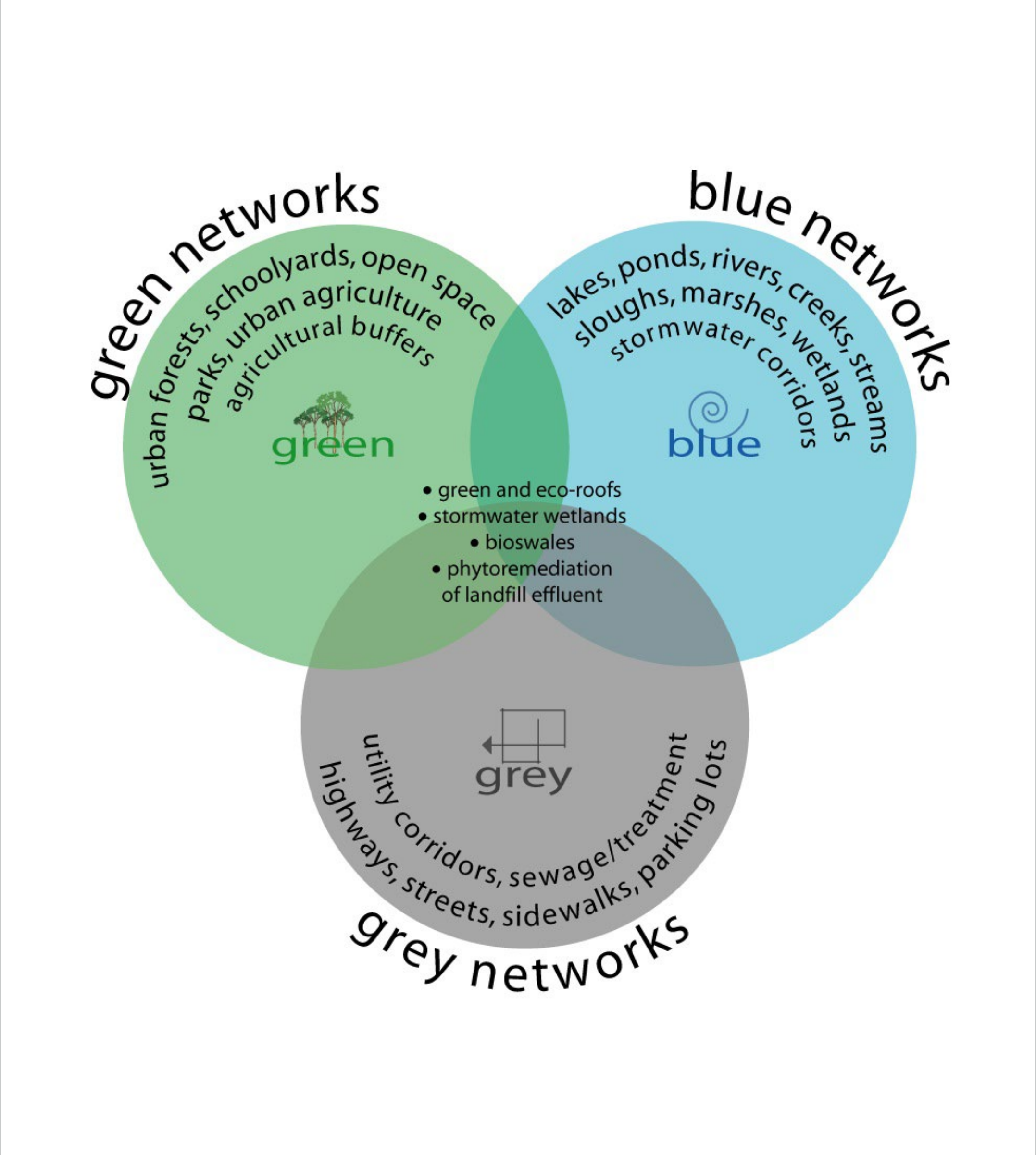
Sustainable, cost- effective solutions are needed to restore degraded lands

*IPBES (2018): Summary for policymakers of the thematic assessment report on land degradation and restoration of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. R. Scholes, L. Montanarella, A. Brainich, N. Barger, B. ten Brink, M. Cantele, B. Erasmus, J. Fisher, T. Gardner, T. G. Holland, F. Kohler, J. S. Kotiaho, G. Von Maltitz, G. Nangendo, R. Pandit, J. Parrotta, M. D. Potts, S. Prince, M. Sankaran and L. Willemen (eds.). IPBES secretariat, Bonn, Germany.

Phytotechnologies

"The **strategic use of plants** to **solve environmental problems** by remediating the qualities and quantities of our soil, water, and air resources and by **restoring ecosystem services** in managed landscapes."

-International Phytotechnology Society



Examples:

Green Roofs / Eco Roofs
Green Infrastructure
Stormwater Wetlands
Constructed Wetlands
Bioswales / Rain Gardens
Urban Tree Canopies
Vegetative Forest Buffers
Brownfields Restoration
Mine Reclamation

Phytoremediation


PC: greenroofs.org

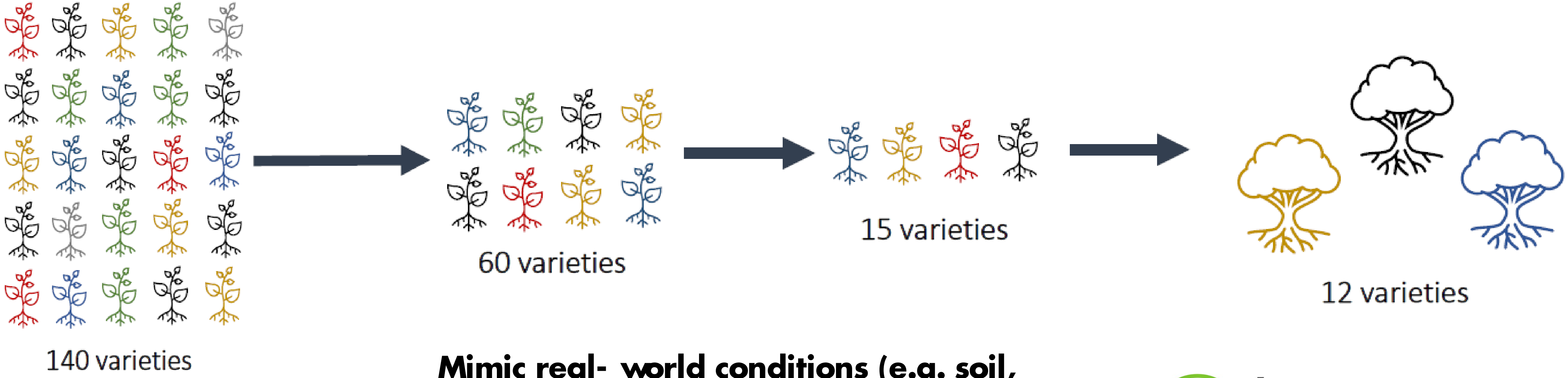

PC: easterlake.org


PC: American Society of Landscape Architects

How do we maximize the environmental benefits of trees grown for phytotechnologies and optimize system success?

Phyto- Recurrent Selection (PRS)

- **Process of choosing tree genotypes that are matched to conditions of individual sites**
- **Involves multiple selection cycles to select superior genotypes that can maximize system success**



Mimic real- world conditions (e.g. soil, irrigation)

Phyto- Recurrent Selection Process

Cycle 1

Cycle 2

Cycle 3

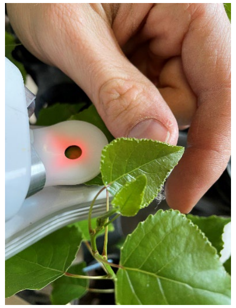
Cycle 4

Number of Genotypes

Data Complexity, Growing

Survival
Growth

Weighted summation index used to select genotypes for subsequent testing cycles based on data collected



Survival
Growth
Health
Physiology
Contaminant
Uptake

Phyto- Recurrent Selection Field Testing

- Long- term testing and monitoring of genotypes through the collection of data on:
  - Survival
  - Growth
  - Health
  - Physiology
    - Water Uptake
    - PEA, chlorophyll fluorescence, stomatal conductance, SPAD
  - Contaminant Uptake

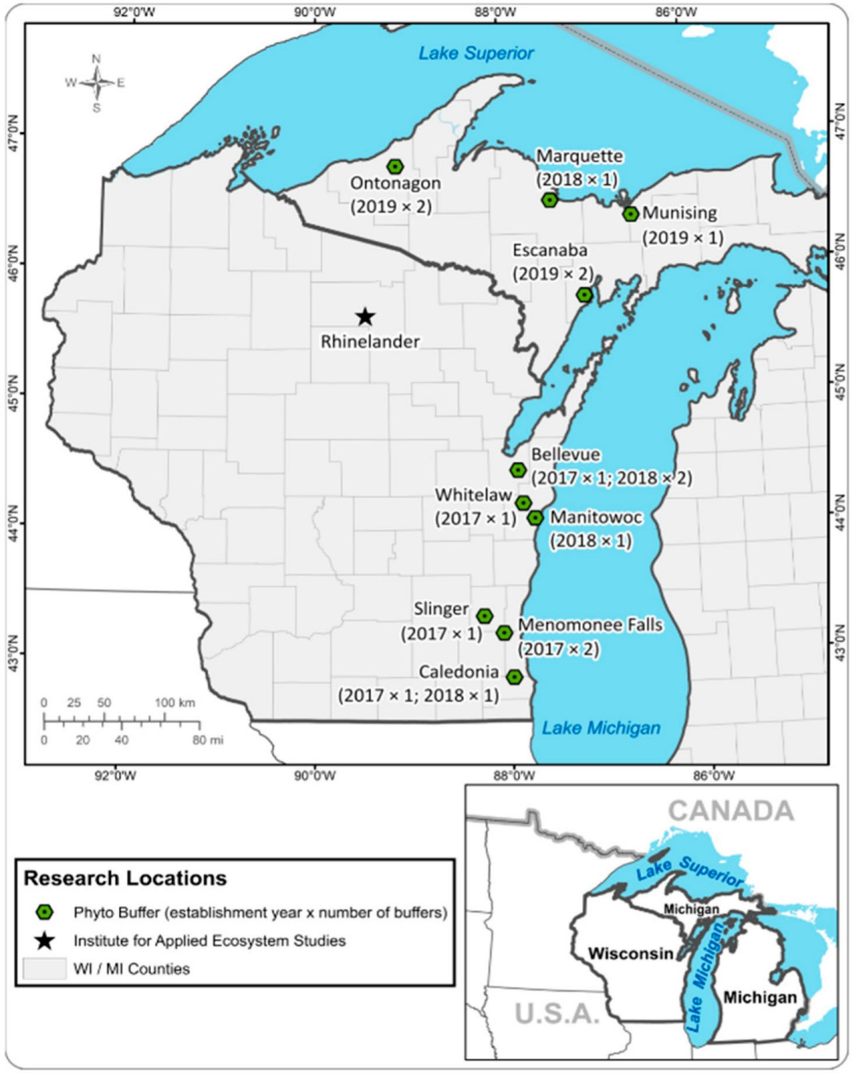
Results are necessary to evaluate performance over time and identify superior clones with long- term success

Environmental Applications of Phyto-Recurrent Selection

Landfill Phytoremediation Using PRS

Great Lakes RESTORATION

- Established 16 phytoremediation buffer systems across Wisconsin and Michigan
- Over 20,000 hybrid poplar and willow trees established across 3 years (2017-2019)
- Genotypes selected for each field site based on phyto- recurrent selection greenhouse cycles



Objective: ***Reduction of non- point source***

Landfill Phytoremediation Using PRS

Cycle 1

Cycle 2

Cycle 3

Multiple Growing Seasons Until Harvest

Greenhouse Testing

Field Implementation and Testing

Long- Term Monitoring of Field Plantings

Long- term phyto projects that maintain the plantings and collect data are important to evaluate long- term success

Phytoremediation/Phytostabilization of Michigans Stamp Sands

- 450,000 yards of copper ore mining waste, known as stamp sands, deposited at the Keweenaw Bay Indian Community's Sand Point
- Stamp sands have elevated levels of heavy metals, which can impact recreation, wildlife and culturally significant areas
- Need to select genotypes with the greatest potential to stabilize and remediate the stamp sands

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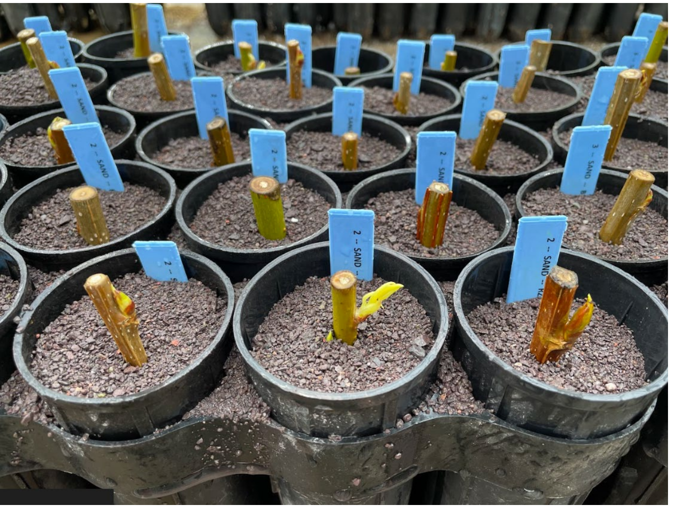
PRS for Stamp Sands Remediation + Stabilization

Keweenaw Bay Indian Community



Forest Service U.S. Department of Agriculture

2 cycles of PRS conducted using hybrid poplars and willows

Cycle 1

- 66 genotypes tested
- Survival and growth data collected
- 98.5% overall survival

Cycle 2

- 22 genotypes tested
- Survival, growth, health and physiology data collected

Data from cycle 2 used to select genotypes for field planting

7 days after planting

14 days after planting

21 days after planting

Remediation of Sulfur Pollution

- US congressional directive to study mercury and sulfur pollution
- Elevated levels of sulfate in waterways due mining, manufacturing and other activities
- Sulfate interacts with mercury to promote the formation of methylmercury, a potent neurotoxin

Objective: ***Develop sustainable, cost-effective methods to p… being t…rted to … accumu…***

FOREST SERVICE
U S
DEPARTMENT OF AGRICULTURE

Natural Resources Research Institute
University of Minnesota Duluth
Driven to Discover


600PPM Rep 3+4

Cycle 1

Identify poplar clones with superior growth and establishment under elevated SO_4^{2-} conditions

20 Hybrid Poplar Clones

Survival

Growth

- *Height*
- *Diameter*
- *Aboveground Biomass*
- *Belowground Biomass*

Cycle 2

Determine the threshold SO_4^{2-} concentration at which poplar growth and physiology are impacted

10 Hybrid Poplar Clones

Survival

Growth

- *Height, Diameter*
- *Aboveground Biomass*
- *Belowground Biomass*

Physiology

- SPAD
- Chlorophyll Fluorescence
- Stomatal Conductance

Cycle 3

Investigate the fate and transport of sulfur within the soil- poplar- water continuum

5 Hybrid Poplar Clones

Survival

Growth

- *Height, Diameter*
- *Leaves, Stems Biomass*
- *Belowground Biomass*

Physiology

- *SPAD*
- *Chlorophyll Fluorescence*
- *Stomatal Conductance*

Sulfur Mass Balance

- *Soil and Leachate Collection*

Other Phyto- Recurrent Selection Applications

Landfill Leachate

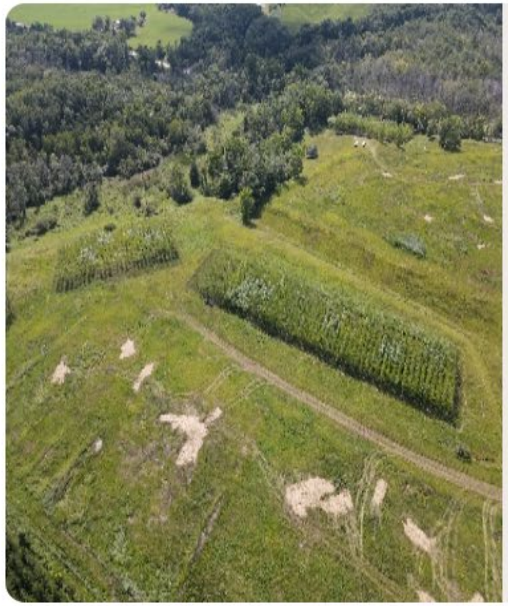
Mine Reclamation

Urban Afforestation

Phyto- Recurrent Selection Endorsed as "Good Practice" by the United Nations.

UNITED NATIONS DECADE ON ECOSYSTEM RESTORATION 2021-2030

Phyto-Recurrent Selection
Test. Select. Deploy.



Phyto-recurrent selection to enhance ecosystem services and livelihoods in rural and urban communities

United States of America

Description:
Phyto-recurrent selection is a technique for selecting and monitoring optimal varieties of trees to be implemented within phytotechnology applications. Typical applications where phyto-recurrent selection has been successfully applied include:...

Organization:
USDA Forest Service, Northern Research Station

Partners:
University of Missouri, Center for Agroforestry
Missouri University of Science and Technology
University of Minnesota Duluth, Natural Resources Research Institute
Waste Management, Inc.
AECOM Technical Services, Inc.
City of Manitowoc, Wisconsin
Marquette County Solid Waste Management Authority
Delta County Solid Waste Management Authority

Reviewers:
Robin Chazdon · Mahoussi Simone Assocle · Anita Diederichsen

Submitted: 2023-03-22
Published: 2023-05-30
Updated: 2023-03-22

Good Practice

source: FRAMEWORK ECOSYSTEM RESTORATION MONITORING

https://ferm- search.fao.org/practices/FERM_BYfbsJeRaOk6aL2vROB9

Scan Here to Learn More!

Thank you

Ryan A. Vinhal | USDA Forest Service

ryan.vinhal@ usda.gov

Elizabeth R. Rogers | USDA Forest Service

elizabeth.r.rogers@ usda.gov

Ronald S. Zalesny Jr. | USDA Forest Service

ronald.zalesny@ usda.gov

Food and Agriculture Organization of the United Nations · Arbor Day Foundation · d. · POLITECNICO MILANO 1863 · SISEF · ISA · Smithsonian · Forest Service U.S. Department of Agriculture

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Washington DC, 2023

Community-driven green infrastructure: an undercanopied neighborhood taking charge and making positive change

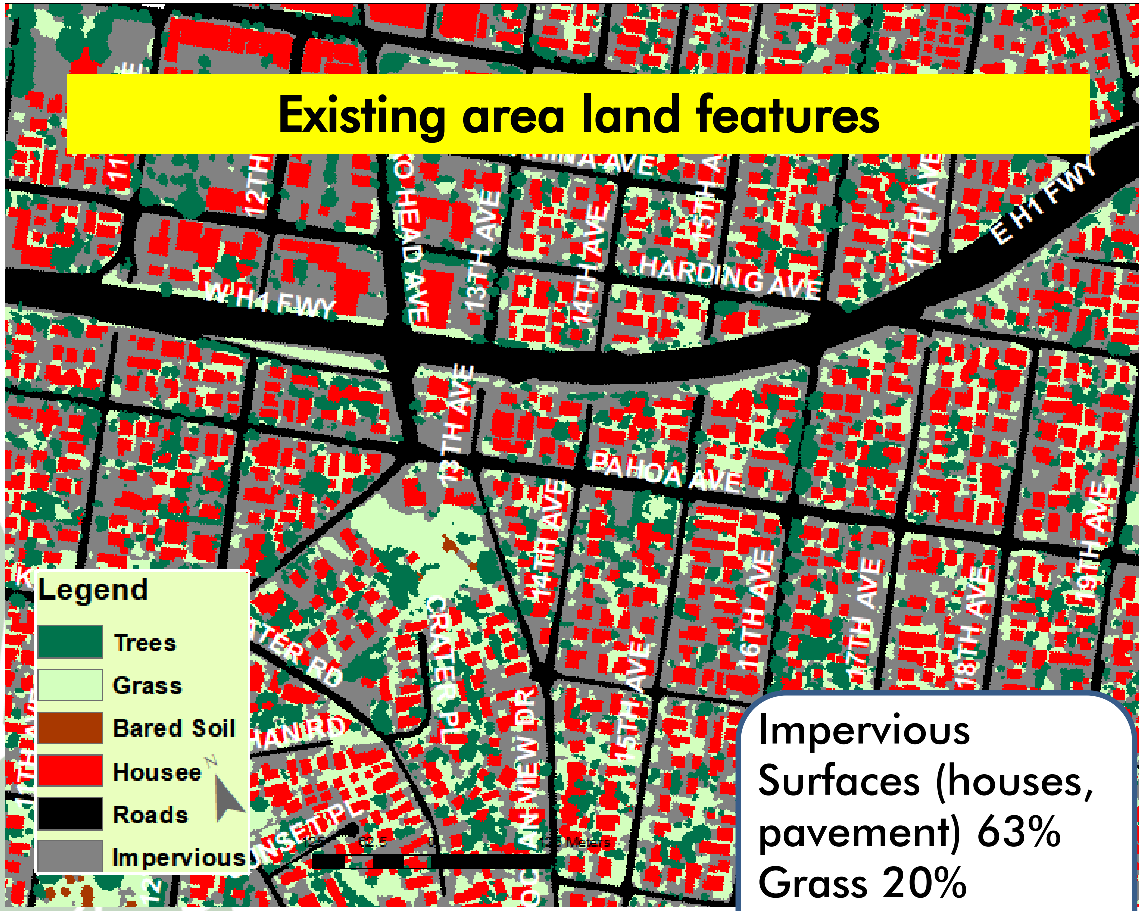
Presented by

Daniel Dinell

President, Trees for Honolulus Future

2nd World Forum on Urban Forests
Washington DC, 2023

TREES FOR KAIMUKĪ

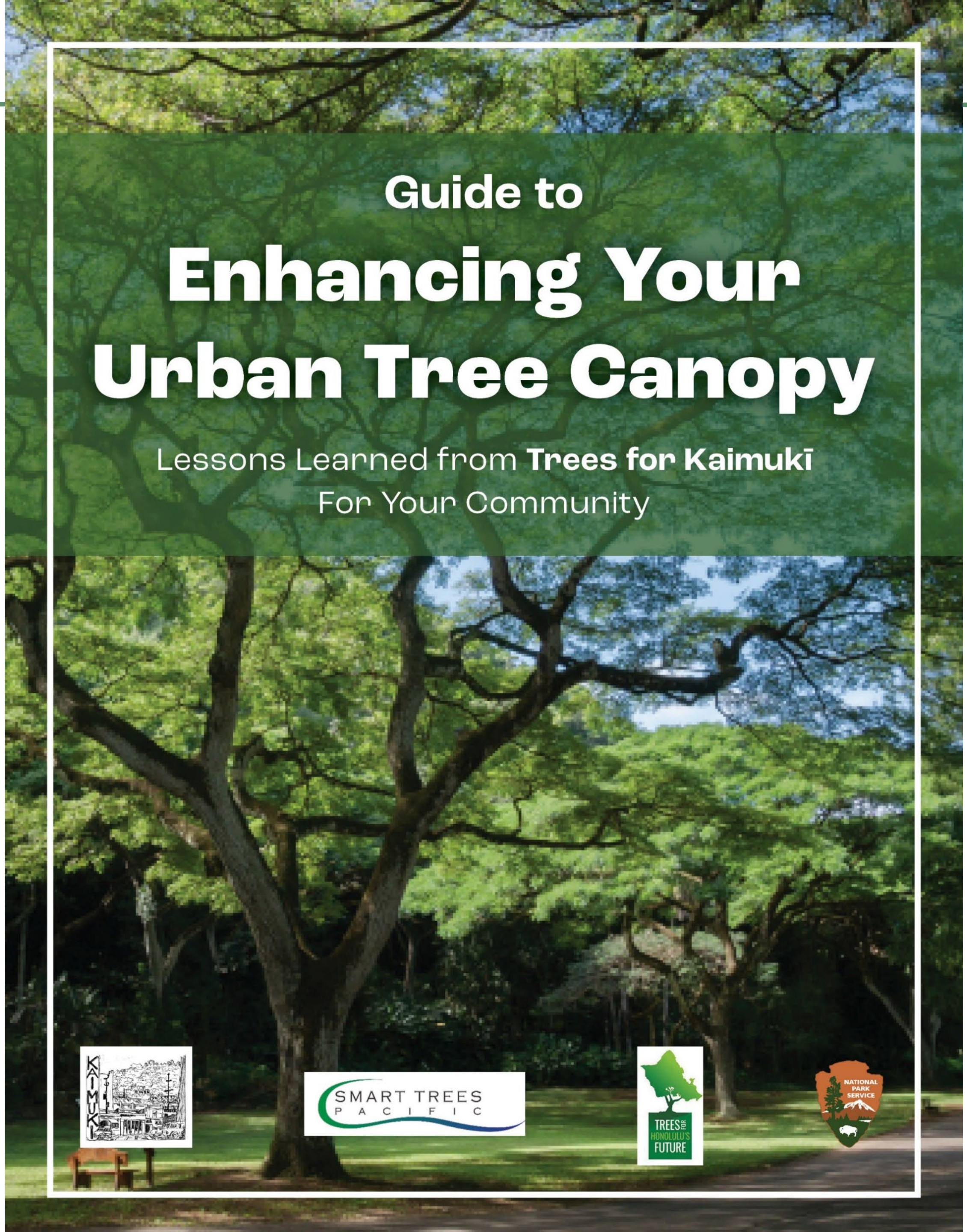


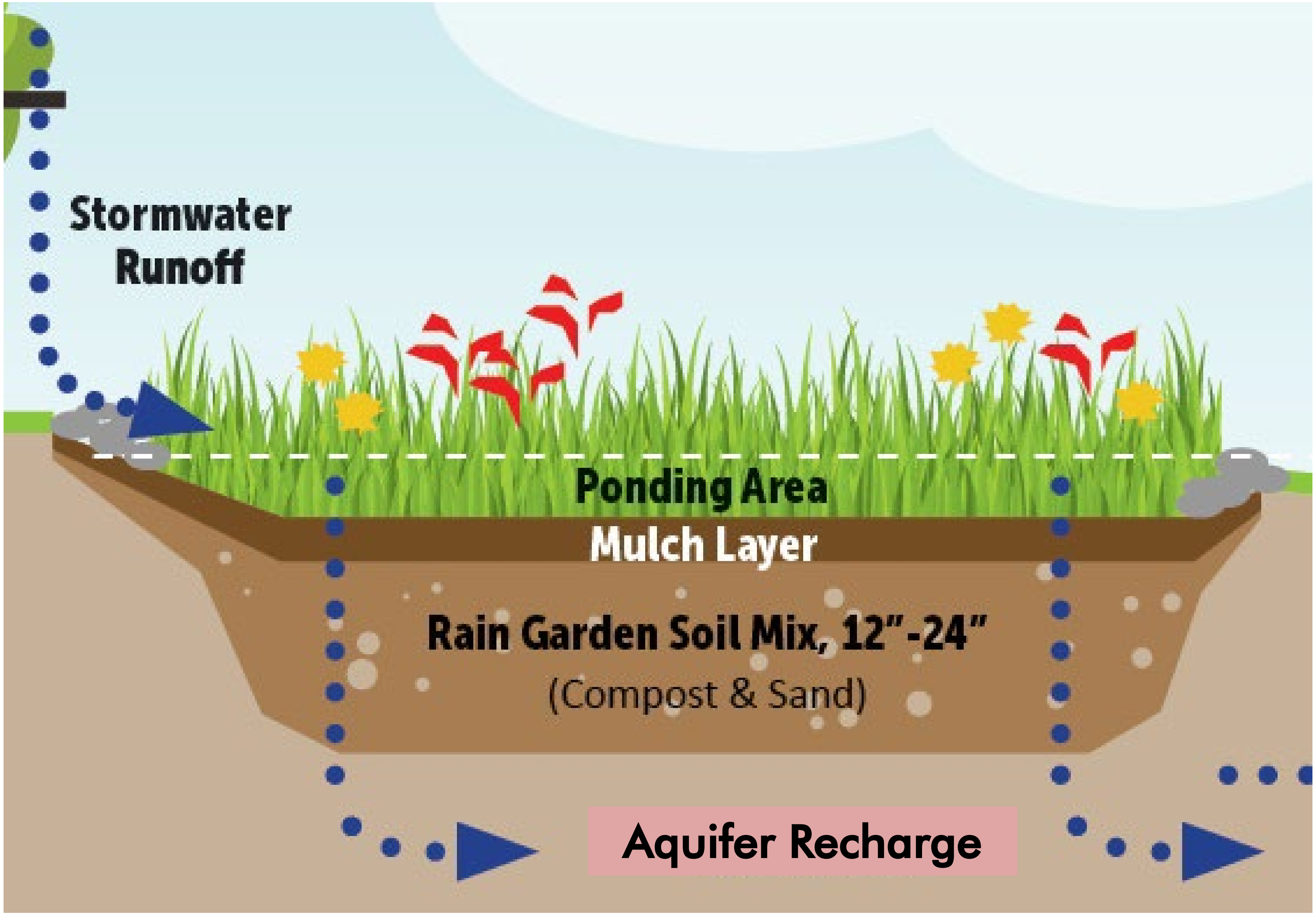
Impervious Surfaces (houses, pavement) 63%
Grass 20%
Trees 17%

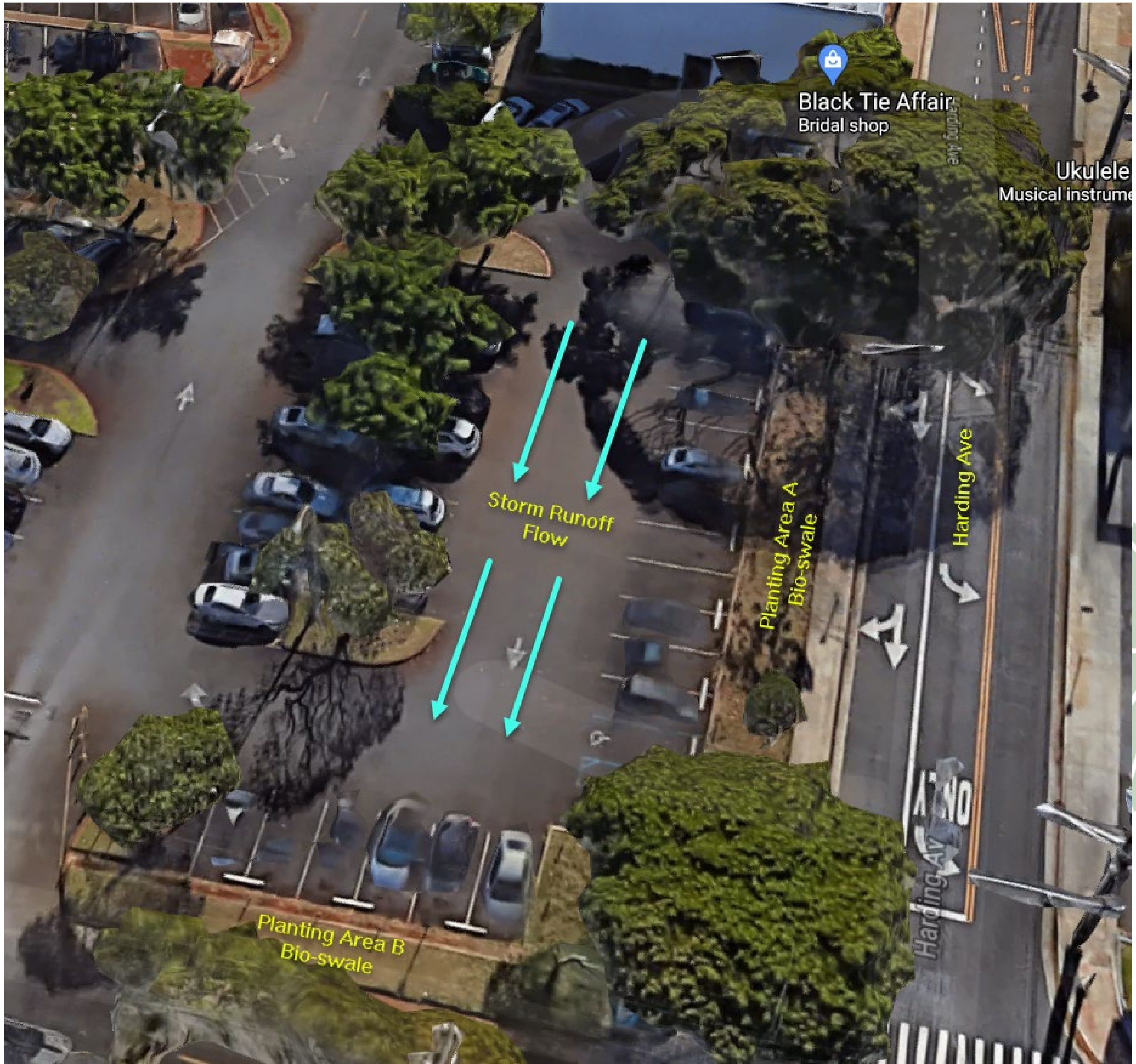
Goals

1. Serve as a replicable community-based model
2. Increase the urban tree canopy
3. Engage with residents and business owners

Community-driven

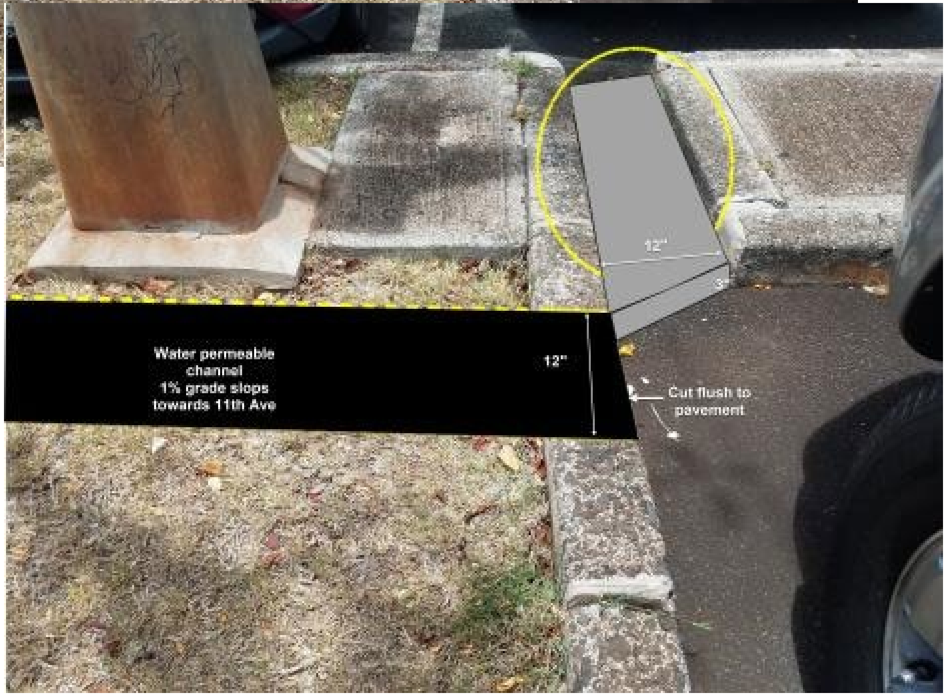

Guide to
Enhancing Your Urban Tree Canopy
Lessons Learned from **Trees for Kaimukī**
For Your Community
SMART TREES PACIFIC
TREES FOR HONOLULU'S FUTURE
NATIONAL PARK SERVICE


Stormwater
Runoff
Ponding Area
Mulch Layer
Rain Garden Soil Mix, 12"-24"
(Compost & Sand)
Aquifer Recharge


Black Tie Affair
Bridal shop
Ukulele
Musical instrume
Storm Runoff Flow
Planting Area A Bio-swale
Harding Ave
Planting Area B Bio-swale

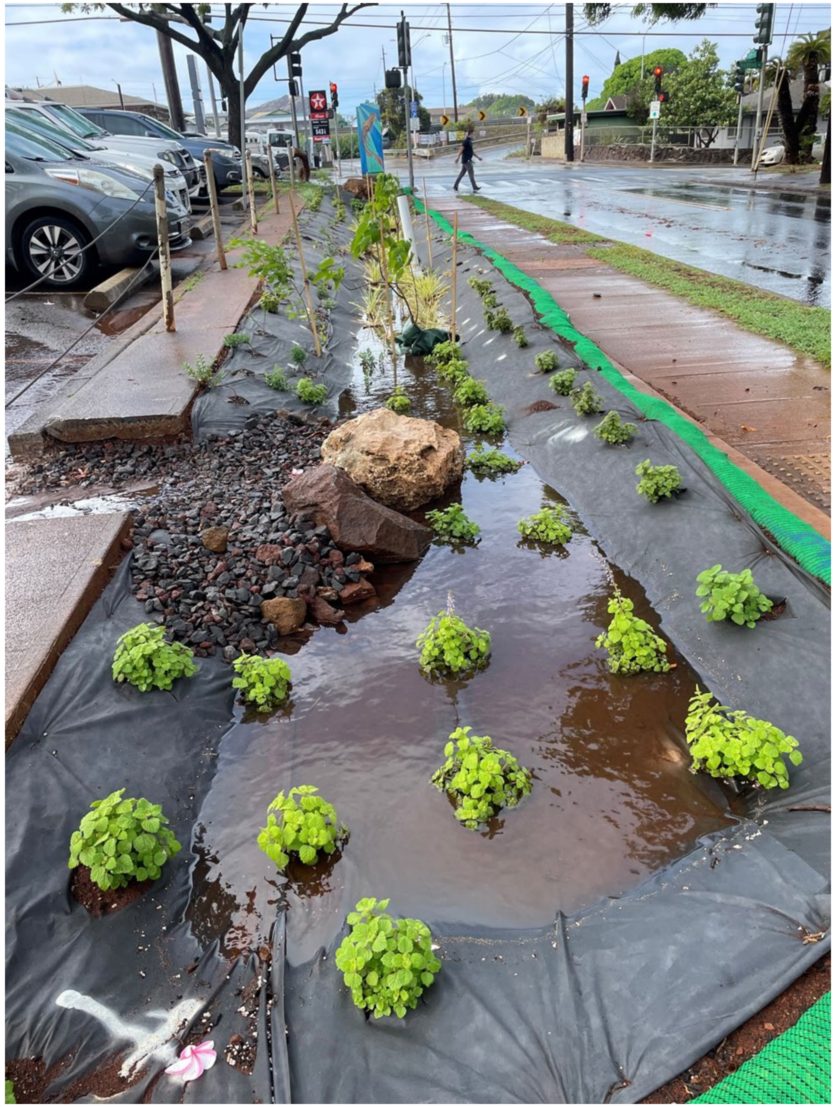

24" curb cut outs
Optional Cut
overflow pipe
cross section
water flow
water flow
over flow pipe
Proposed Rain Garden layout
11th Ave


fill gap
create channel
curb cut


12"
Water permeable channel
1% grade slops towards 11th Ave
12"
Cut flush to pavement

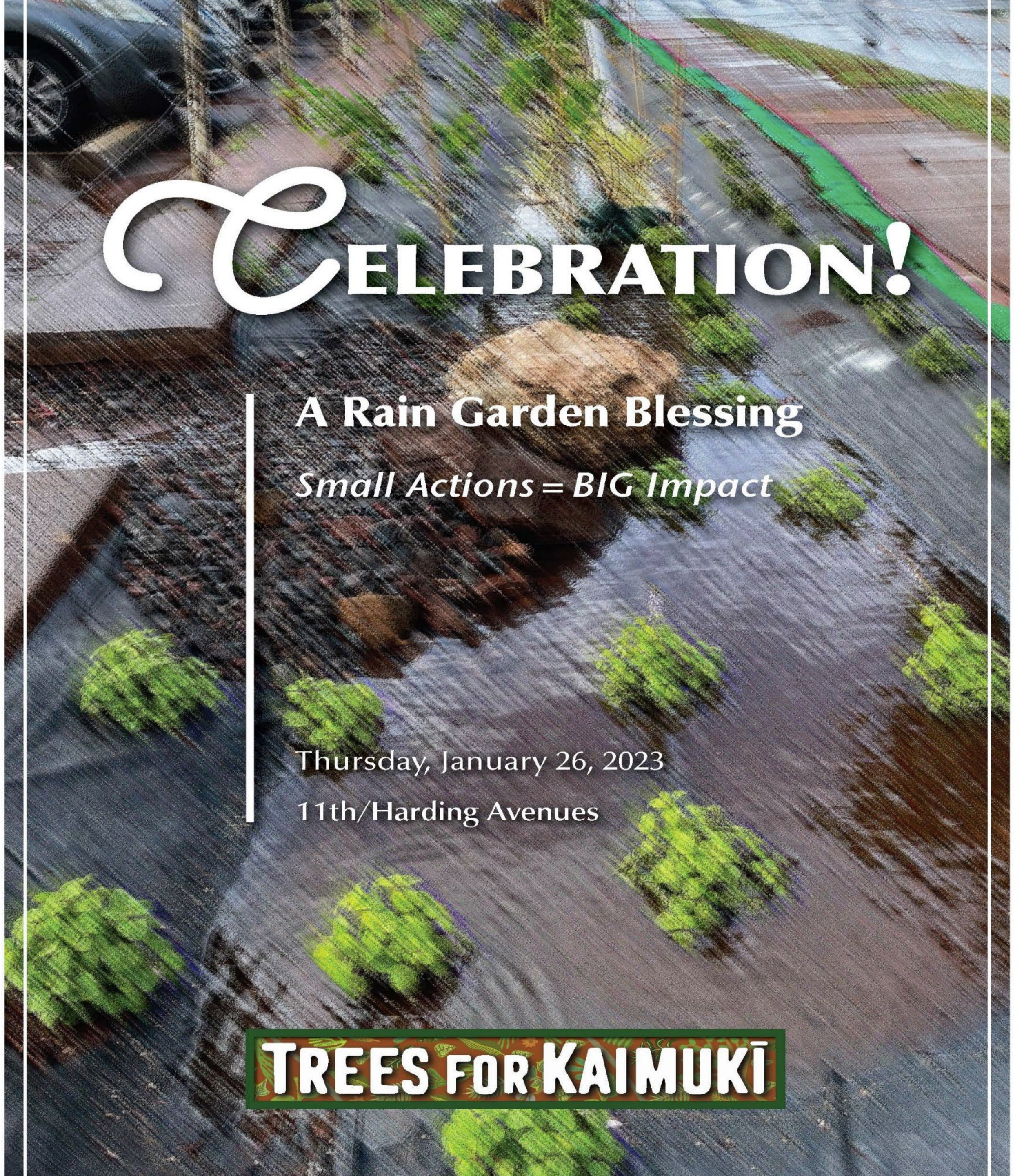

fill gap
curb cut


Removed Concrete
24"
3"



Keys to Success

10) Engage Community
9) Right Site
8) Supportive Landowner
7) Simple Design
6) Timing & Right Plants
5) Smart Construction
4) Ongoing Care
3) Educate/Higher Purpose
2) Find Yoda!
1) Thank/Celebrate



Mahalo

(Thank you)

Daniel Dinell| Trees for Honolulus Future

ddinell@ TreesForHonolulu.org

2nd World Forum on Urban Forests

2023

World Forum on Urban Forests

2nd World Forum on Urban Forests

Washington DC, 2023

Agroforestry phytoremediation buffer systems reduce water and soil pollution in the Great Lakes Basin, USA

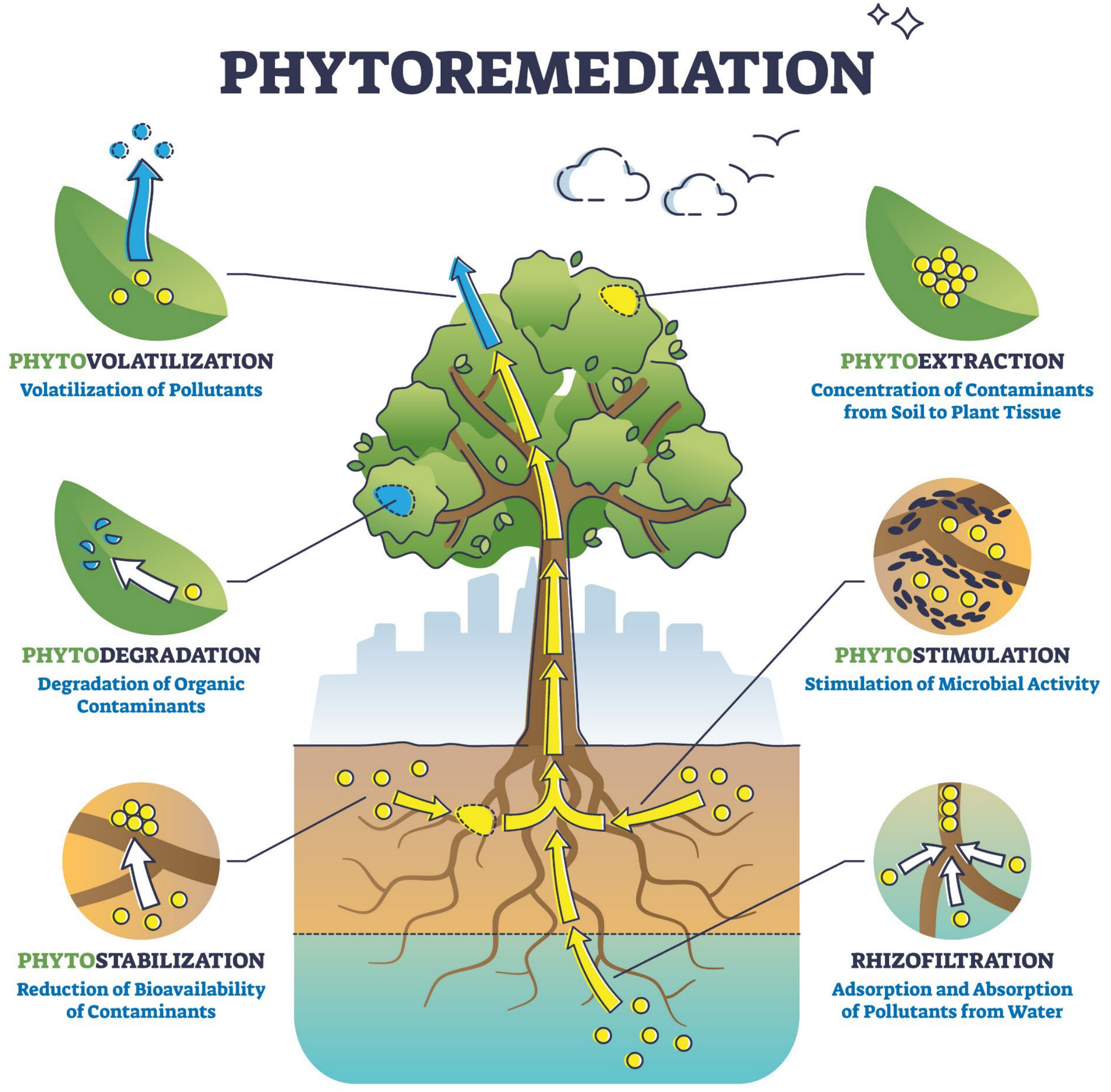
Presented by

R.S. Zalesny Jr.[1], R.A. Vinhal[1], E.R. Rogers[1,2], C-H. Lin[2], R.A. Hallett[3], J.G. Burken[4], B.S. DeBauche[2], J. Jackson[5], A. Pilipović[6], A.H. Wiese[7]

[1] USDA Forest Service, Northern Research Station, Rhinelander, Wisconsin, USA
[2] University of Missouri, Center for Agroforestry, Columbia, Missouri, USA
[3] USDA Forest Service, Northern Research Station, Bayside, New York, USA
[4] Missouri University of Science and Technology, Dept. of Civil, Architectural, and Environmental Engineering, Rolla, Missouri, USA
[5] University of Minnesota Extension, Duluth, Minnesota, USA
[6] University of Novi Sad, Institute of Lowland Forestry and Environment, Novi Sad, Serbia

Phytoremediation:

The use of trees to clean contaminated soils and waters



Source: Adobe Stock

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Opportunities at WFUF…

Phytoremediation side event

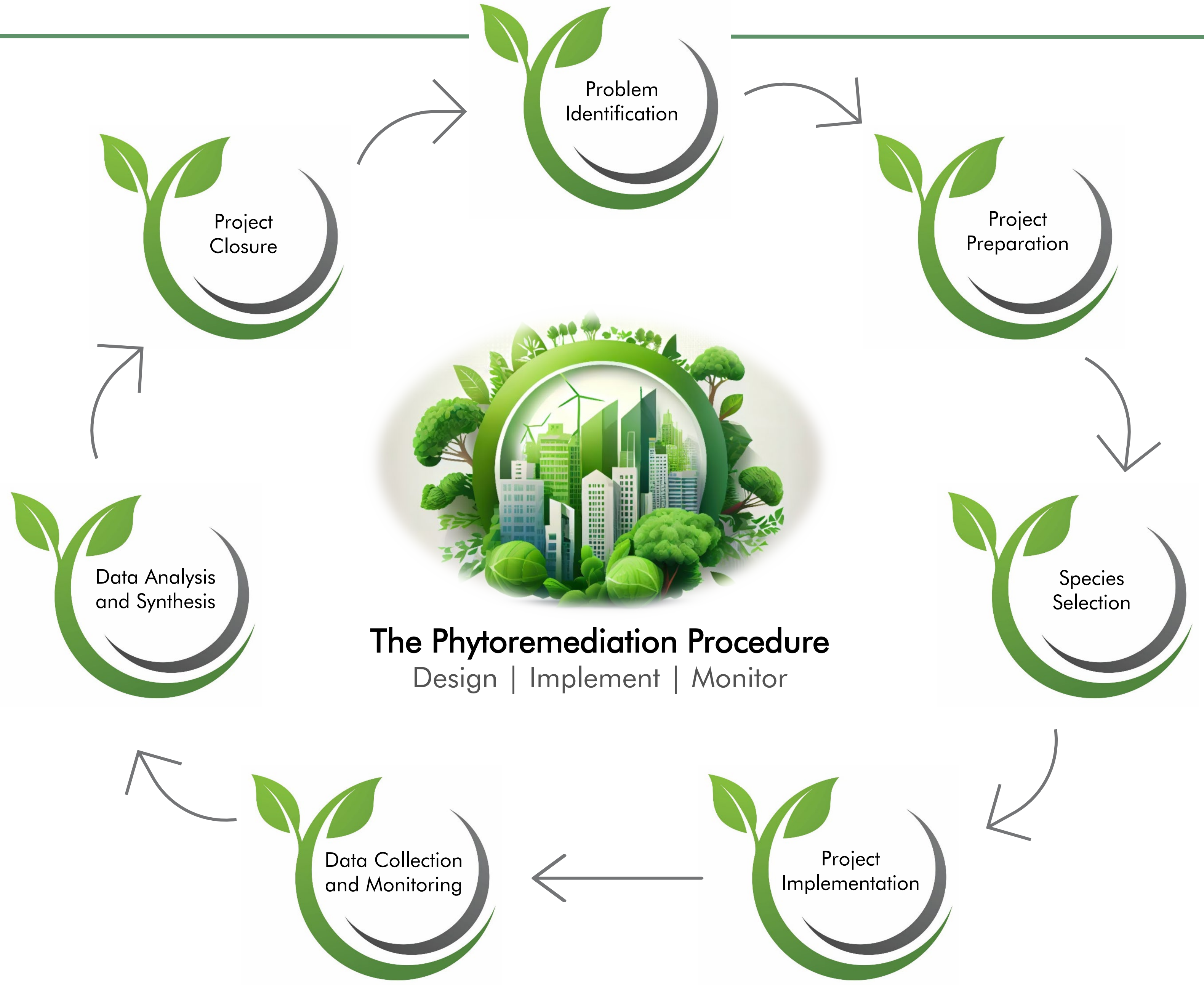
Breathless presentation by Liz Rogers

Phytoremediation Training Academy at USDA Forest Service International Programs

Thursday, October 19, 2023

0930 to 1230

1 Thomas Circle, NW, Suite 400
Washington, DC 20005



Temporal Benefits of Phytoremediation

Short-Term | Medium-Term | Long-Term

Enhanced aesthetics

Improved mood
Lowered stress
Improved psychological wellbeing

Improved soil health
Noise reduction
Improved air quality
Erosion control
Wind speed reduction

Carbon sequestration
Pollution remediation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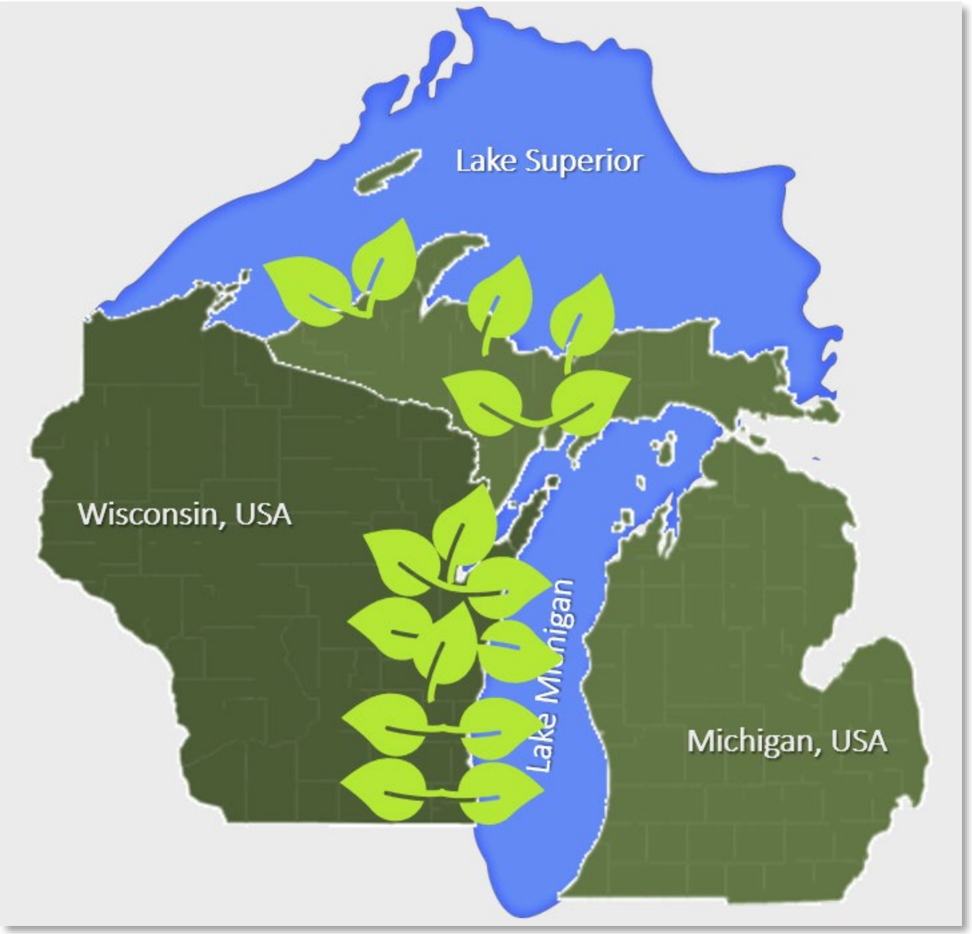
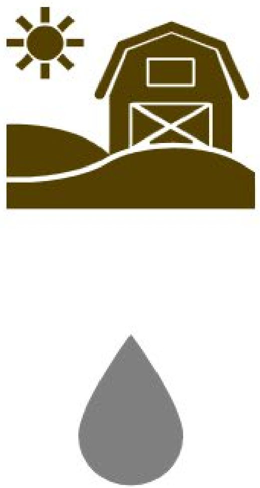
https://youtu.be/7e2bqtnU75g

GREAT LAKES PHYTO
Enhancing Ecosystem Services

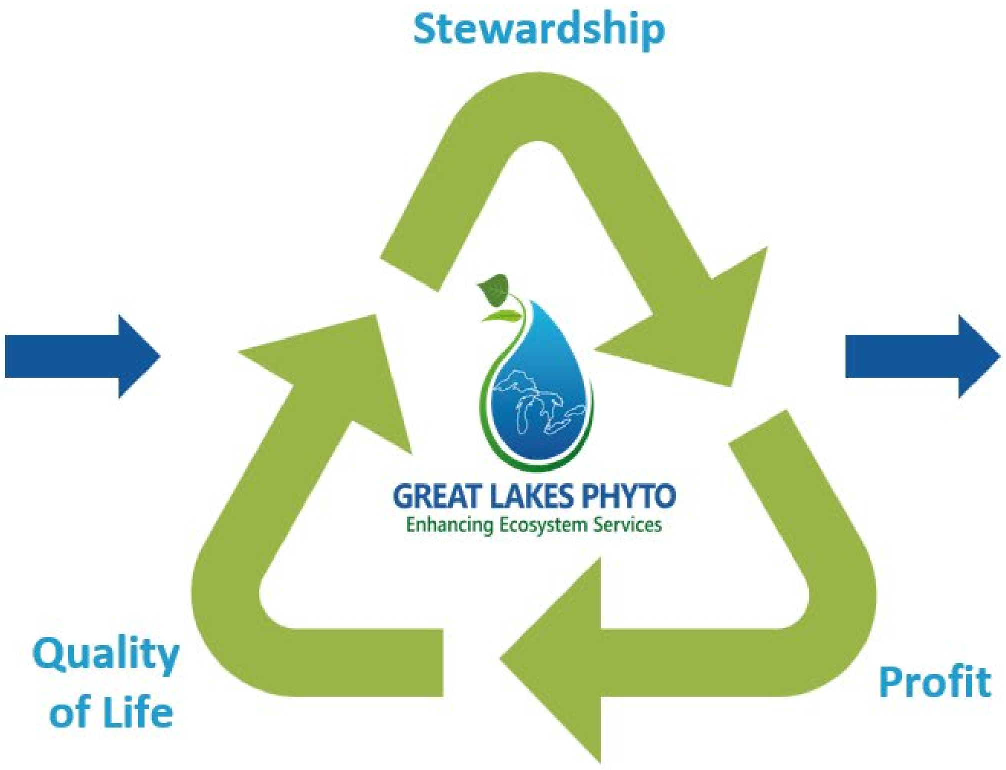


The overall mission of **Great Lakes Phyto** is to optimize genotype × environment interactions and enhance ecosystem services across the rural to urban continuum in order to develop sustainable silvicultural prescriptions that inform pollution solutions which are regionally adapted yet globally relevant.

The Problem
Degraded Lands and Waters



The Solution
Agroforestry Phyto Buffers



The Outcomes
Pillars of Sustainability

Quality of Life

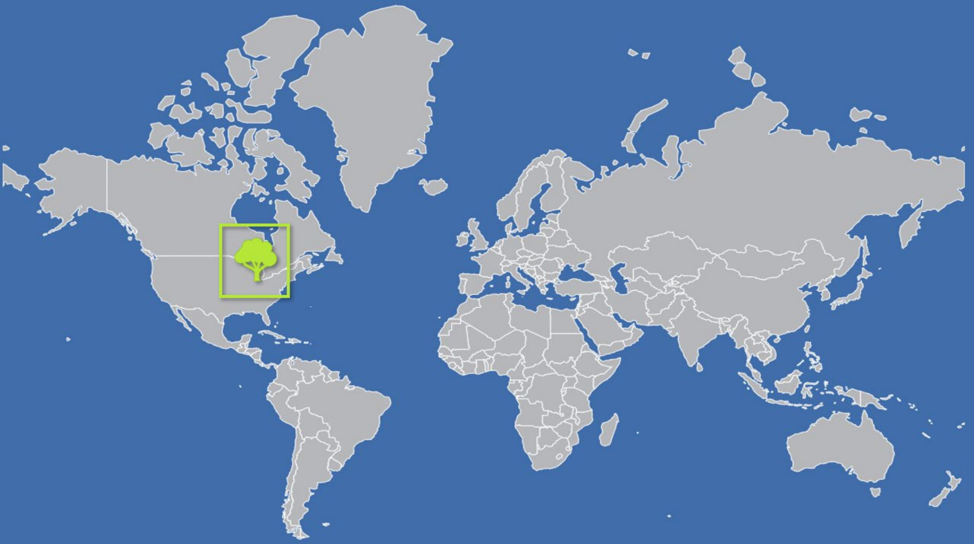
- Reduced Health Risks from Pollution
- Public Engagement
- Best Management Practices

Stewardship

- Clean Water
- Healthy Soils
- Carbon Sequestration

Profit

- Bioenergy
- Biofuels
- Bioproducts
- Enhanced Productivity of the Land



Laurentian Great Lakes of North America

Lake Superior
Lake Michigan
Lake Huron
Lake Erie
Lake Ontario

Great Lakes: Benefits to People and the Environment

Largest surface freshwater ecosystem in the world

21% of the world's freshwater supply

84% of North America's surface freshwater

Substantial ecosystem services to >34 million people

10% of United States population

32% of Canadian population

Gross regional product (GRP) estimated at ~4.1 trillion USD

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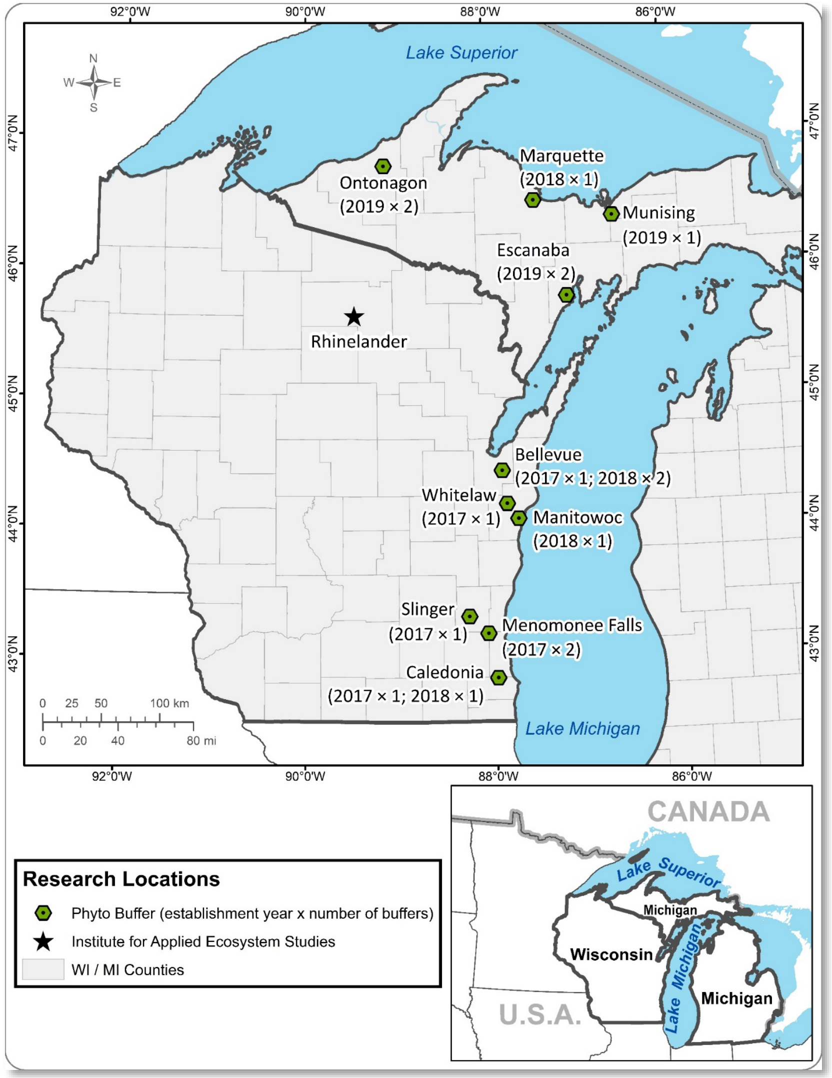
Agroforestry Phytoremediation Buffer Systems in the Great Lakes Basin



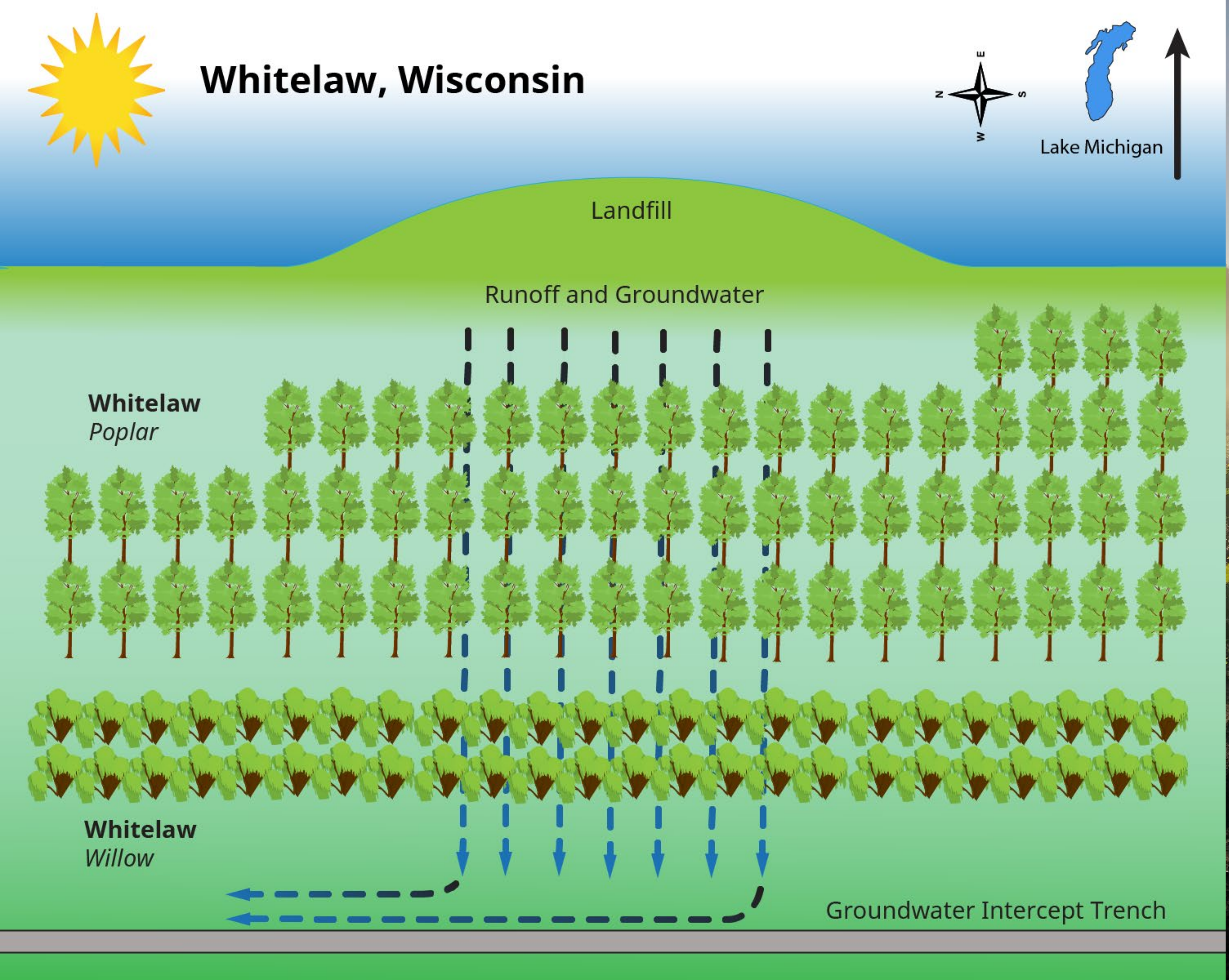
Great Lakes RESTORATION

GREAT LAKES PHYTO
Enhancing Ecosystem Services

Whitelaw, Wisconsin, USA

PC: P.V. Manley, J.G. Burken, Missouri S&T

Applications: Groundwater Recycling, Phytoremediation
Partners: Waste Management, Inc.; Wisconsin DNR



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Manitowoc, Wisconsin, USA

PC: P.V. Manley, J.G. Burken, Missouri S&T

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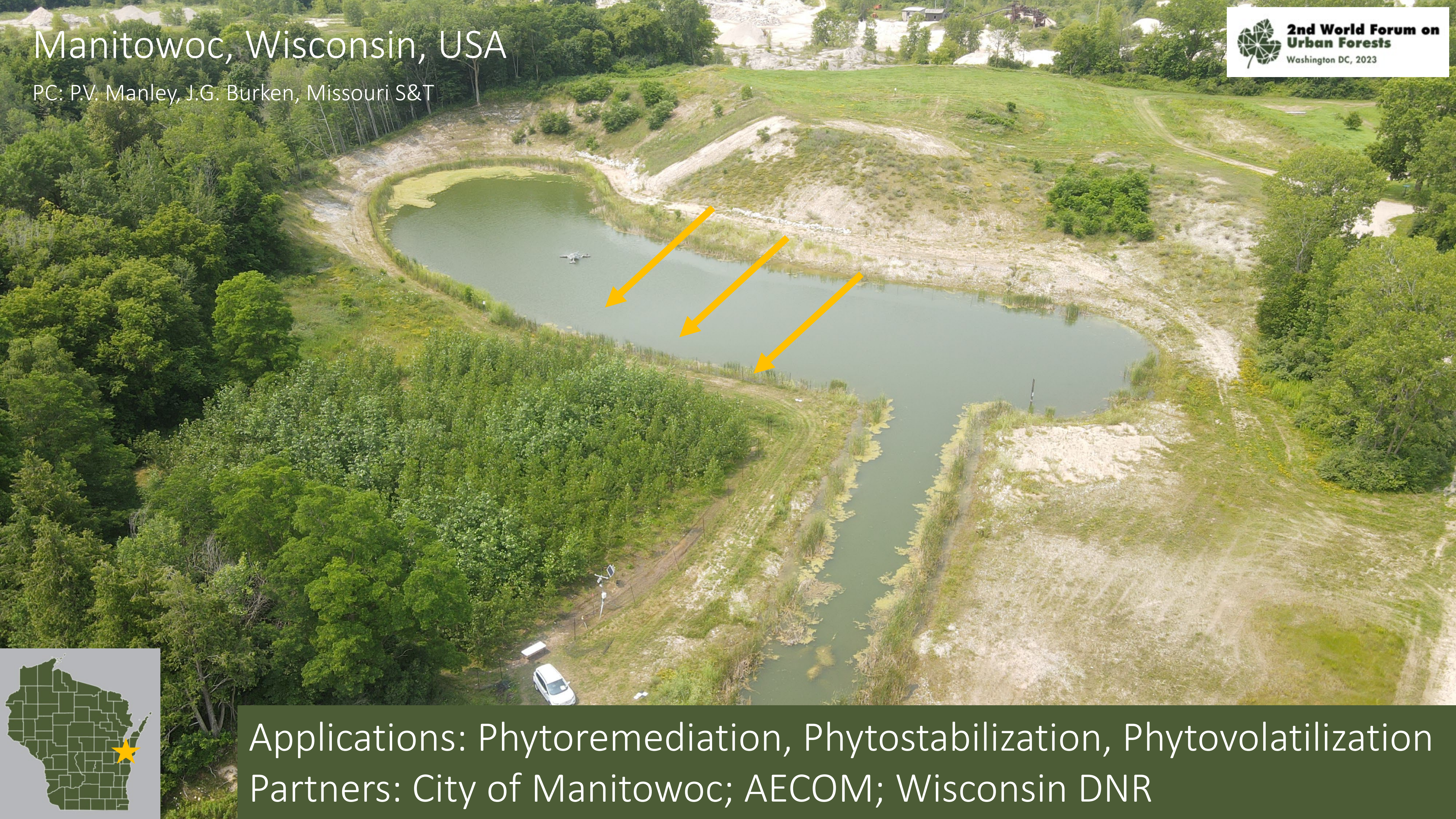

Applications: Phytoremediation, Phytostabilization, Phytovolatilization

Partners: City of Manitowoc; AECOM; Wisconsin DNR

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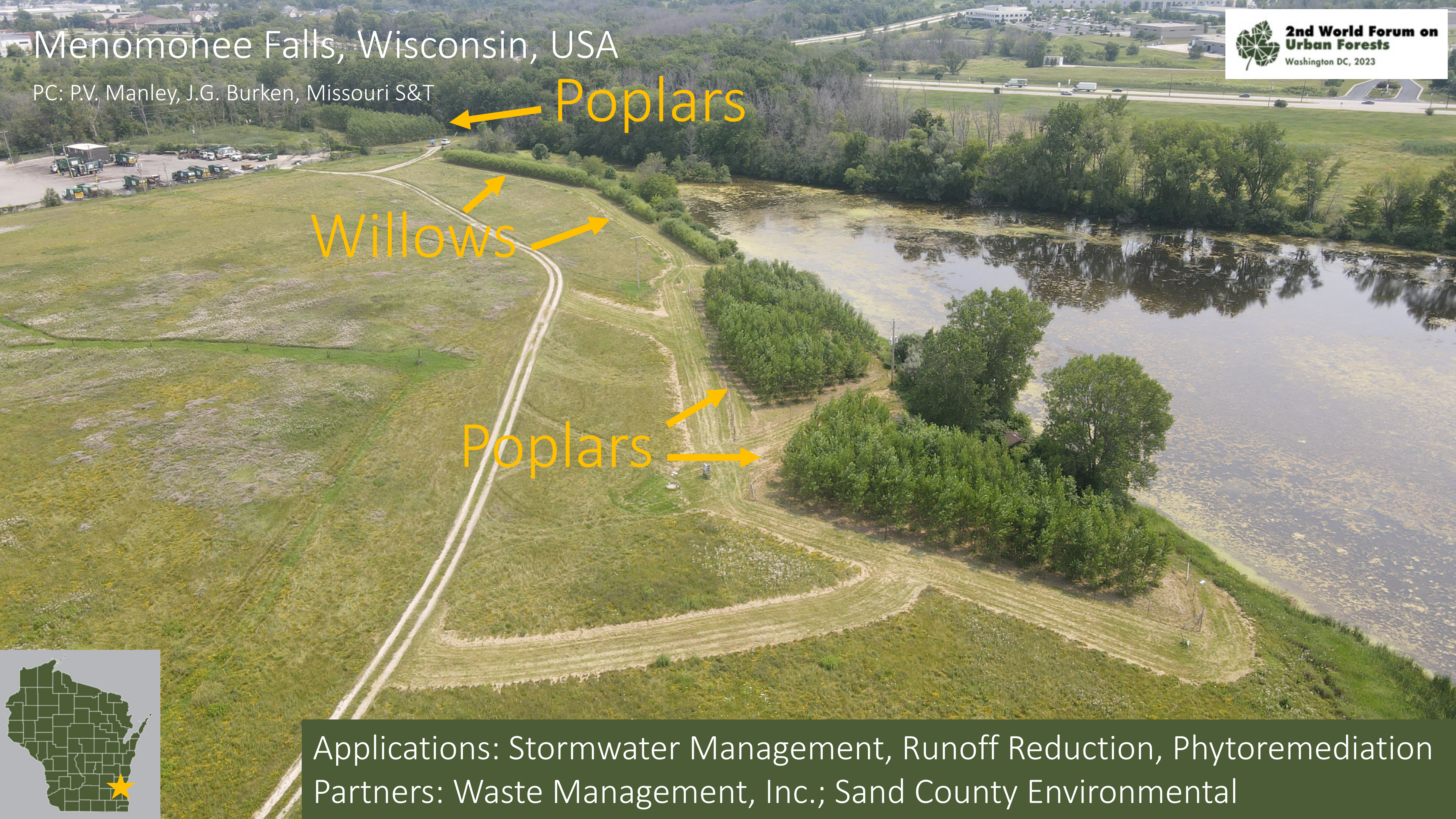

Menomonee Falls, Wisconsin, USA
PC: P.V. Manley, J.G. Burken, Missouri S&T
2nd World Forum on Urban Forests
Washington DC, 2023
Poplars
Willows
Poplars
Applications: Stormwater Management, Runoff Reduction, Phytoremediation
Partners: Waste Management, Inc.; Sand County Environmental


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Menomonee Falls, Wisconsin
N
W
E
S
Lake Michigan
Landfill
Menomonee Falls West
Poplar
Menomonee Falls
Willow
Stormwater
Treatment Pond
Runoff
Runoff
Runoff
Runoff
Menomonee Falls East
Poplar
Constructed
Wetland
Stormwater
Retention Pond
Wetland

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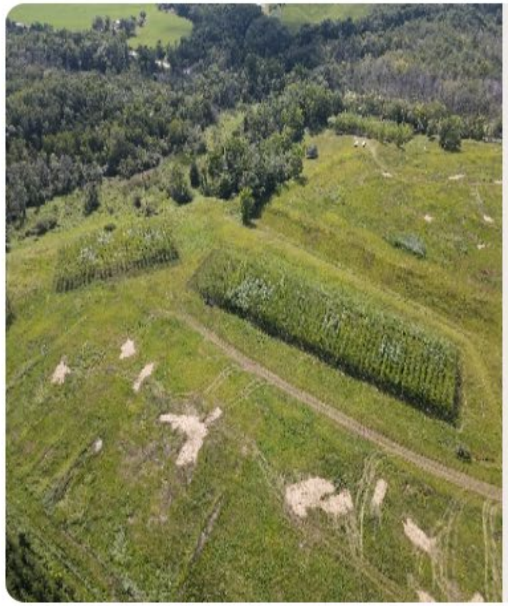
Phyto-Recurrent Selection Endorsed as 'Good Practice' by the United Nations



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Missouri University of Science and Technology
University of Minnesota Duluth, Natural Resources Research Institute
Waste Management, Inc.
AECOM Technical Services, Inc.
City of Manitowoc, Wisconsin
Marquette County Solid Waste Management Authority
Delta County Solid Waste Management Authority

Reviewers:
Robin Chazdon · Mahoussi Simone Assocle · Anita Diederichsen

Submitted: 2023-03-22
Published: 2023-05-30
Updated: 2023-03-22

Good Practice

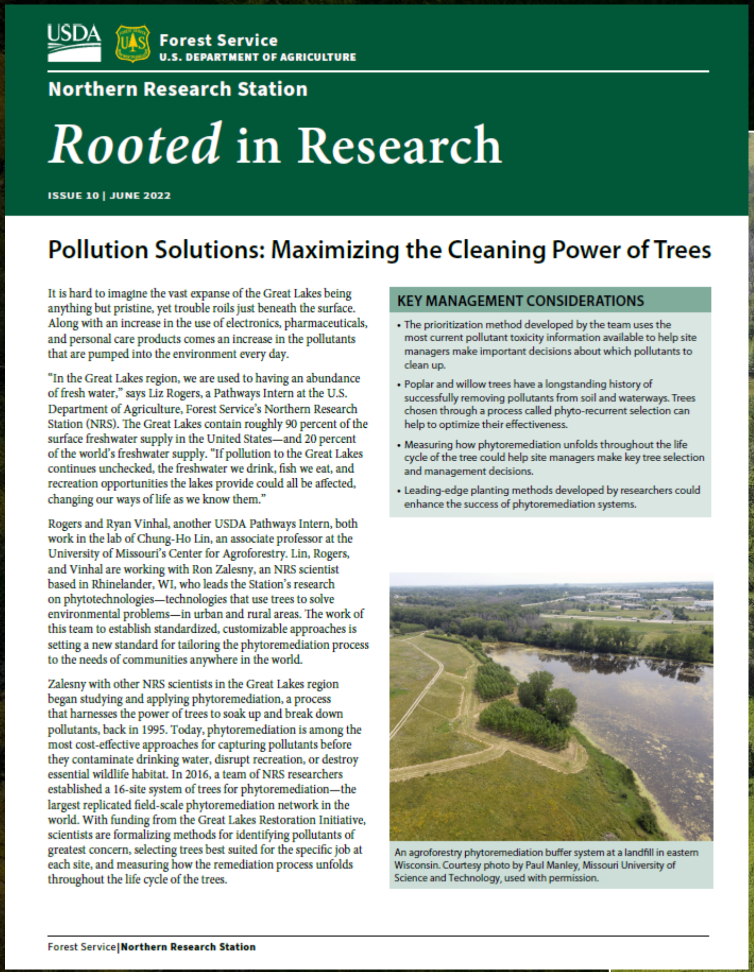
source: FRAMEWORK ECOSYSTEM RESTORATION MONITORING

Scan here to learn more!

https://ferm-search.fao.org/practices/FERM_BYfbsJeRaOk6aL2vROB9

Phyto-Recurrent Selection
Test. Select. Deploy.

UNITED NATIONS DECADE ON ECOSYSTEM RESTORATION 2021-2030



USDA Forest Service
U.S. DEPARTMENT OF AGRICULTURE

Northern Research Station

Rooted in Research

ISSUE 10 | JUNE 2022

Pollution Solutions: Maximizing the Cleaning Power of Trees

It is hard to imagine the vast expanse of the Great Lakes being anything but pristine, yet trouble roils just beneath the surface. Along with an increase in the use of electronics, pharmaceuticals, and personal care products comes an increase in the pollutants that are pumped into the environment every day.

"In the Great Lakes region, we are used to having an abundance of fresh water," says Liz Rogers, a Pathways Intern at the U.S. Department of Agriculture, Forest Service's Northern Research Station (NRS). The Great Lakes contain roughly 90 percent of the surface freshwater supply in the United States—and 20 percent of the world's freshwater supply. "If pollution to the Great Lakes continues unchecked, the freshwater we drink, fish we eat, and recreation opportunities the lakes provide could all be affected, changing our ways of life as we know them."

Rogers and Ryan Vinhal, another USDA Pathways Intern, both work in the lab of Chung-Ho Lin, an associate professor at the University of Missouri's Center for Agroforestry. Lin, Rogers, and Vinhal are working with Ron Zalesny, an NRS scientist based in Rhinelander, WI, who leads the Station's research on phytotechnologies—technologies that use trees to solve environmental problems—in urban and rural areas. The work of this team to establish standardized, customizable approaches is setting a new standard for tailoring the phytoremediation process to the needs of communities anywhere in the world.

Zalesny with other NRS scientists in the Great Lakes region began studying and applying phytoremediation, a process that harnesses the power of trees to soak up and break down pollutants, back in 1995. Today, phytoremediation is among the most cost-effective approaches for capturing pollutants before they contaminate drinking water, disrupt recreation, or destroy essential wildlife habitat. In 2016, a team of NRS researchers established a 16-site system of trees for phytoremediation—the largest replicated field-scale phytoremediation network in the world. With funding from the Great Lakes Restoration Initiative, scientists are formalizing methods for identifying pollutants of greatest concern, selecting trees best suited for the specific job at each site, and measuring how the remediation process unfolds throughout the life cycle of the trees.

KEY MANAGEMENT CONSIDERATIONS

- The prioritization method developed by the team uses the most current pollutant toxicity information available to help site managers make important decisions about which pollutants to clean up.
- Poplar and willow trees have a longstanding history of successfully removing pollutants from soil and waterways. Trees chosen through a process called phyto-recurrent selection can help to optimize their effectiveness.
- Measuring how phytoremediation unfolds throughout the life cycle of the tree could help site managers make key tree selection and management decisions.
- Leading-edge planting methods developed by researchers could enhance the success of phytoremediation systems.

An agroforestry phytoremediation buffer system at a landfill in eastern Wisconsin. Courtesy photo by Paul Manley, Missouri University of Science and Technology, used with permission.


forests
Growth and Development of Short Rotation Woody Crops for Rural and Urban Applications
Edited by
Ronald S. Zalesny, Jr. and Andrej Pilipović
Printed Edition of the Special Issue Published in Forests
www.mdpi.com/journal/forests
MDPI
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Thank you

Ronald S. Zalesny Jr. | USDA Forest Service

ronald.zalesny@ usda.gov

Food and Agriculture Organization of the United Nations

Arbor Day Foundation

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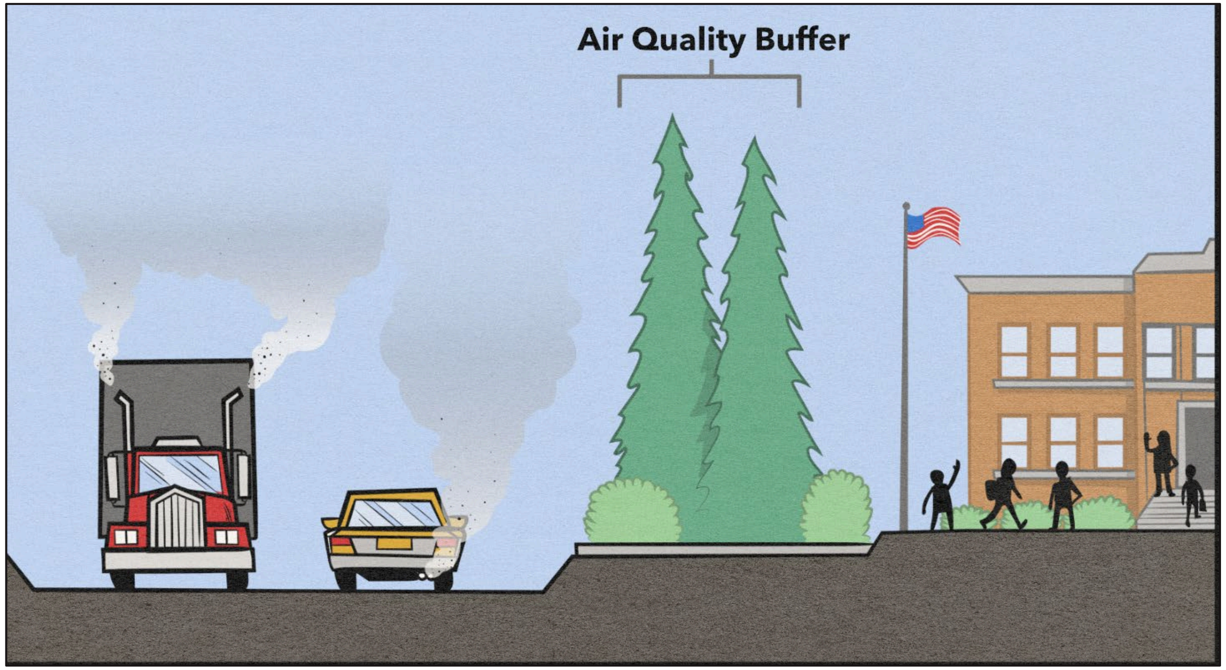
2023

World Forum on Urban Forests

2nd World Forum on Urban Forests
Washington DC, 2023

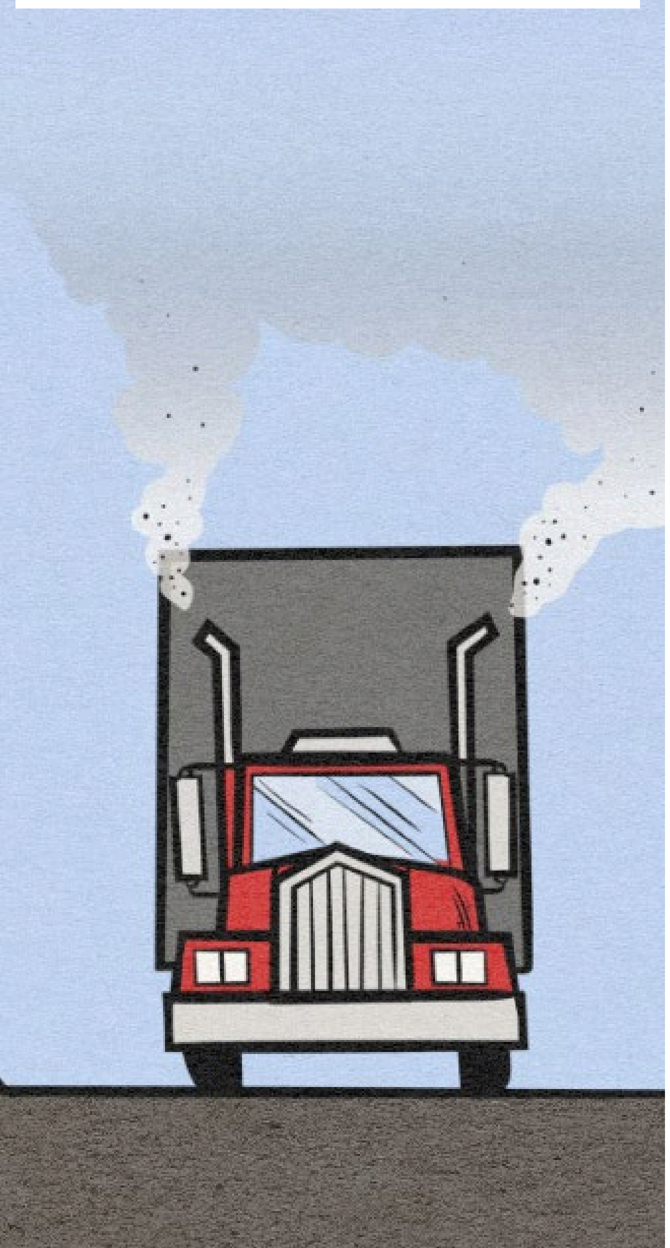
Breathless

Improving Schoolyard Air Quality with Vegetative Buffers



Presented by

Michelle N. Catania
Green Industry Outreach Coordinator
The Morton Arboretum - Lisle, Illinois, USA



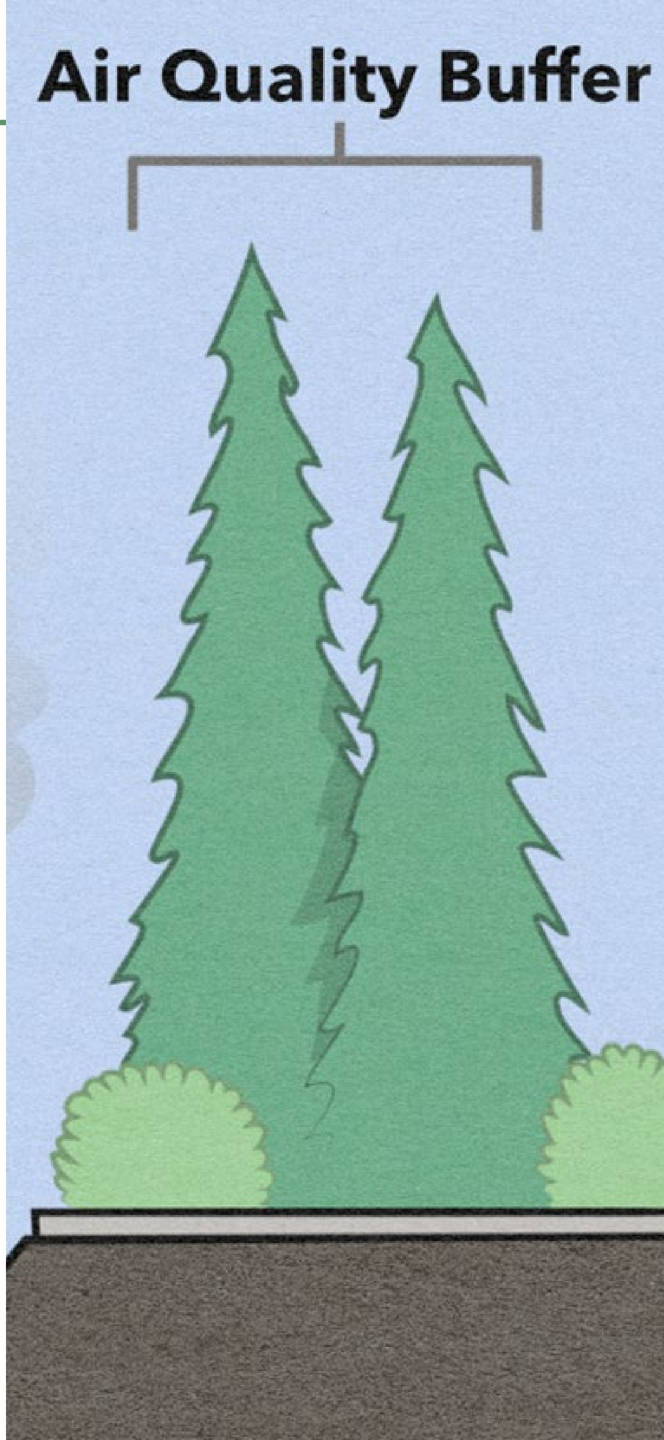
Outline

Poor Air Quality

Vegetation Barriers

Vegetation Barrier Toolkit for Schools & Communities

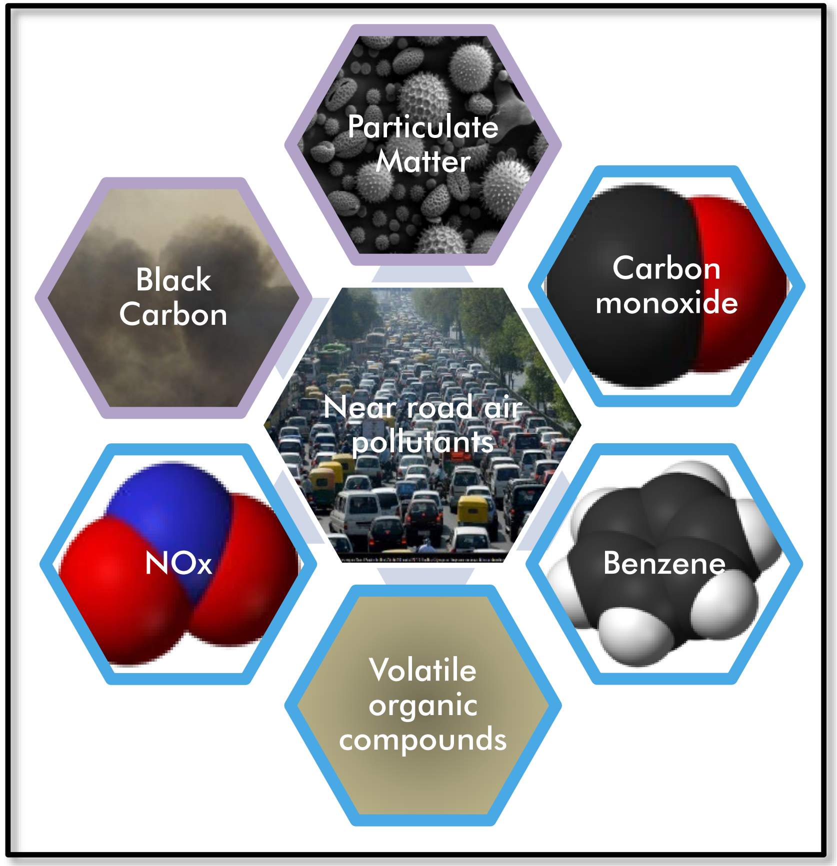
Chicago, Illinois, USA &
Potential Sites for Vegetative Barriers



Poor Air Quality

Poor Air Quality

- Combination of <u>gases</u> and <u>particulate matter</u>

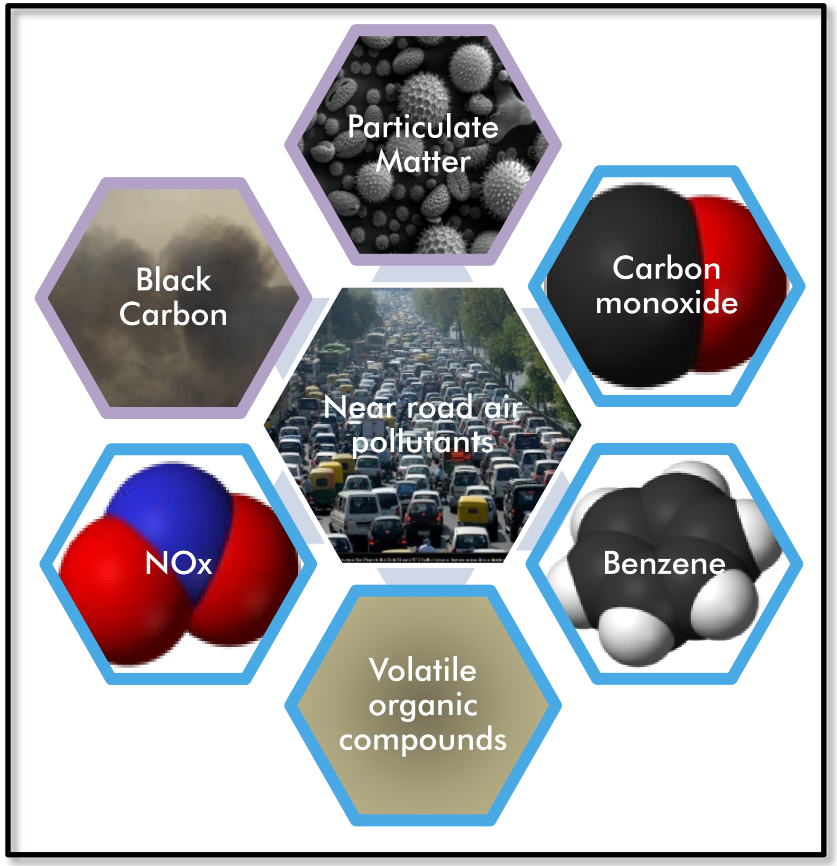


Criteria Air Pollutants

EPA calls these pollutants "criteria" air pollutants because it sets NAAQS for them based on the criteria, which are characterizations of the latest scientific information regarding their effect on health or welfare.

Poor Air Quality

- Combination of gases and particulate matter



Criteria Air Pollutants

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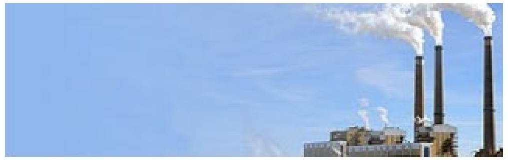
Sulfur Dioxide



Ground-level Ozone

Nitrogen Dioxide

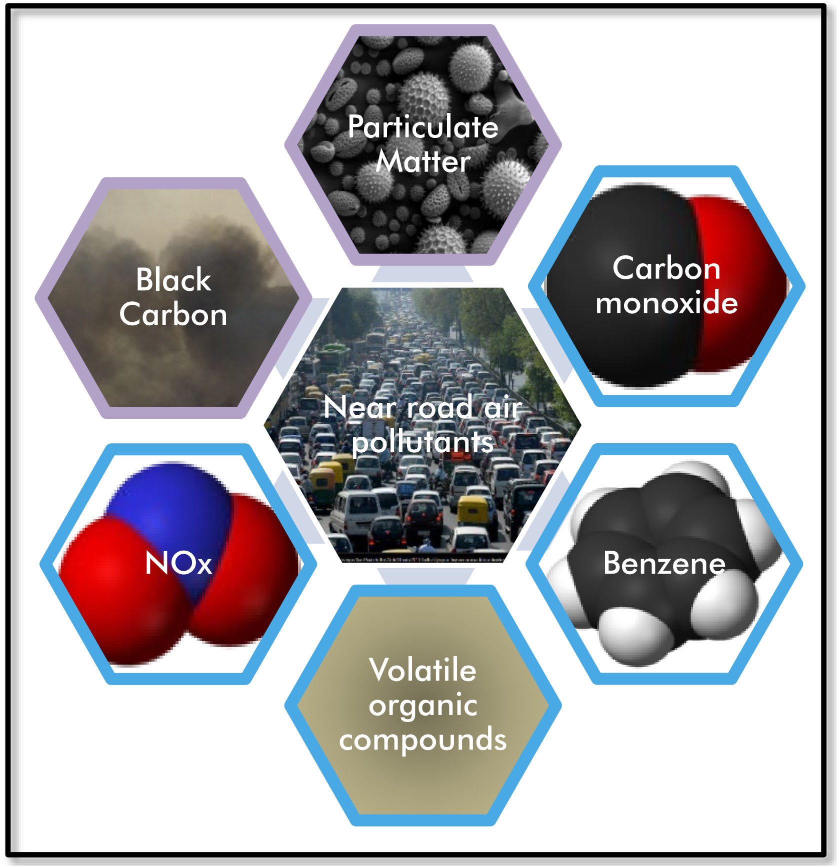
Lead

Carbon Monoxide

Particulate Matter

Poor Air Quality

- Combination of gases and particulate matter



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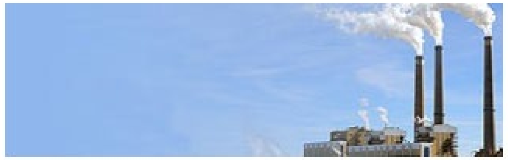


Ground-level Ozone

Nitrogen Dioxide

Lead

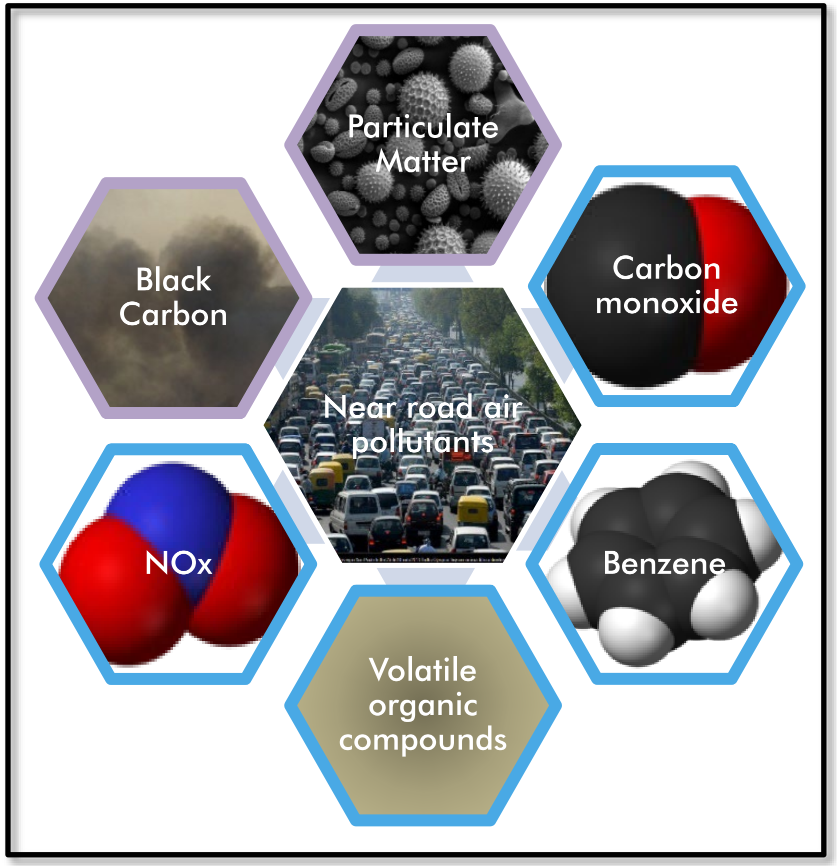
ENTIRELY DIFFERENT ISSUE

Carbon Monoxide

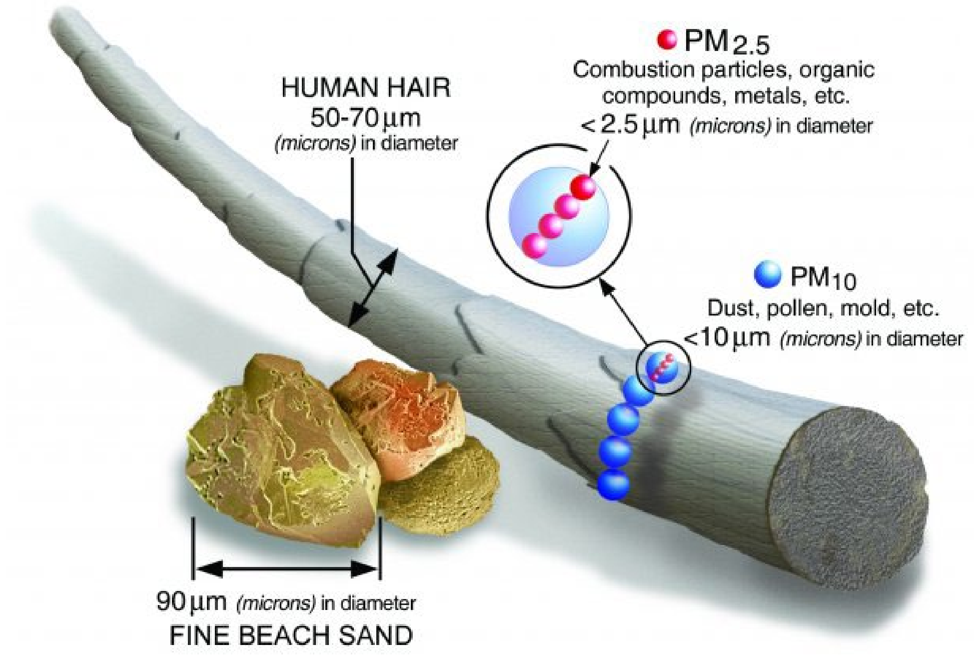
Particulate Matter

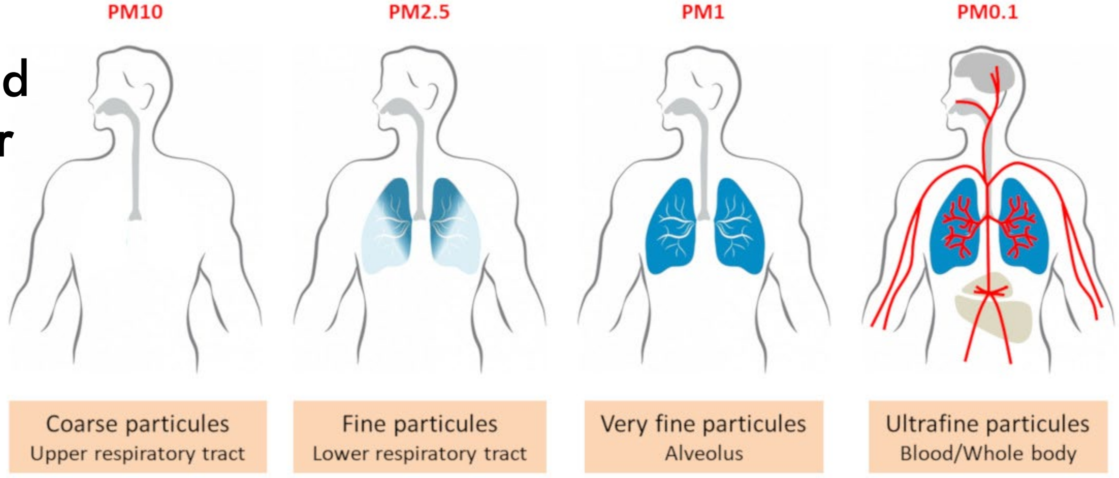
Poor Air Quality

- Combination of <u>gases</u> and **<u>particulate matter</u>**



- **PM** is the mixture of **solid** particles and **liquid** droplets in **suspension**
- Dust, dirt, soot or smoke
- Commonly found **suspended in air**





Source: Encyclopedia of the Environment

Poor Air Quality

Sources

- Anthropogenic sources
  - Stationary emissions
    - Factories, powerplants, smelters, etc.
    - Road dust
  - Mobile emissions – on road & nonroad
    - Vehicles, planes, trains emissions
    - Brake and tire wear

Poor Air Quality






Sources

- Anthropogenic
  - Stationary emissions
    - Factories, powerplants, smelters, etc.
    - Road dust
  - Mobile emissions – on road & nonroad
    - Vehicles, planes, trains emissions
    - Brake and tire wear
- Natural
  - Volcanic
  - Wind-blown dust (eolian sands)


Poor Air Quality

Composition of Near-Road Air Pollution

- Elevated concentrations near road due to:
  - Increasing **traffic**
  - Congestion with "**stop & go**"
  - Certain meteorological or **terrain**
    - –calm winds during rush hour
    - –street canyons
  - **Old, poorly maintained vehicles**

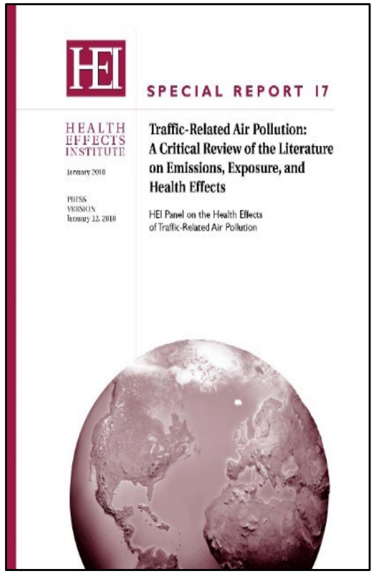
- Populations in close proximity to source:
  - – **In USA** –
    - Over **50 million people** estimated to live **within 300 ft (100 m)** of a source
    - Almost **17,000 schools** are estimated to be **within (820 ft) 250 m** of a source
  - – Massive health impacts

Poor Air Quality

Asthma & Cardiovascular Health Concerns

Increased health risks from air pollution near roadways:

- Kids, older adults, those with cardiopulmonary disease
- Greater impacts in lower socioeconomic populations



Studies have linked:

- Respiratory and cardiovascular health
- Cancer including childhood leukemia
- **Cognitive development**
- Birth and developmental effects

- Onset of childhood asthma
- Other respiratory problems
- Impaired lung function
- Total mortality
- Cardiovascular mortality
- Cardiovascular morbidity

Modified EPA Slide

References: Health Effects Institute, 2010; Perez et al., Environ. Health Persp., 2012; Gauderman et al., LANCET, 2007; https://chicagohealthatlas.org/indicators/HCSATHP?topic=adult-asthma-rate

Slide acknowledgement: U.S. EPA *Best Practices for Reducing Near Road Pollution at Schools* Oct 2020 Webinar ; Photo: The Guardian.com

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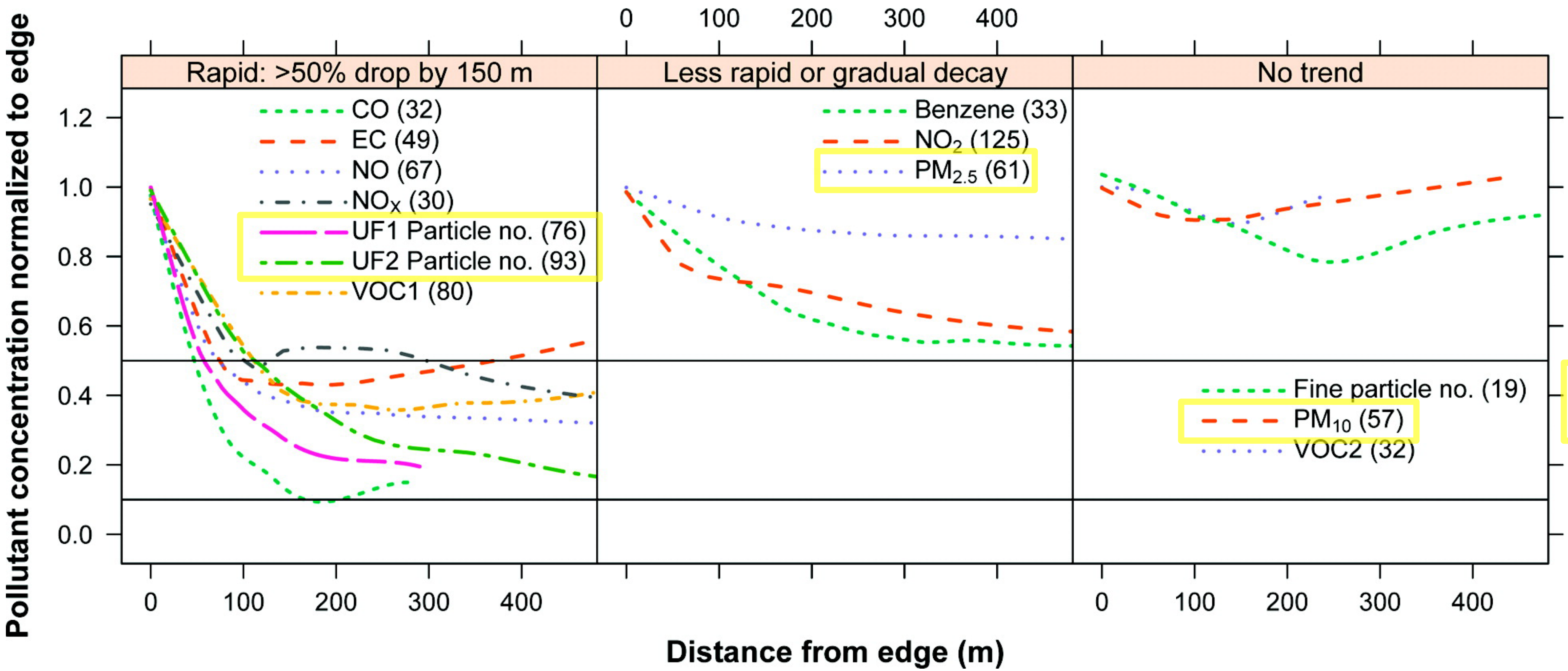
Washington DC, 2023

Poor Air Quality

- Combination of gases and **particulate matter**
- Often elevated near large transportation corridors
  - Highest concentrations 500 – 1,000 ft (150-300 m) from source

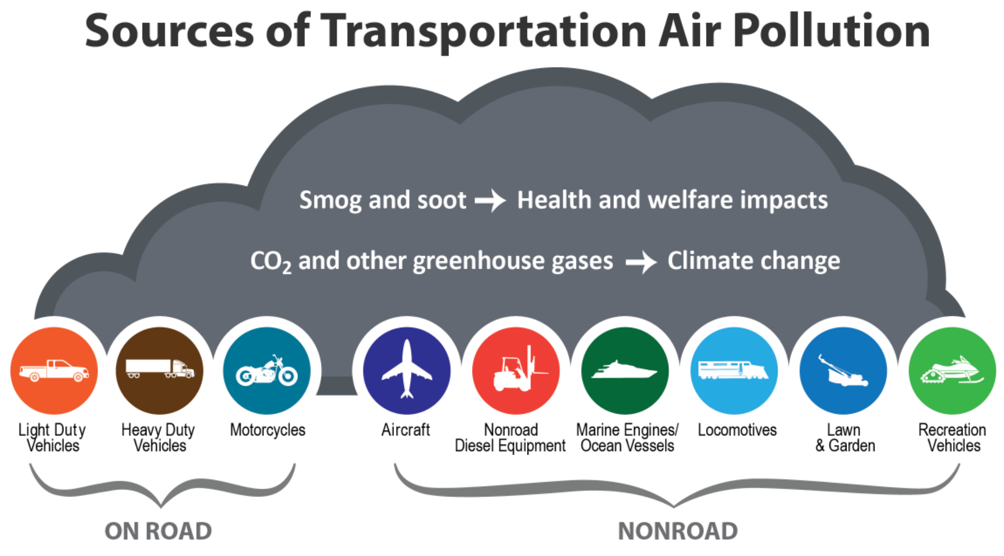


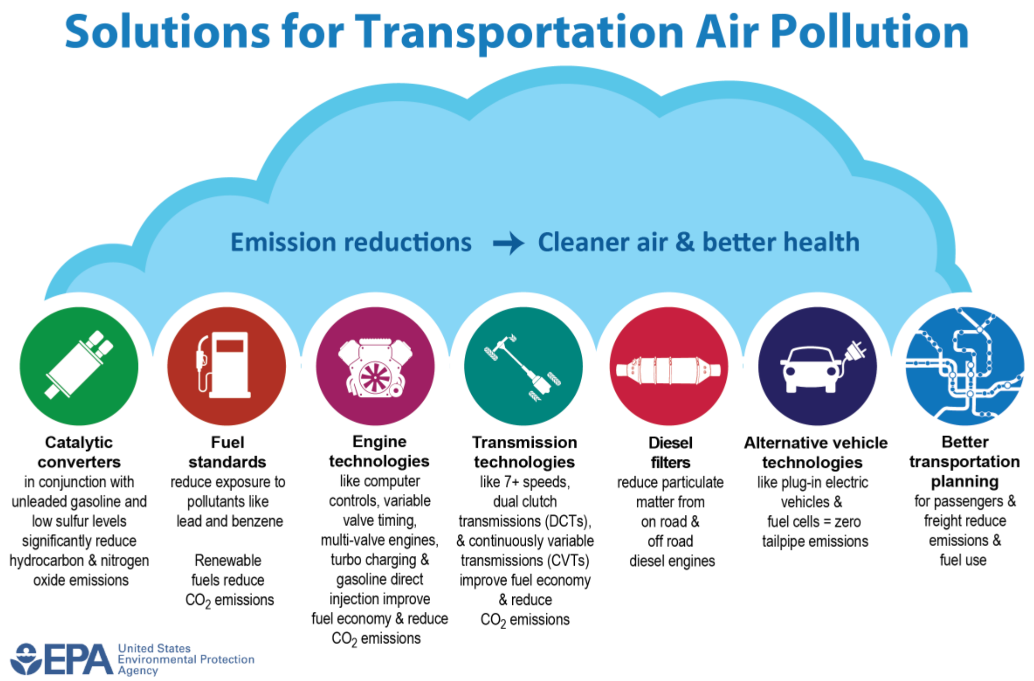
CO – carbon monoxide
EC- elemental carbon
NO- nitric oxide
NOx – nitrogen oxides
UF1 - >3 nm – 352 nm *
UF2 – 15 nm – 1000 nm *
VOC1 – varies w distance
Benzene – petroleum bioproduct
NO2 – Nitrogen dioxide
Fine Particle - 300-20,000nm
PM10 – less than 10 nm
VOC2 – does not vary w distance

* Size range in literature

Near-roadway air quality: synthesizing the findings from real-world data.
A. Karner, D. Eisinger, D. Niemeier • Published 18 June 2010 • Environmental Science • Environmental science & technology

Poor Air Quality

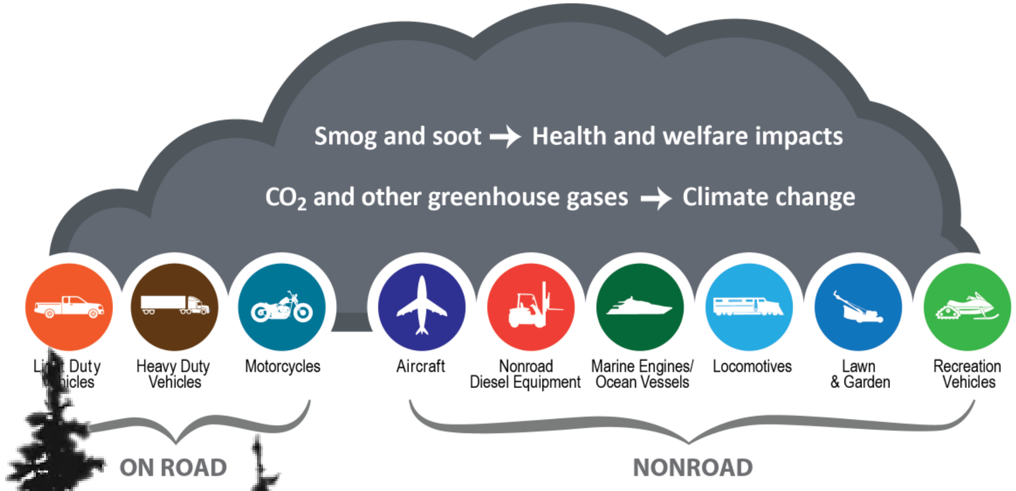




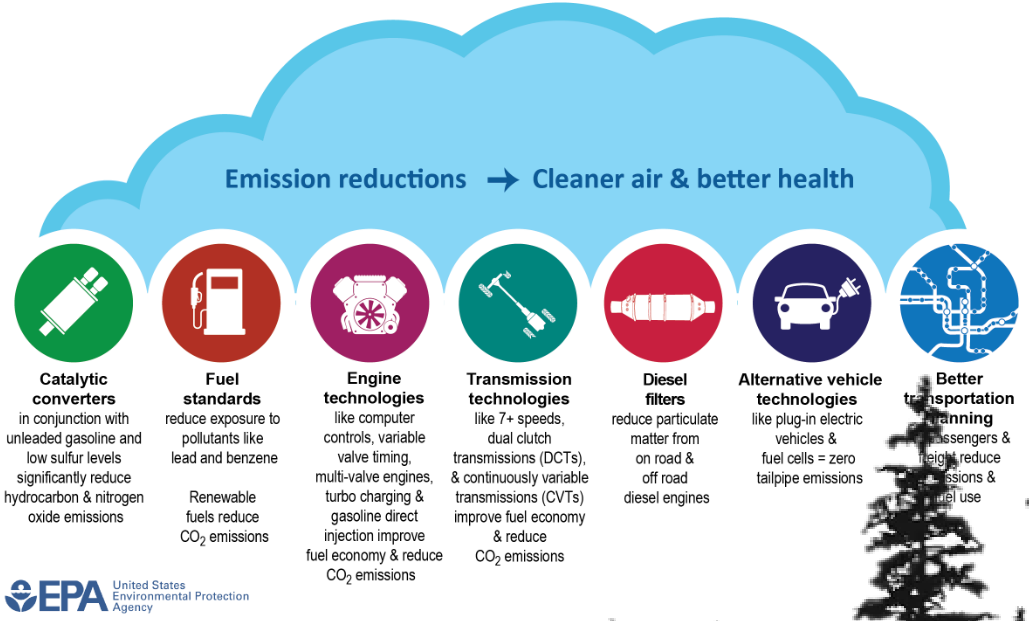
Source: EPA

Poor Air Quality

Sources of Transportation Air Pollution



Solutions for Transportation Air Pollution



Let's add Vegetation Barriers to Solutions

Poor Air Quality

- Vegetative barriers have other positive attributes
  - Reduce noise
  - Reduce stormwater runoff/flooding
  - Improve water quality
  - Increase carbon sequestration
  - Reduce heat island effects
  - Improve aesthetics/property values
  - Enhance community livability
  - Generally, improve public health

Green spaces and cognitive development in primary schoolchildren

Payam Dadvand[a,b,c,1], Mark J. Nieuwenhuijsen[a,b,c], Mikel Esnaola[a,b,c], Joan Forns[a,b,c,d], Xavier Basagaña[a,b,c], Mar Alvarez-Pedrerol[a,b,c], Ioar Rivas[a,b,c,e], Mónica López-Vicente[a,b,c], Montserrat De Castro Pascual[a,b,c], Jason Su[f], Michael Jerrett[g], Xavier Querol[e], and Jordi Sunyer[a,b,c,h]

[a]Centre for Research in Environmental Epidemiology (CREAL), 08003 Barcelona, Spain; [b]Experimental and Health Sciences, Pompeu Fabra University, 08003 Barcelona, Catalonia, Spain; [c]Ciber on Epidemiology and Public Health (CIBERESP), 28029 Madrid, Spain; [d]Department of Genes and Environment, Division of Epidemiology, Norwegian Institute of Public Health, 0473, Oslo, Norway; [e]Department of Geosciences, Institute of Environmental Assessment and Water Research, Spanish National Research Council (CSIC-IDEA), 08034 Barcelona, Catalonia, Spain; [f]Environmental Health Sciences, School of Public Health, University of California, Berkeley, CA 94720-7360; [g]Department of Environmental Health Sciences, Fielding School of Public Health, University of California, Los Angeles, CA 90095; and [h]Hospital del Mar Medical Research Institute (IMIM), 08003 Barcelona, Catalonia, Spain

Edited by Susan Hanson, Clark University, Worcester, MA, and approved May 15, 2015 (received for review February 18, 2015)

Exposure to green space has been associated with better physical and mental health. Although this exposure could also influence cognitive development in children, available epidemiological evidence on such an impact is scarce. This study aimed to assess the association between exposure to green space and measures of cognitive development in primary schoolchildren. This study was based on 2,593 schoolchildren in the second to fourth grades (7–10 y) of 36 primary schools in Barcelona, Spain (2012–2013). Cognitive development was assessed as 12-mo change in developmental trajectory of working memory, superior working memory, and inattentiveness by using four repeated (every 3 mo) computerized cognitive tests for each outcome. We assessed exposure to green space by characterizing outdoor surrounding greenness at home and school and during commuting by using high-resolution (5 m × 5 m) satellite data on greenness (normalized difference vegetation index). Multilevel modeling was used to estimate the associations between green spaces and cognitive development. We observed an enhanced 12-mo progress in working memory and superior working memory and a greater 12-mo reduction in inattentiveness associated with greenness within and surrounding school boundaries and with total surrounding greenness index (including greenness surrounding home, commuting route, and school). Adding a traffic-related air pollutant (elemental carbon) to models explained 20–65% of our estimated associations between school greenness and 12-mo cognitive development. Our study showed a beneficial association between exposure to green space and cognitive development among schoolchildren that was partly mediated by reduction in exposure to air pollution.

neurodevelopment | greenness | cognition | built environment | school

Contact with nature is thought to play a crucial and irreplaceable role in brain development (1, 2). Natural environments including green spaces provide children with unique opportunities such as inciting engagement, risk taking, discovery, creativity, mastery and control, strengthening sense of self, inspiring basic emotional states including sense of wonder, and enhancing psychological restoration, which are suggested to influence positively different aspects of cognitive development (1–3). Beneficial effects of green spaces on cognitive development might accrue from direct influences such as those above, with green space itself exerting the positive influence or through indirect, mediated pathways. The ability of green spaces to mitigate traffic-related air pollution (TRAP) (4) could lead to a beneficial impact of green spaces on cognitive development, because exposure to TRAP has been negatively associated with cognitive development in children (5). Further to TRAP, green spaces can also reduce noise (6), which itself too has been negatively associated with cognitive development (7). Moreover, proximity to green spaces, particularly parks, has been suggested to increase physical activity (8), and higher levels of physical activity are related to improved cognitive development (9). Outdoor surrounding greenness has also been reported to enrich microbial input from the environment (10), which may positively influence cognitive development (10). Through these pathways, exposure to green space, including outdoor surrounding greenness and proximity to green spaces, could influence cognitive development in children, yet the available population-based evidence on the association between such exposure and cognitive development in children remains scarce.

The brain develops steadily during prenatal and early postnatal periods, which are considered as the most vulnerable windows for effects of environmental exposures (11). However, some cognitive functions closely related with learning and school achievement—such as working memory and attention—develop across childhood and adolescence as an essential part of cognitive maturation (12–14). We therefore hypothesized a priori that exposure to green space in primary schoolchildren could enhance cognitive development. Accordingly, our study aimed to assess the association between indicators of exposure to green space and measures of cognitive development, including working memory (the system that holds multiple pieces of transitory information in the mind where they can be manipulated), superior working memory (working memory that involves continuous updating of the working memory buffer), and inattentiveness in primary schoolchildren. As a secondary aim, we also evaluated the mediating role of a reduction in air pollution as one of the potential mechanisms underlying this association.

Significance

Green spaces have a range of health benefits, but little is known in relation to cognitive development in children. This study, based on comprehensive characterization of outdoor surrounding greenness (at home, school, and during commuting) and repeated computerized cognitive tests in schoolchildren, found an improvement in cognitive development associated with surrounding greenness, particularly with greenness at schools. This association was partly mediated by reductions in air pollution. Our findings provide policymakers with evidence for feasible and achievable targeted interventions such as improving green spaces at schools to attain improvements in mental capital at population level.

Author contributions: P.D., M.J.N., X.Q., and J. Sunyer designed research; M.J.N., J.F., M.A.-P., I.R., M.L.-V., M.D.C.P., X.Q., and J. Sunyer performed research; M.E., X.B., J. Su, and M.J. contributed new reagents/analytic tools; P.D., M.E., and X.B. analyzed data; and P.D. and J. Sunyer wrote the paper.

The authors declare no conflict of interest.

This article is a PNAS Direct Submission.

[1]To whom correspondence should be addressed. Email: pdadvand@creal.cat.

This article contains supporting information online at www.pnas.org/lookup/suppl/doi:10.1073/pnas.1503402112/-/DCSupplemental.

ENVIRONMENTAL SCIENCES

www.pnas.org/cgi/doi/10.1073/pnas.1503402112

PNAS | June 30, 2015 | vol. 112 | no. 26 | 7937–7942

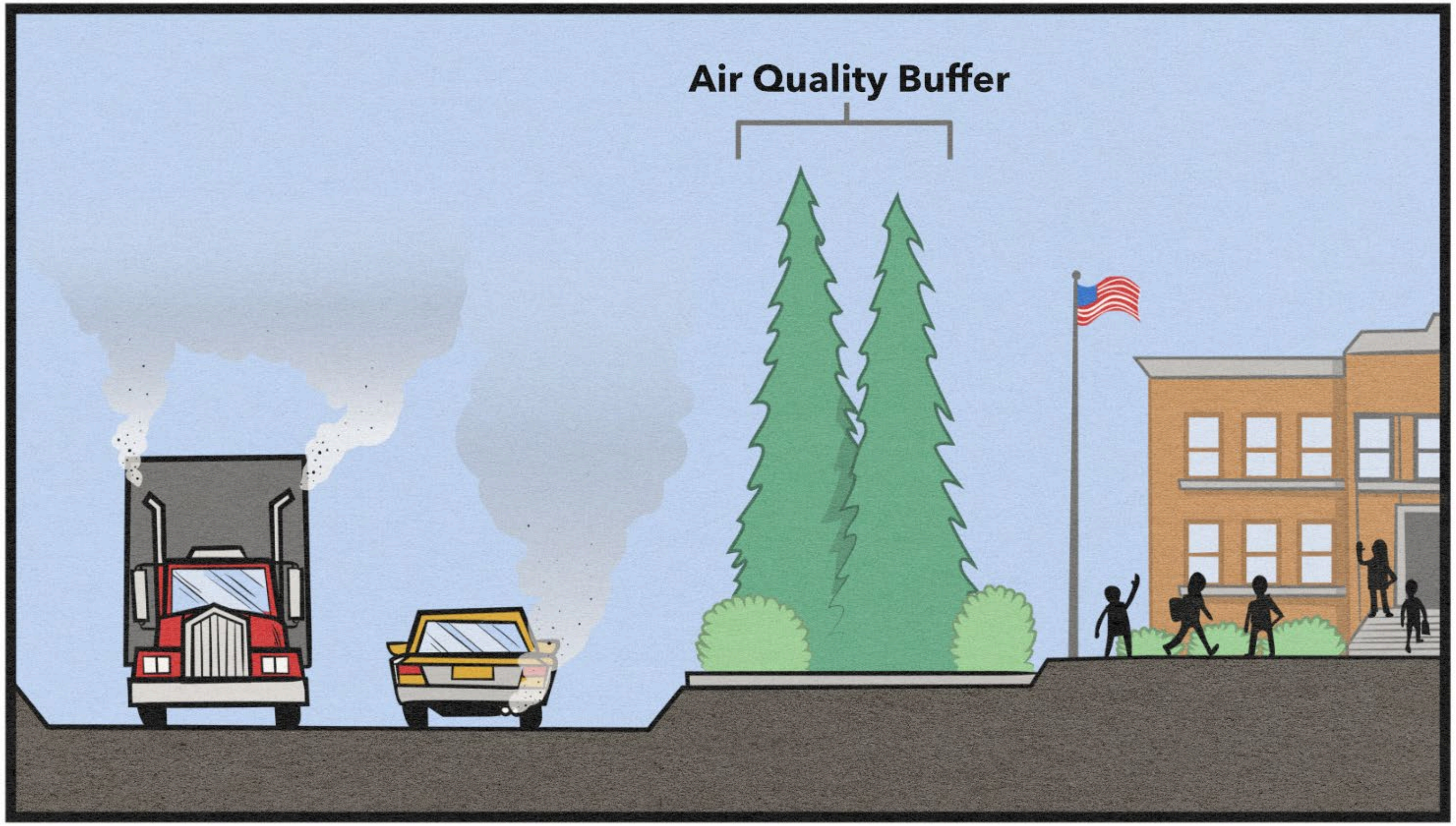
"Exposure to green space has been associated with better physical and mental health"

Slide: U.S. EPA

Vegetative Barriers

What is a Vegetative Barrier?

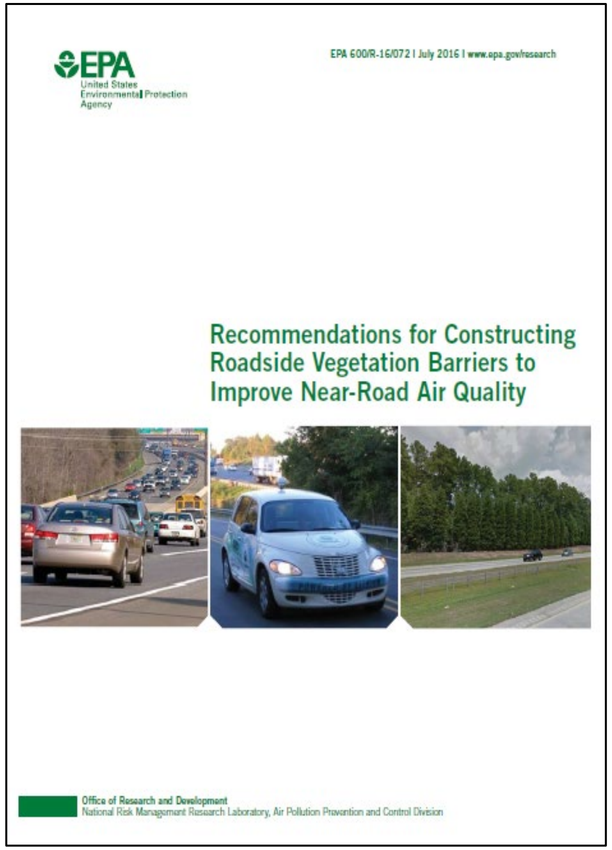
"Vegetation barriers are a collection of trees and shrubs that separate a source of pollutions such as a highway from places where people live, learn, work, and play."



TMA Toolkit

EPA Urban Vegetation Recommendations

- Design & implement planting projects in US & Europe
- <u>vegetation alone</u> OR <u>combined with solid barriers</u>
- Higher the barrier = higher the pollution reduction
  - **> 13 ft (4 m) tall, ideally 9.8 ft (3m) thick**
- Pollutants CAN meander around edges – **<u>go long</u>**!
  - Sensitive areas should be **> 164 ft (50 m) from edge**
- Pollutants do not disappear!
  - "upwind" sources may need to be considered
  - Expect deposition at barrier
    - accumulate in soil
- The closer to the source the better!


EPA
United States
Environmental Protection
Agency
EPA 600/R-16/072 I July 2016 I www.epa.gov/research
Recommendations for Constructing Roadside Vegetation Barriers to Improve Near-Road Air Quality
Office of Research and Development
National Risk Management Research Laboratory, Air Pollution Prevention and Control Division

Slide adopted from Dr. Richard Baldauf, EPA

2nd World Forum on Urban Forests
Washington DC, 2023

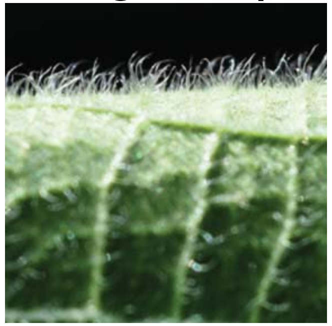
Adequate

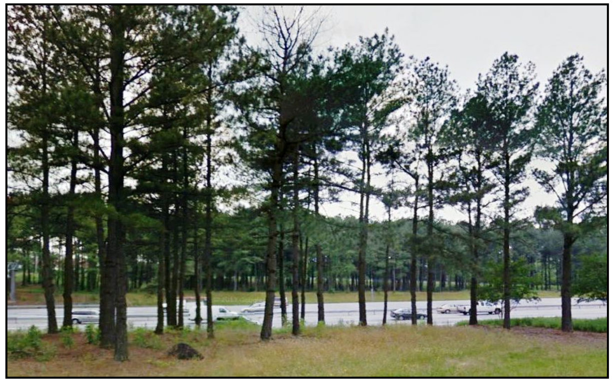
- No gaps in vegetation
- Complete coverage from ground to top of canopy
- Thickness adequate to reduce porosity & avoid gaps
- Conifers and thick shrubs are ideal
  - Minimal seasonal effects
  - Complex, rough, waxy surfaces

Inadequate

- Gaps in vegetation
- Incomplete coverage from ground to top of canopy
- Not thick enough
- Deciduous trees used where conifers would have thrived
  - Effectiveness fluctuates with seasons

Filtering Component

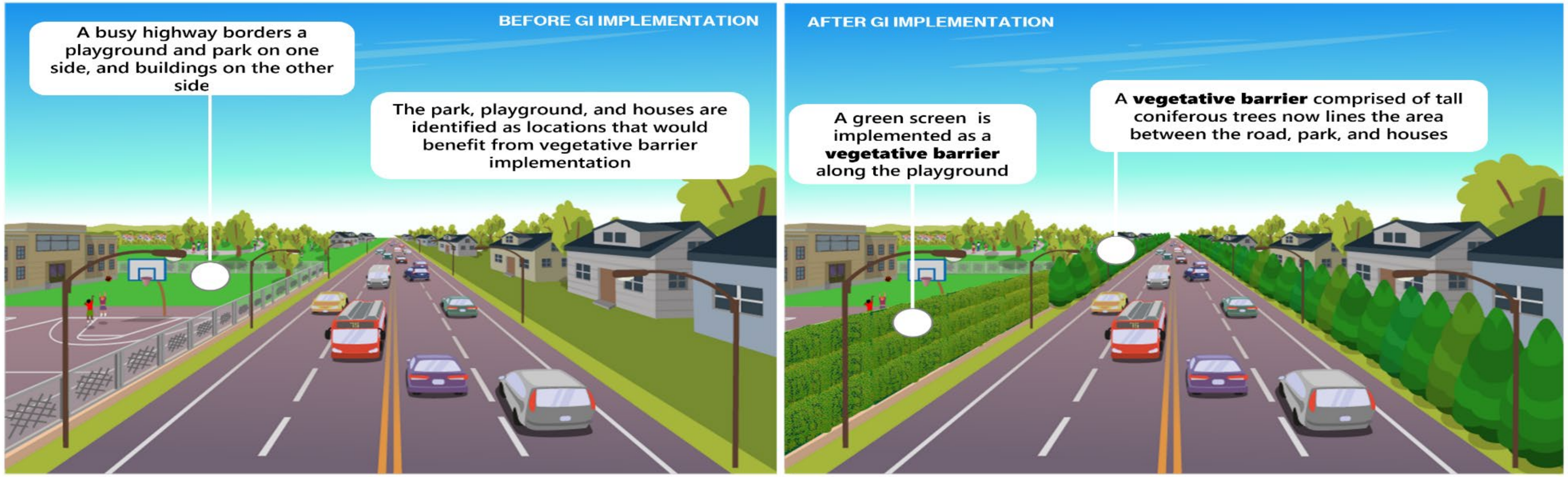




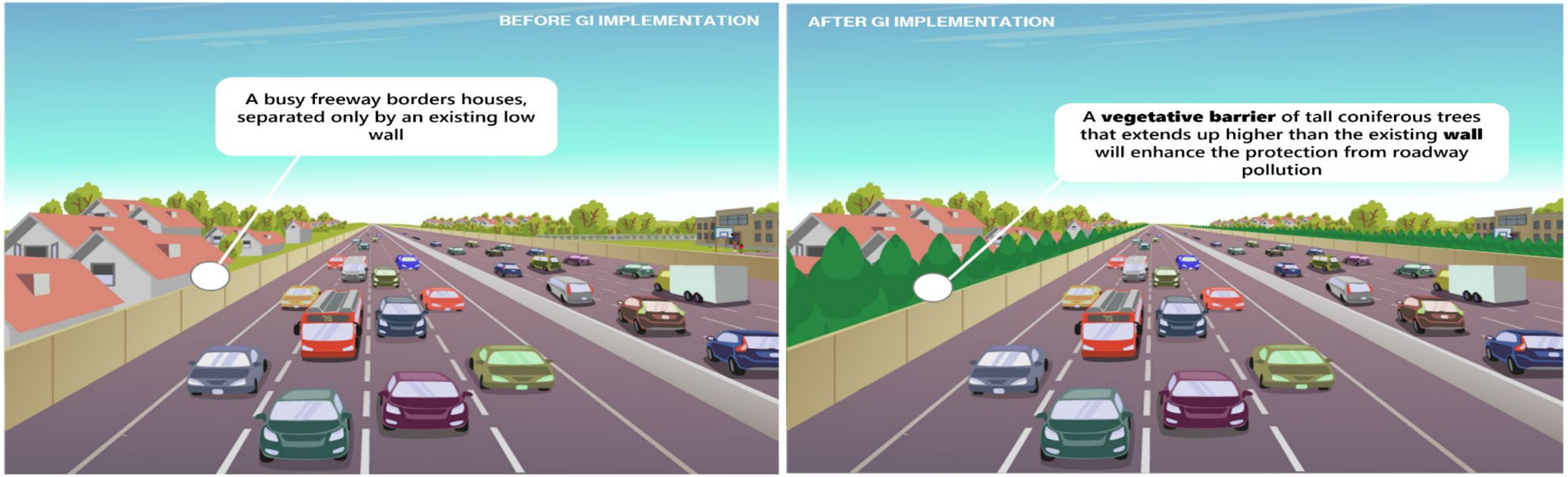
Slide credit: Baldauf, EPA

Examples of Trees & Trees+Wall

Open Road: Single or low multi-story buildings along a busy road



Open Road: A busy freeway alongside houses



Slide credit: Baldauf, EPA

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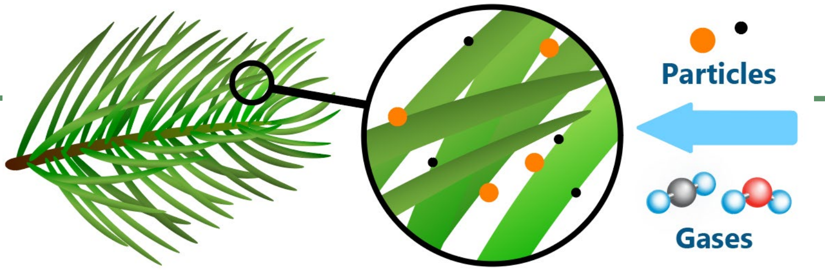
Plants Trap & Filter PM



The result is lower roadway pollutant concentrations in the area protected by the vegetative barrier

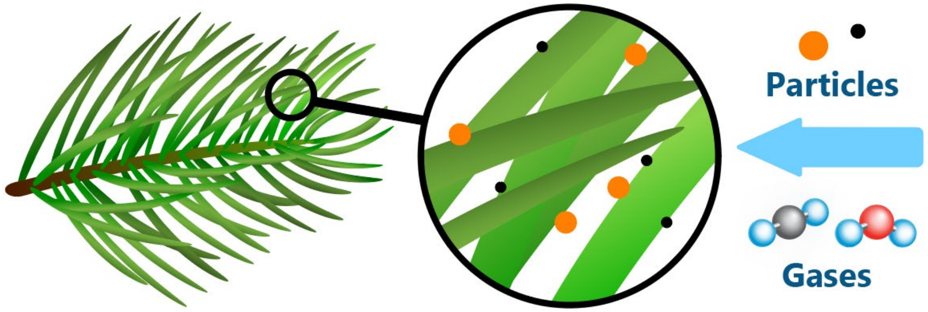
Pollutants are dispersed into the air by roadside trees

Some pollutants are filtered and others are absorbed directly by foliage

Air pollution produced by vehicles on heavily trafficked roadway

Slide: Baldauf, EPA and Region 5 Air Quality Team

What happens to the PM?
Let's take a closer look!



SEM Images

- Produces detailed, magnified images by scanning its surface using focused beam of electrons
- Provide information on:
  - Topography – distribution of features
  - Composition – what the material is made of
  - Morphology – the form, shape, or structure

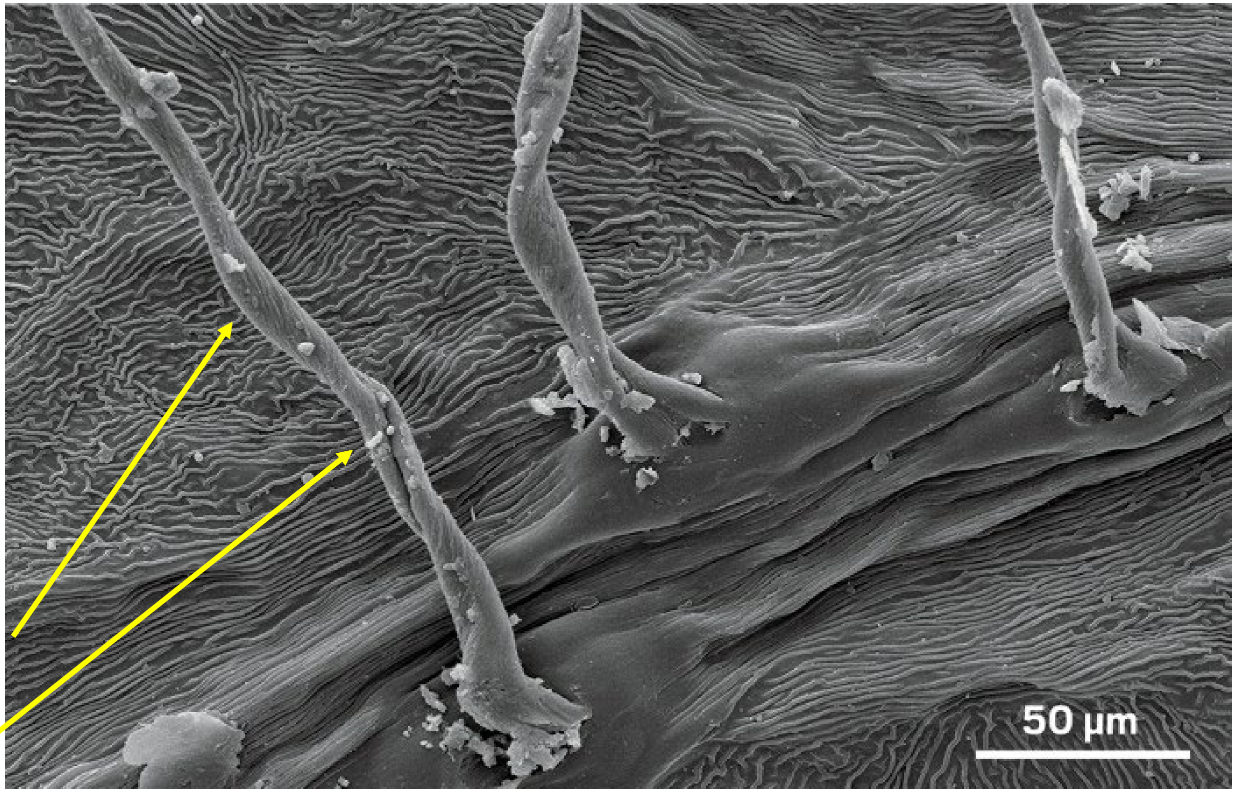


Image: SEM silver birch leaf (Wang et al, 2019)

Costs:
$80,000-2,000,000 USD

Vegetative Barrier Toolkit for Schools & Communities

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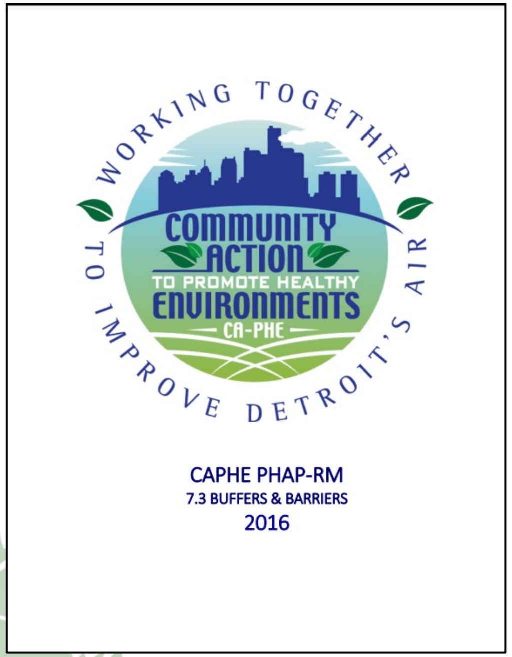
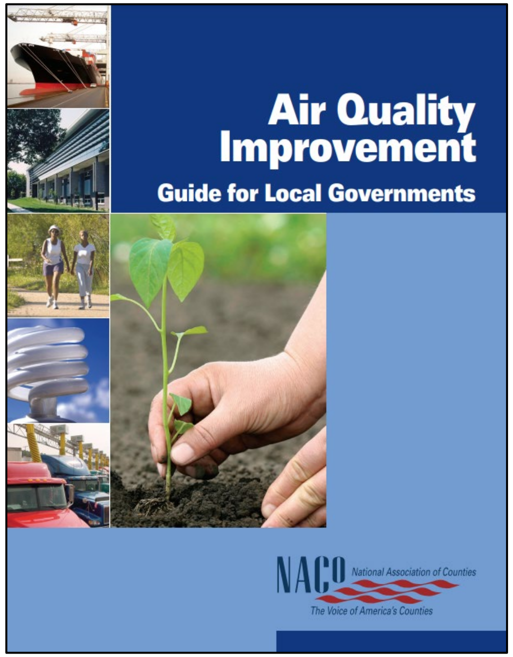
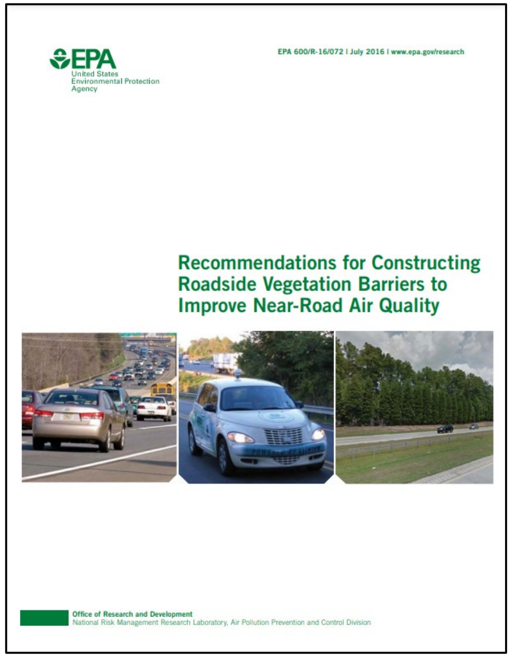
Many guides exist to --

Improve Air Quality







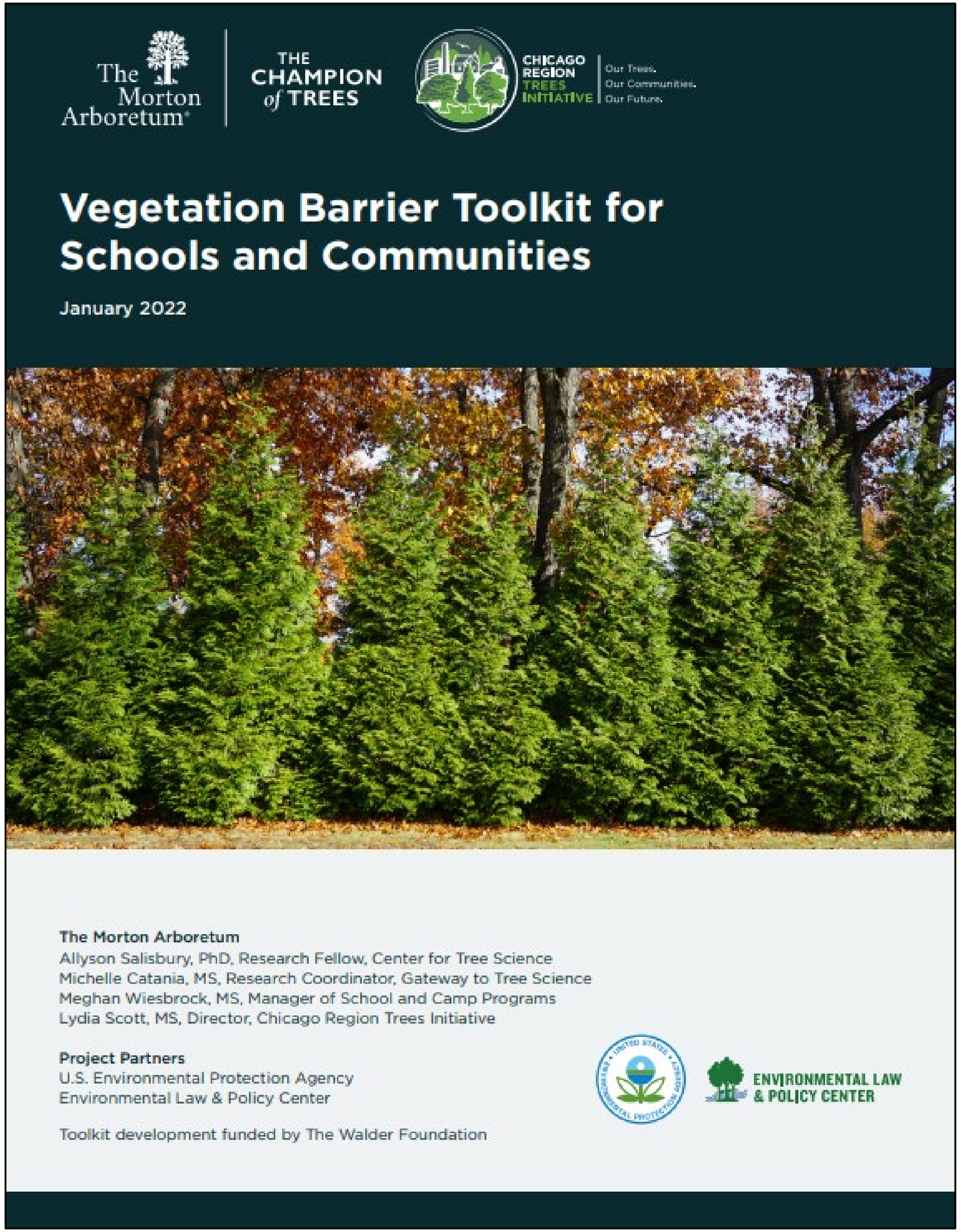
Lacks in-depth, tree-focused step-by-step detailed directions to help community members through the process

Install Trees

Directed at industry, too technical

GOAL:

Take a community group step-by-step through the process of planning, creating, & caring for a vegetation barrier in addition to using vegetation barriers as part of science curricula.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Vegetation Barrier Toolkit for Schools and Communities

January 2022

The Morton Arboretum
Allyson Salisbury, PhD, Research Fellow, Center for Tree Science
Michelle Catania, MS, Research Coordinator, Gateway to Tree Science
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Project Partners
U.S. Environmental Protection Agency
Environmental Law & Policy Center

Toolkit development funded by The Walder Foundation

ENVIRONMENTAL LAW & POLICY CENTER

What's in the Toolkit?

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Table of Contents

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Related Documents

Guides -- Field Sheets

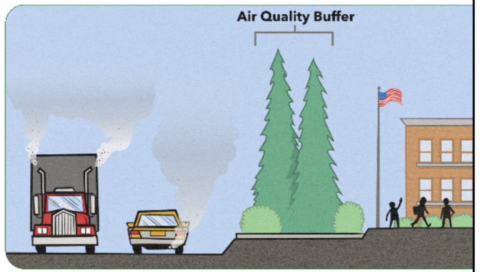
GUIDE #1

What's the Best Place for a Vegetation Barrier?

To reduce air pollution, a vegetation barrier will be most effective if it is downwind of and close and parallel to a ground-level source of pollution, such as a busy roadway. This way, the wall of trees or shrubs intercepts the wind that would bring polluted air onto a site. The methods described in these guides are typically used for open areas. While vegetation barriers can be designed for streets between crowded buildings in cities, those conditions are much more complex and consequently more challenging to ensure the vegetation barrier will work effectively.[1]

Vegetation barriers are generally made of a few rows of trees and/or shrubs. These plants grow to form a living wall or hedge that can trap air pollutants or direct polluted air away from the area you want to protect. Vegetation barriers planted near an actual wall or solid fence also provide effective air pollution improvements. As the plants grow, their branches should be close enough so the barrier does not have any gaps near the ground or between the trees. Gaps in the vegetation barrier can act like a funnel for air pollutants and let them through to the other side. The vegetation barrier can also be more than functional: You can add more decorative plants around and below the barrier. (See the Additional Plants to Complement Vegetation Barriers section.)

If there are already some trees or large plants between the road and the area you want to protect, it is preferable NOT to remove those plants to make a new barrier. Those plants are probably providing other benefits and are already mature. If you have existing trees where you think a vegetation barrier should go, it could be helpful to work with an arborist to determine if those trees are healthy and should be saved. If you do want to keep existing trees at your site, you can add vegetation barrier species around existing planted areas to enhance its ability to improve air quality.



Vegetation barriers should be planted between the source of ground-level air pollution, such as a road, and the area you want to protect, such as a playground.

Think about where you might want to put a vegetation barrier; this is your planting area. Take a walk around your site and look at it with an online map. Use your observations to answer the questions in Field Sheet #1.

If you answered "Yes" to all of the questions in Field Sheet #1, proceed to Guide #2 to start making measurements that will help you figure out if your planting area has enough space to grow vegetation barrier trees and shrubs. If your location doesn't have a good place for a vegetation barrier, the Additional Resources section can direct you to other practices that can help improve local air quality.

If you answer "No" to question #4, a vegetation barrier could still be planted in some circumstances. In this case, the vegetation barrier should be higher than the pollution source to be effective. For example, imagine a planting area that is 7 feet lower than a nearby highway. The vegetation barriers would need to grow at least 23 feet tall so that the trees extend 16 feet higher than the road.

Cited sources
1. Abhijith, K.V., Kumar, P., Gallagher, J., McNabola, A., Baldauf, R., Pilla, F., Broderick, B., Di Sabatino, S. and Pulvirenti, B., 2017. Air pollution abatement performances of green infrastructure in open road and built-up street canyon environments–A review. Atmospheric Environment, 162, pp.71-86.

FIELD SHEET #1

What's the Best Place for a Vegetation Barrier?

Bring this field sheet with you to your potential vegetation barrier location.

Materials

- Field Sheet #1
- Pen or pencil
- Phone or separate camera (can be helpful to take pictures of areas you think could be a good space for a vegetation barrier)

Estimated time

1 hour

Observations

While walking around the area you want to shield from ground-level pollution, use your observations to answer the questions in the table below. Using online maps and aerial photos can also help you answer these questions.

Is your potential vegetation barrier planting area....	Yes	No
1. Parallel and downwind to a ground-level pollution source such as a busy road?		
2. Separating the source of ground-level air pollution from areas where people spend time outside?		
3. Longer than the area you want to protect?		
4. At the same elevation or above the pollution source?		
5. Not located in between two pollution sources such as a busy roadway and a side street where cars and buses idle? (This situation can trap air pollution on the side of the vegetation barrier where people are located.)		

Other notes:

Guides -- Field Sheets

GUIDE #5

Get to Know Your Soil

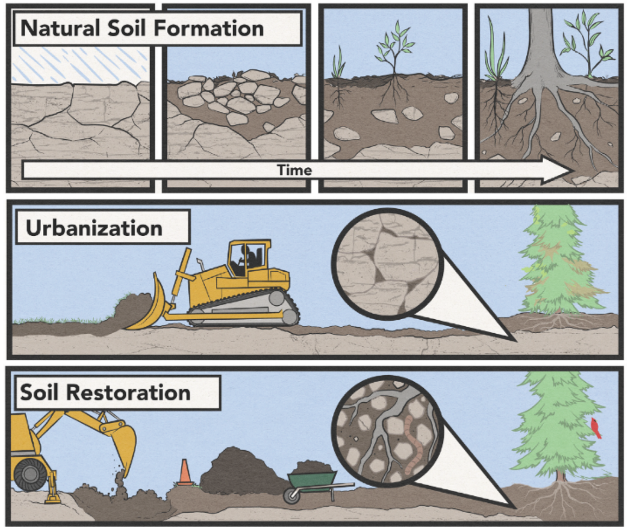
If you want to grow healthy trees and plants, you need healthy soil. Trees and other plants get water and essential nutrients from soil and rely on soil to hold them in place. This guide provides background about soil and helps you check for several common soil problems that can be found near roadways and other places affected by construction. Use Field Guide #5 to record your observations about the planting area soil.

Background: Healthy trees need healthy soil

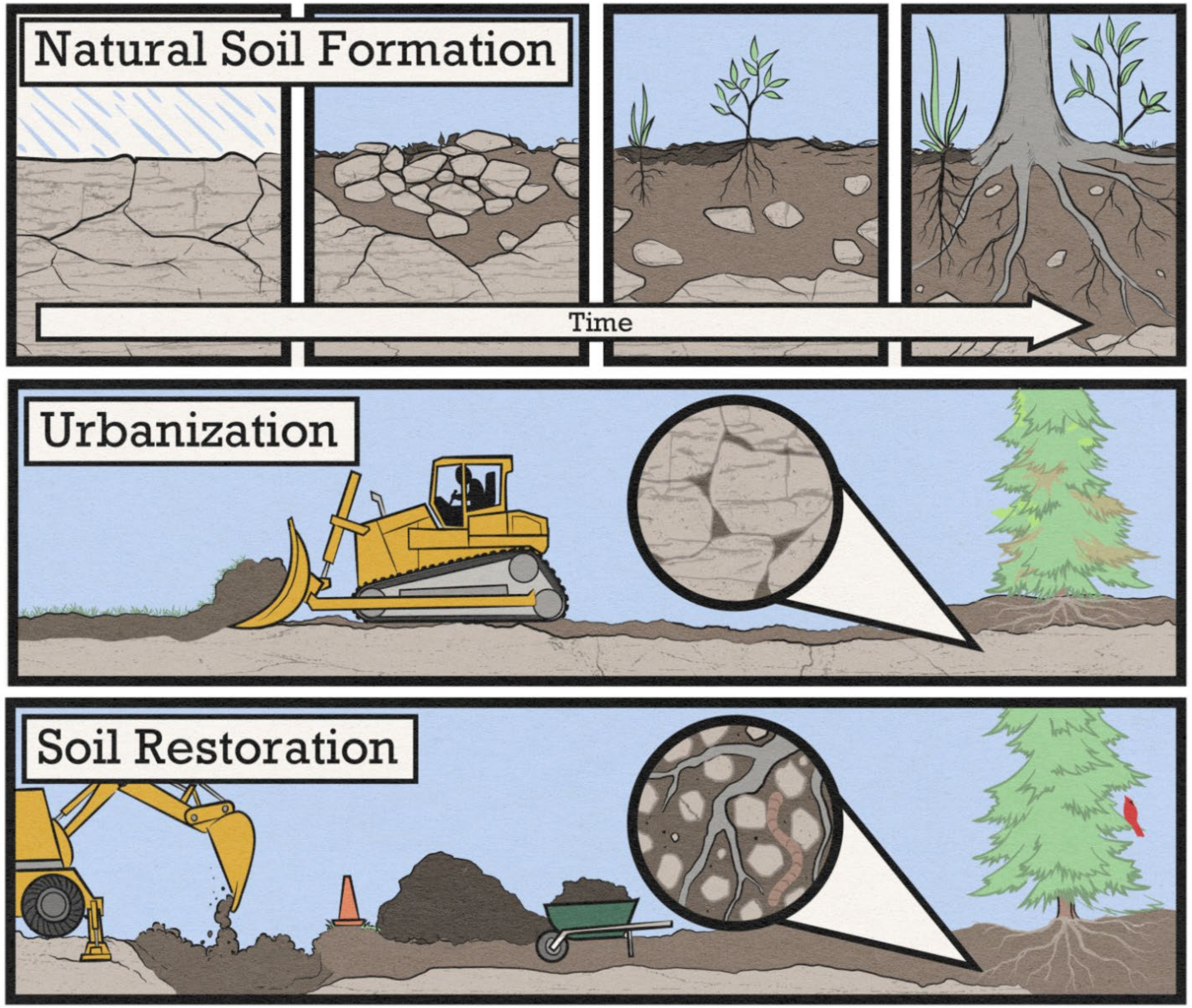
Healthy and happy trees start with healthy soil. Soil is a collection of tiny rock and mineral particles, organic matter, water, and air. Soils are unique: They vary from place to place, and they are constantly changing over time. Soil is fundamental for the growth of plants on land. It helps store and filter water, breaks down dead materials and wastes so their nutrients can be reused, and is a home for many creatures. Ideally soil is about 5% organic matter (the remains and wastes of plants and animals) and 45% tiny rock fragments. The rest is empty space between the solid pieces that can be filled with the air and water plants and soil critters need to live.

Have you ever wondered where soil comes from? The answer is not a bag from the hardware store. In nature, soil forms slowly over time as weather, plants, animals, and microbes break rocks into smaller and smaller particles and add organic matter. In some parts of the world, it can take 100 years to form an inch of rich, organic topsoil.

Unfortunately, removing or damaging good-quality soil can happen quickly. Construction activities usually remove topsoil — an upper layer of soil that can be rich in nutrients and good for plant growth.



Soil forms from bare rock over very long periods of time with the help of microbes, insects, fungi, plants, and animals. Construction severely changes soil by removing topsoil rich in organic matter and compacting the soil. Soil restoration can improve the condition of soil after construction so it is more suitable for growing trees and other plants.



Guides -- Field Sheets

FIELD SHEET #5

Get to Know Your Soil

Bring this field sheet with you to your potential vegetation barrier location.

Materials for all soil tests

- Field Sheet #5
- Pen or pencil
- Phone or separate camera
- Tape measure or yardstick that can get wet
- Shovel/soil auger
- Water source and bucket/hose
- Resealable plastic sandwich bags
- Permanent marker
- Wire probe (description below)
- Squirt or spray bottle (optional)

Soil Test #1 – Soil profile assessment and drainage

Record your observations about each soil profile you remove.

	Sample #1	Sample #2
Example	Soil is brown, deeper soil is darker. Grass roots grow about 10 cm deep. Soil forms larger clumps 10-20 cm deep.	Top 10 cm of soil is brown, forms large dens clumps. 10-20 cm is ligh tan color, mostly sand and gravel.
Observations (number of soil layers, colors, gravel, smell, other notes)		
Causes for concern: gray soils, buried human-made materials such as asphalt, rotten smell		

Record your measurements of the soil drainage test. Remember to save the soil f
a bucket for the other soil tests.

Poor drainage – less than 4 inches per hour
Moderate drainage – 4 to 8 inches per hour
Excessive drainage – more than 8 inches per hour

Sample location	Depth of hole	Initial water height	15 min. water height	Change (initial minus 15 min.)	C 1 (x
Example	12 in.	10 in.	8 in.	10-8 = 2 in.	2 8
#1					
#2					
#3					

Soil Test #2 – Soil texture

Soil texture type determined by the texture-by-feel method (for example, "silty lo

Soil texture	Category	Notes
• Sand • Loamy sand • Sandy loam	Coarse	Water flows through ver Difficult to compact Not good at holding nut
• Sandy clay loam • Loam • Silt loam • Silt	Medium	Water flows through at r Somewhat easy to comp Good at holding nutrien
• Silty clay loam • Clay loam • Sandy clay • Silty clay • Clay	Fine	Water flows through ver Easy to compact Very good at holding nu

Soil Test #3 – Organic matter

Estimate the amount of organic matter by matching your soil sample color to the chart below.

Soil color	Organic matter	Soil sample
	>10%	•
	5%–10%	•
	3%–4%	•
	1%–2%	•
	<1%	•

Soil Test #4 – pH

Record the results of your soil pH test here: ____________

Soil Test #5 – Soil compaction

After each penetration test, check off if a sample location had severe, moderate, or acceptable soil compaction.

How deep did the wire go?	Soil compaction	Sample location #1	Sample location #2	Sample location #3
Less than 4 inches	Severe	•	•	•
4 to 12 inches	Moderate	•	•	•
More than 12 inches	Acceptable	•	•	•

Curriculum Toolkit for Educators – STEM based lessons

Lesson Plans

The following set of lesson plans using problem-based learning and citizen science approaches are available from The Morton Arboretum's Education Department in both PDF and Word document forms. Materials such as portable air quality sensors can also be available for classrooms to borrow. Connect with The Morton Arboretum's Education Department at registrar-ed@mortonarb.org.

Curriculum outline and lesson progression (Strategy-based: problem-Based learning & citizen science)

- **Setting the stage**
  - Introduction Activity – Anticipation Set- Find the Fiction – Air Quality Headlines Activity
  - Vocabulary Build: Vocabulary Story – Air Quality and Trees
- **Investigating the problem**
  - Observation: Measuring the Air Quality at Your Site, How to Use the Sensors, and Understanding Air Quality.
    - Additional resources: U.S. Environmental Protection Agency (Air Sensor Loaning Resource) (only available as an appendix in toolkit's printed resource)
  - Connect: Trees, Shrubs and Air Quality – Science Notebook Activity
- **Designing a solution**
  - Action Planning Worksheet
  - Planning Your Vegetation Buffer
  - Investigating Soil on Your Schoolyard
  - Choosing the Trees for Your Barrier – Final Planning Activity
  - Bringing It All Together – Planting Design Proposal

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Vegetation Barrier Lesson Plans

January 2022

Separate document for Educators

Toolkit education loaning resources

- Learning objectives
- Curriculum outline & lesson progression
- <u>Toolkit education loaning resources</u>

Bin contents

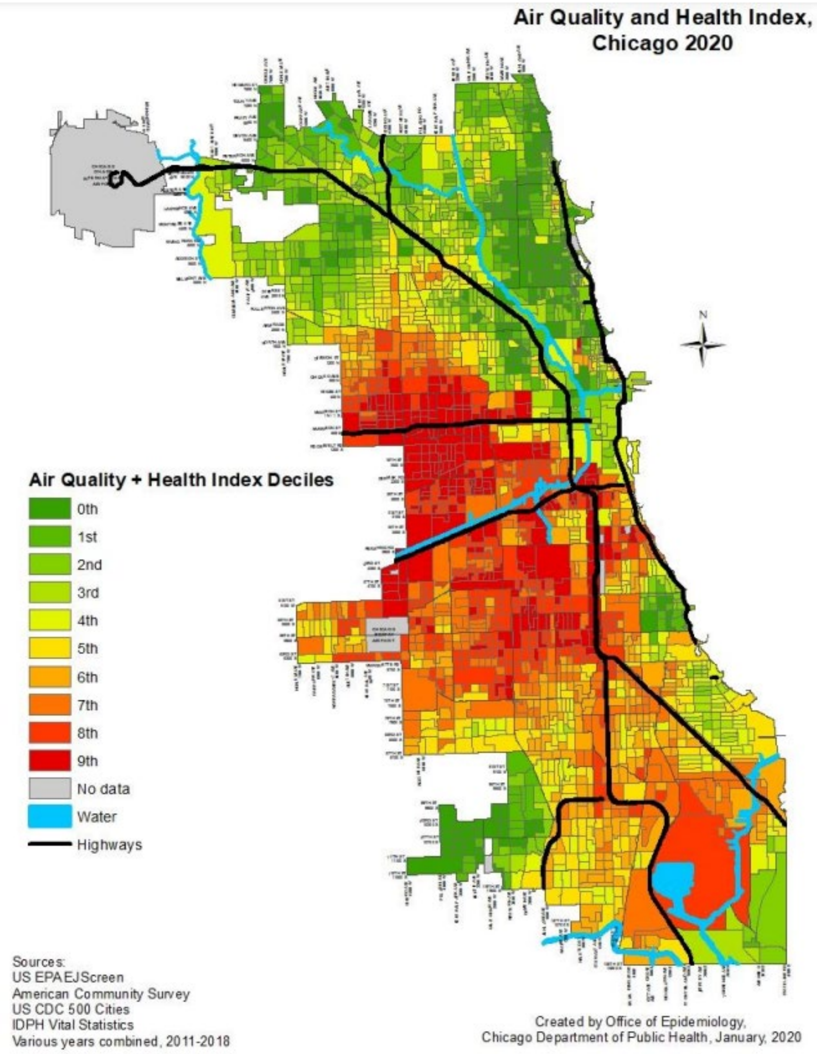
- Binder with printed toolkit and jump drive (digital content)
- Soil probes and/or shovels (qty: 3-5)
- Clipboard(s) (qty: 3-5)
- Large tape measure (qty: 3-5)
- AirBeam2 sensor (EPA Loaning Resource, quantity determined by educators during toolkit registration)
- Mobile device for sensor (EPA Loaning Resource, quantity determined by educators during toolkit registration)

Chicago, IL, USA & Potential Sites

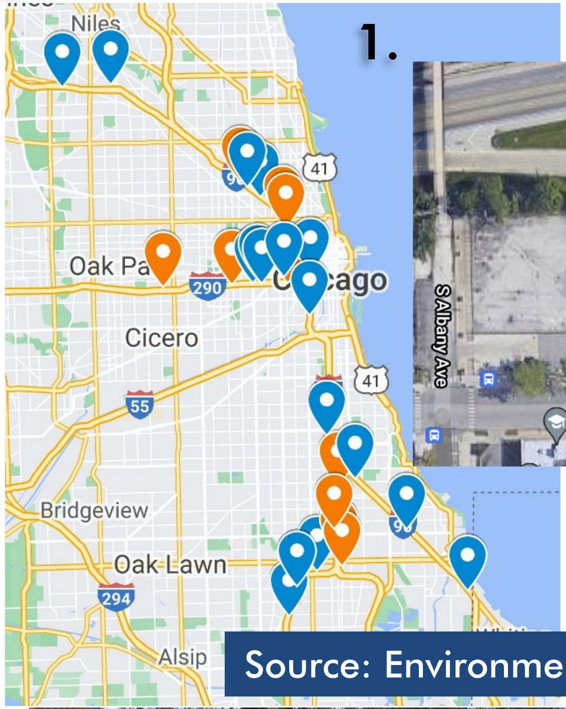
Chicago, Illinois, USA

- 235 sq miles (606 km^2), 597 ft asl. (182 m asl)
- **2.7 million people** in city -- 3rd biggest US city
  - **9.6 million people** in metro
- Lake Michigan -- lake breeze & lake-effect snow
- Humid continental climate, 4 distinct seasons
- Average ppt **42"** (16 cm) -- rain and snow
- Plant hardiness **zone 5 -- zone 6** close to lake

Three Levels of Screening



1.



2.

Source: Environmental Law and Policy Center

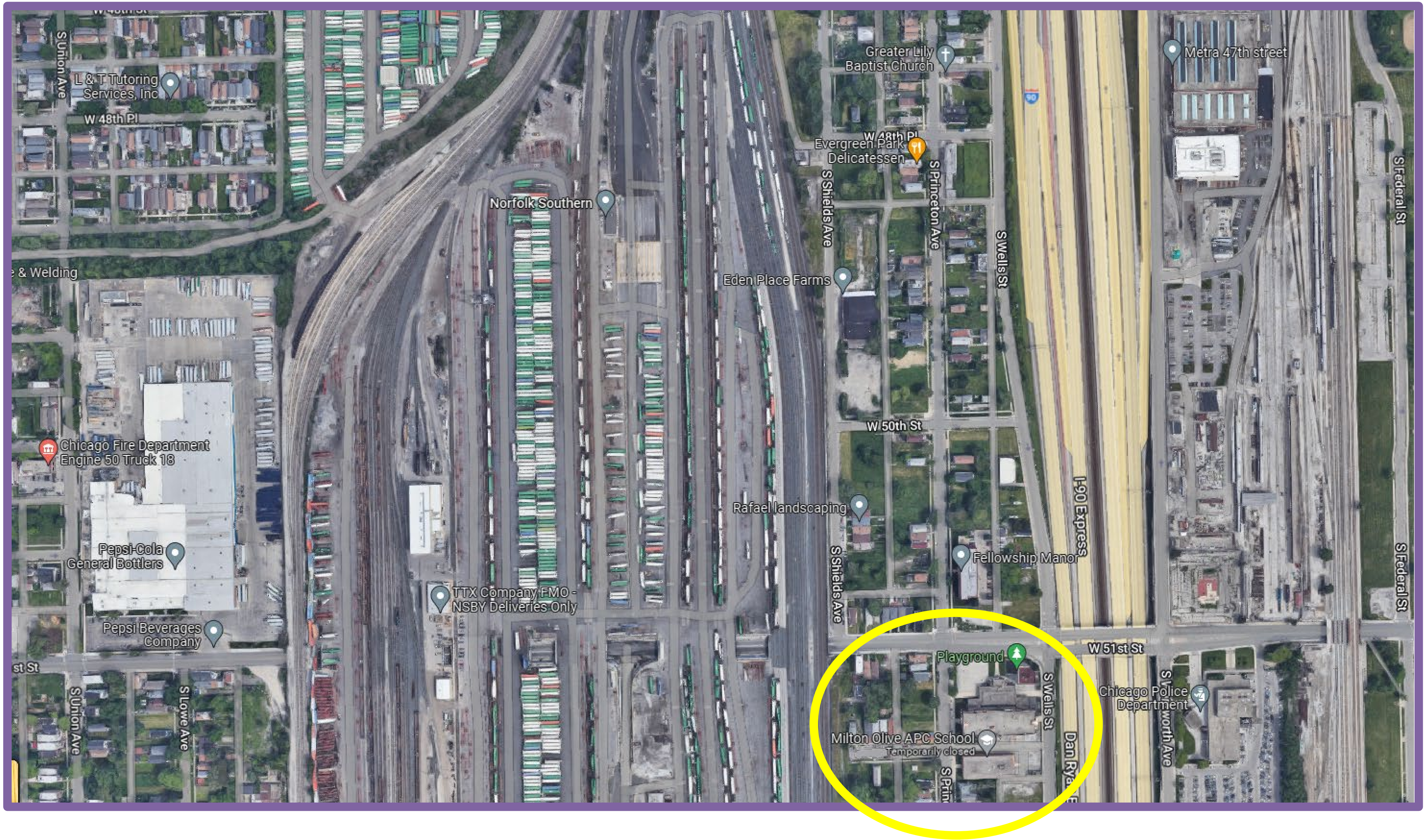
Source: U.S EPA

3

Schools within 500 ft (152 m) of source

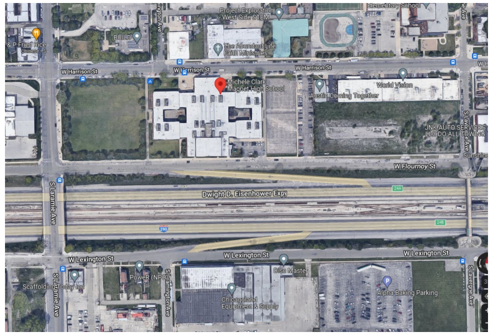
1. BROAD – Identified 28+ Schools (ELPC)
2. INTERMEDIATE – 15, down to 10
3. ON-THE-GROUND – Site visit to 10 schools

Slide credit: EPA

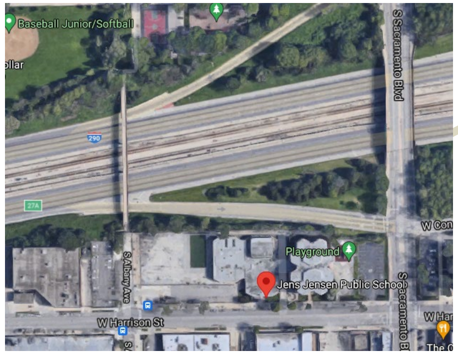

S Union Ave
L & T Tutoring Services, Inc
W 48th Pl
Norfolk Southern
Greater Lily Baptist Church
Metra 47th street
Evergreen Park Delicatessen
S Shields Ave
S Princeton Ave
S Wells St
S Federal St
Eden Place Farms
& Welding
W 50th St
Chicago Fire Department Engine 50 Truck 18
Rafael landscaping
I-90 Express
Fellowship Manor
Pepsi-Cola General Bottlers
TTX Company FMO - NSBY Deliveries Only
Pepsi Beverages Company
W 51st St
Playground
Chicago Police Department
S Lowe Ave
Milton Olive APC School
Temporarily closed
Dan Ryan

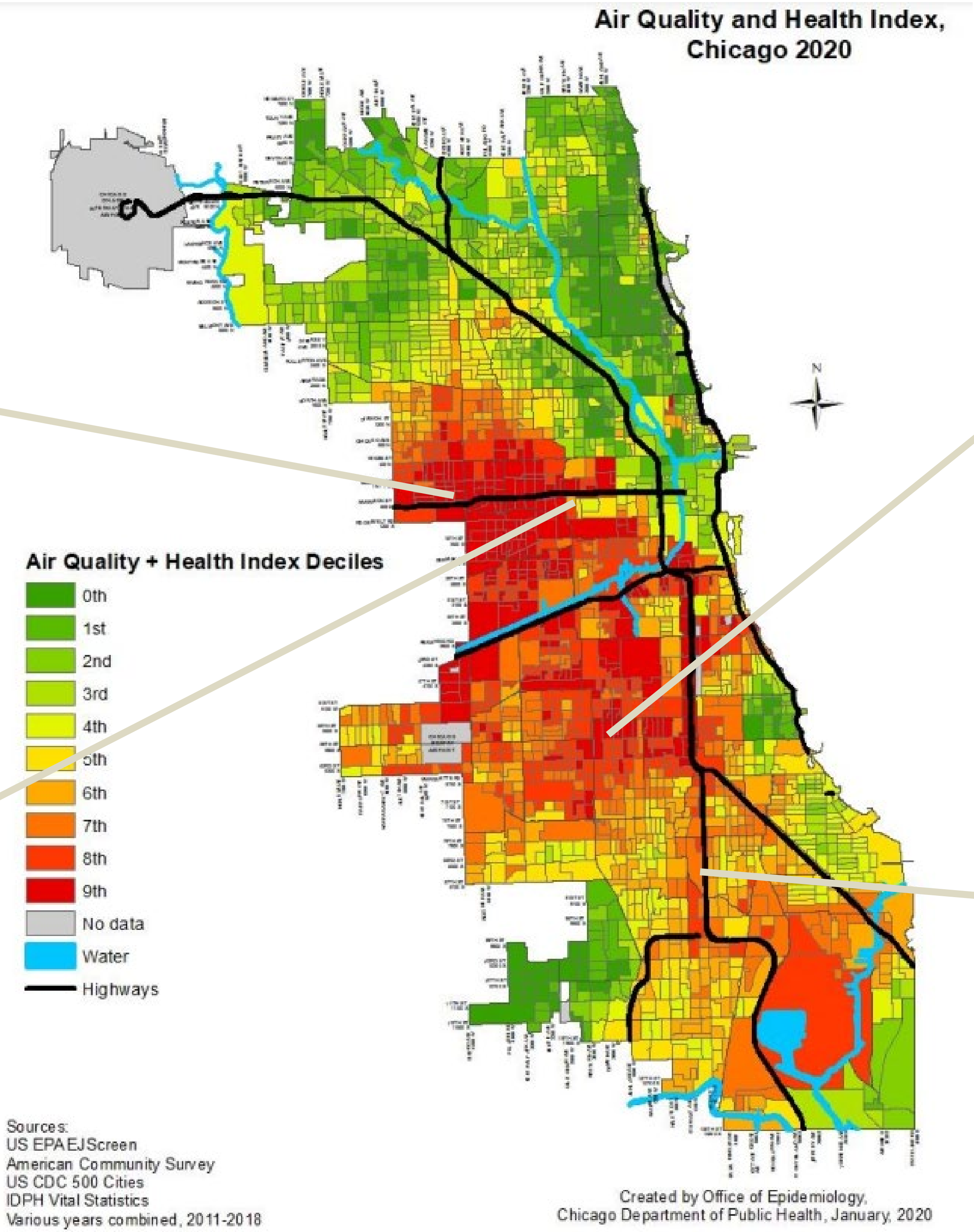
Final 4

Michele Clark H.S.

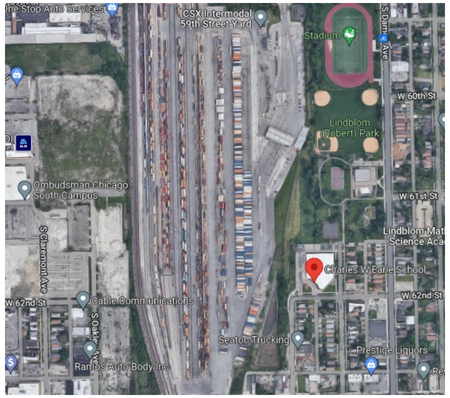


Jens Jensen Elementary

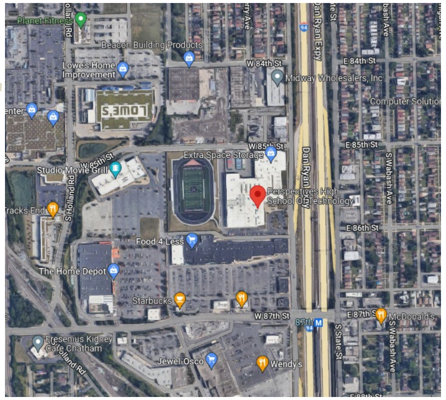




Earle Stem Elementary



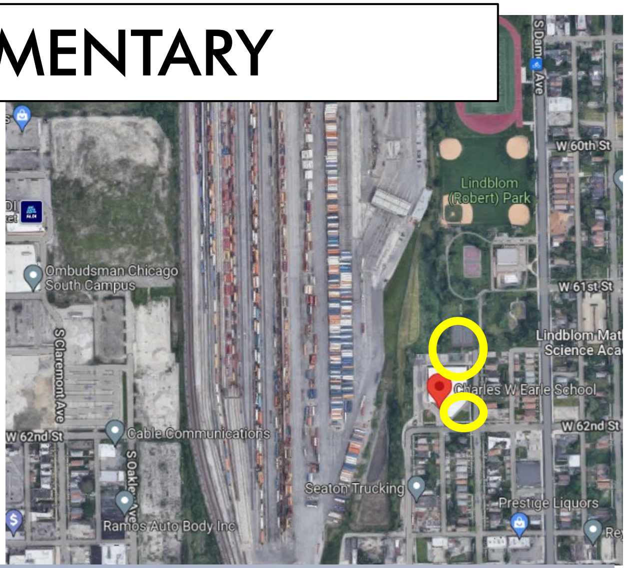
Perspectives H.S. of Technology

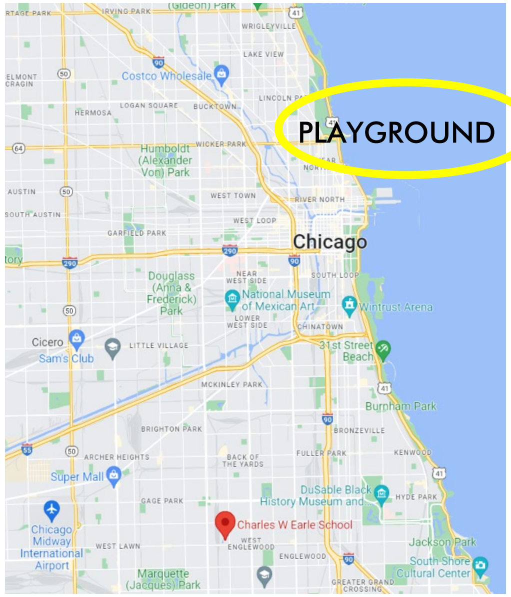


CDPH
Chicago Department of Public Health

Slide credit: EPA

EARLE STEM ELEMENTARY

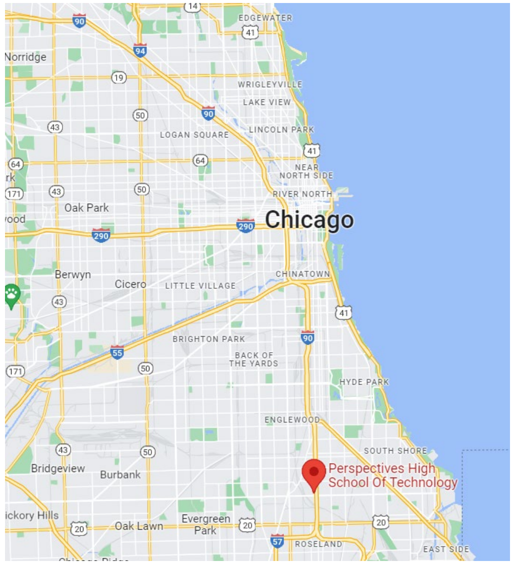


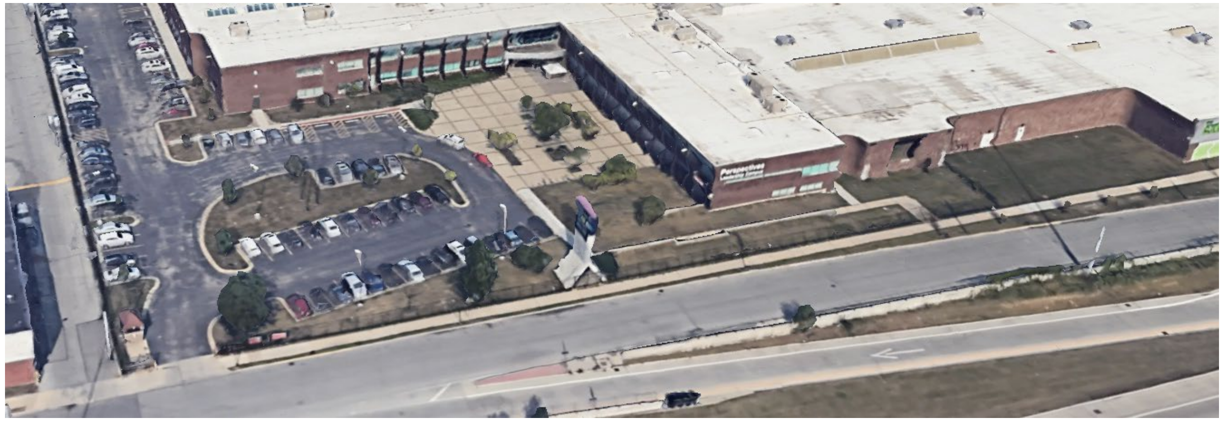


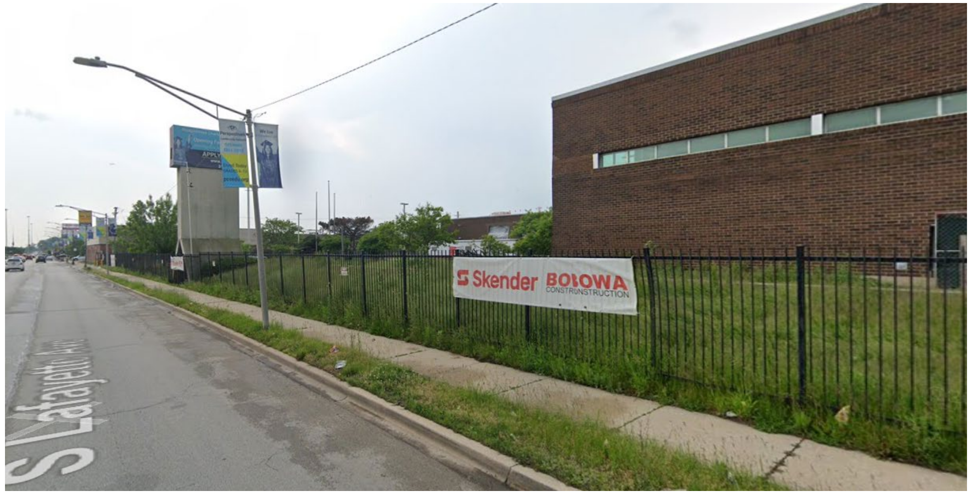
CSX 132 acre (53.4 ha) site	
Distance from RAILYARD to planting site	40-100 ft (12 - 32 m)
Distance from RAILYARD to school	216 ft (66 m)
Lift counts per year (2012)	261,025
School elevation compared to source	Lower by 13 ft (4 m)

Students served (2019)	304
% low income	92
% homeless	14
% black	84

PERSPECTIVES H.S. OF TECHNOLOGY



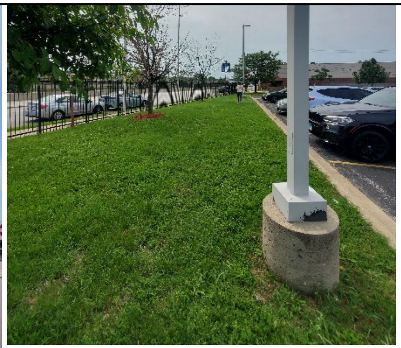




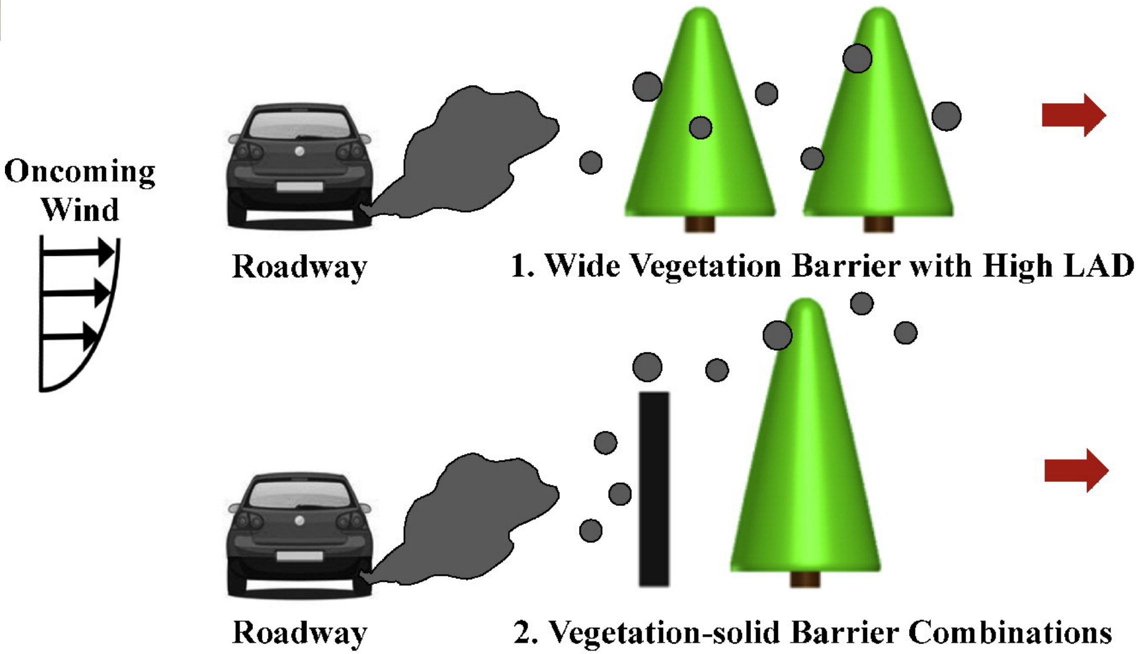
Distance from highway to planting site	137 – 165 ft (42-50 m)
Distance from highway to school	180 ft (55 m)
Annual avg daily traffic count (2019)	247,600
Annual avg daily heavy commercial -- 6+ tires (2020)	16,000
School elevation compared to source	Higher at 9.8 ft (3 m)

Students served (2021)	336
% low income	93
% homeless	na
% black	99.1

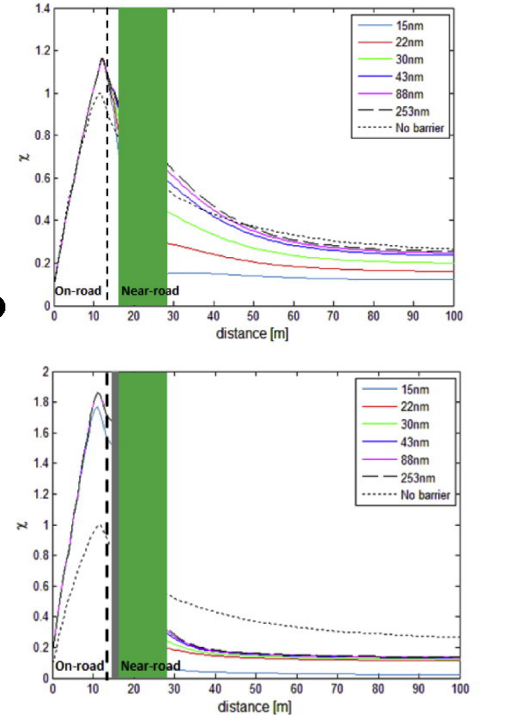
PHASE 1 TREE PLANTING SCHDULED FOR NEXT WEEK!



Two Viable Roadside Barrier Designs



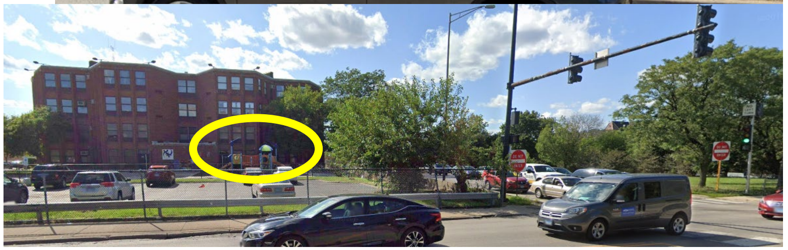
Horizontal Gradients of Particle Concentration

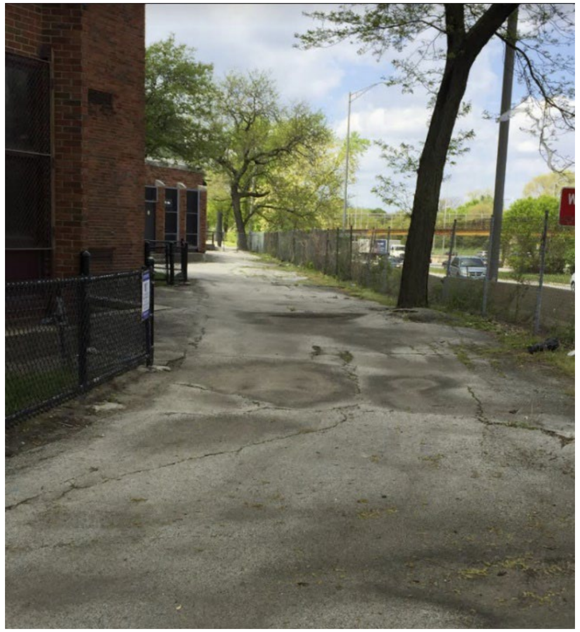


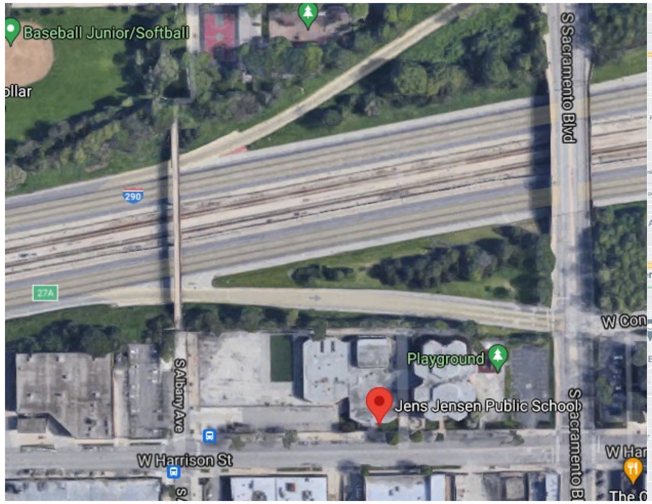
Fantastic potential for hybrid!

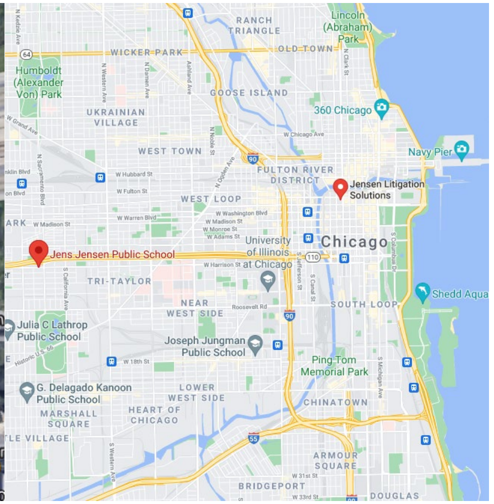
(Graphic) Tong, Baldauf…et al., 2016, Science of The Total Environment (EPA)

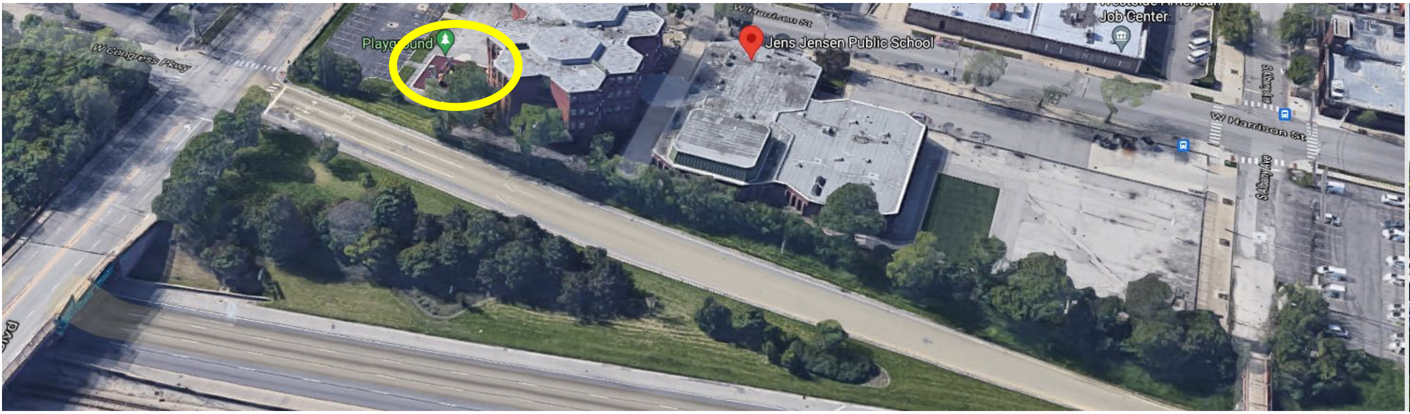
JENS JENSEN ELEMENTARY

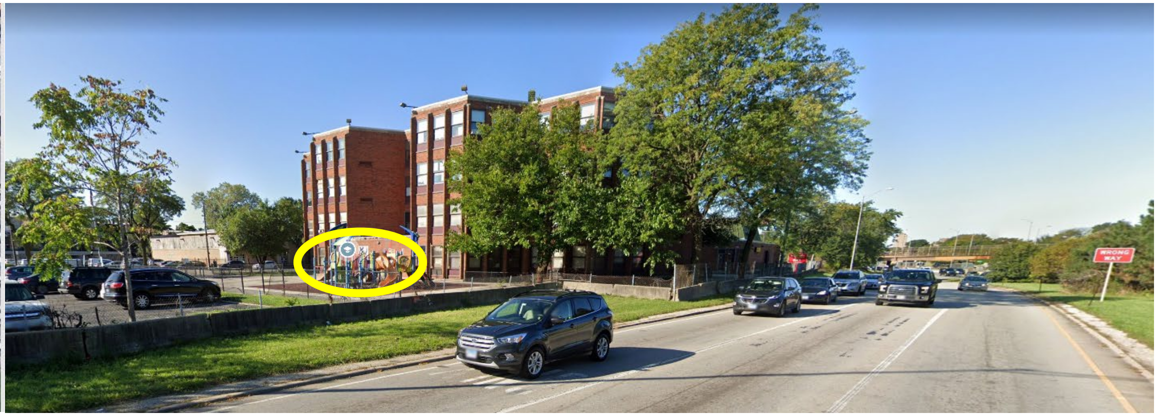










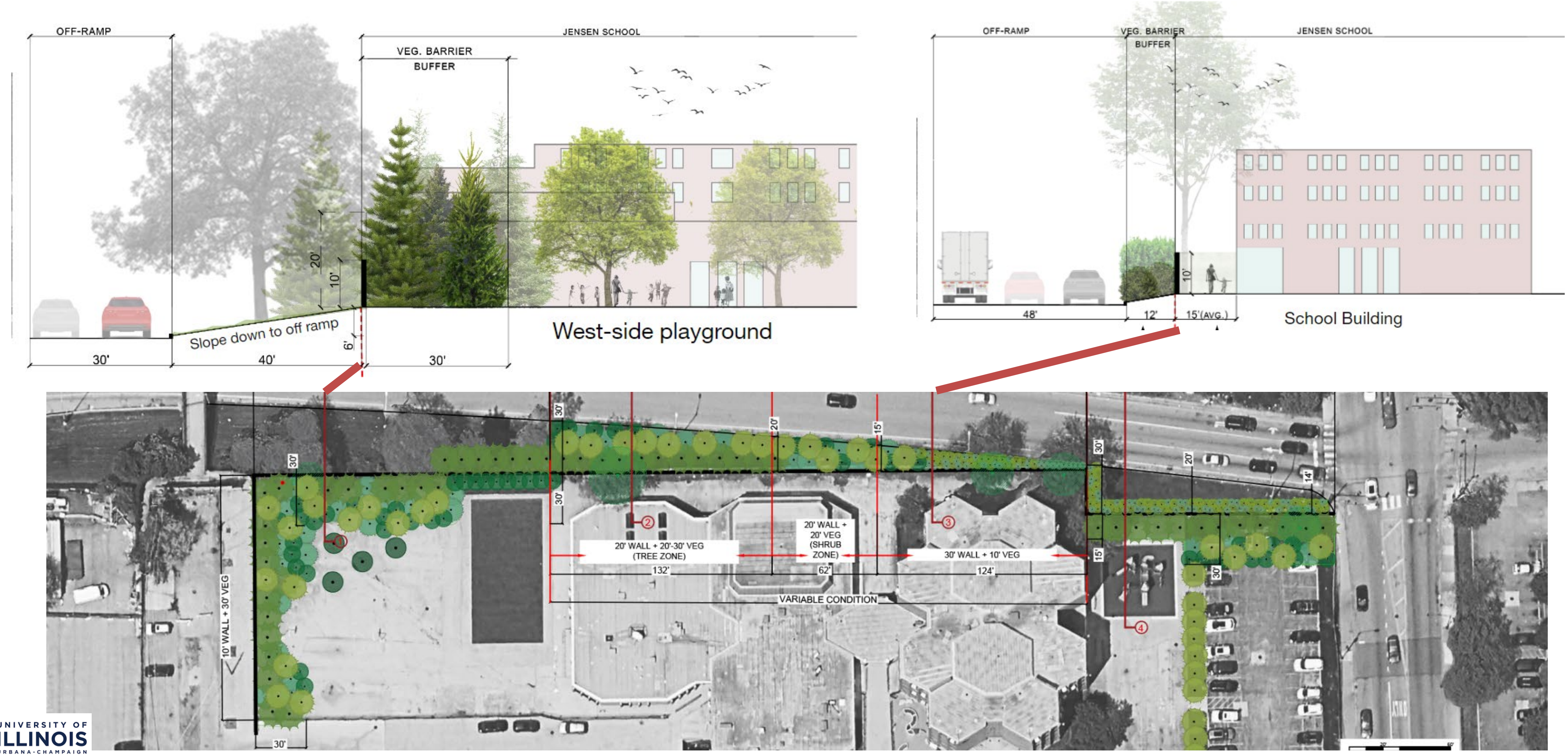


Distance from highway to planting site	40-200 ft (12.2-61 m)
Distance from highway to school	160 ft (48.8 m)
Annual avg daily traffic count (2019)	193,700
Annual avg daily heavy commercial -- 6+ tires (2017)	8,000
School elevation compared to source	Higher at 11.3 ft (3.4 m)

Students served (2019)	371
% low income	99.2
% homeless	3.8
% black	98

VEGETATION BUFFER DESIGN AREA - Adequate Planting, No Planting (Possible), Constrained Planting (On CPS Property)

Slide modified from McGuire, UIUC



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Slide modified from McGuire, UIUC

Slide modified from McGuire, UIUC

Next Steps

- Work with EPA to reinstate
  - Portable Air Quality Samplers (PAQS)
  - Solar Powered Air Quality Bird House (S-PAQ)
    - Arduino-based portable systems with GPS (PAQS)
    - Black Carbon Aethlabs MA-200
    - NO_2 with CairClip
    - Interactive Display – RETIGO- ready files
    - Wind speed and direction (S-PAQ)
    - Solar Powered Air Quality Bird House (S-PAQ)
  - Move from car to cart!
- CDPH is interested
- **Improved placement of future schools**

Mobile & Stationary Vehicles:
BC, NO_2, PM, CO & other parameters

Slide credit: EPA

OUR TEAM & FUNDERS

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CHICAGO REGION TREES INITIATIVE

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In Coordination with IL DOT
- Melissa Del Rosario, Landscape Maintenance
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Toolkit developed by grant from the

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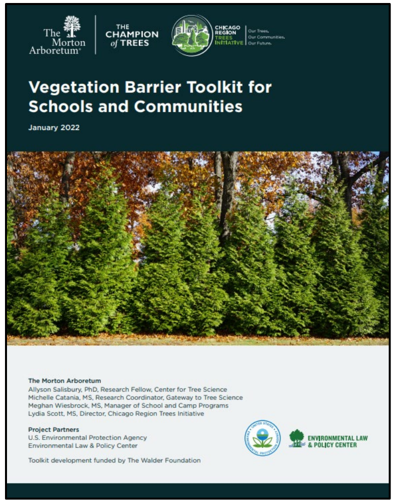
Thank you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Food and Agriculture Organization of the United Nations · Arbor Day Foundation · POLITECNICO MILANO 1863 · SISEF · ISA International Society of Arboriculture · Smithsonian

2nd World Forum on Urban Forests

2023

World Forum on Urban Forests

2nd World Forum on Urban Forests

Washington DC, 2023

A novel approach for enhancing the effectiveness of tree-based systems

Presented by

Elizabeth Rogers[1,2]

Chung-Ho Lin[1], Ronald Zalesny Jr.[2], Mohamed Bayati[1,3], Shu-Yu Hsu[2]

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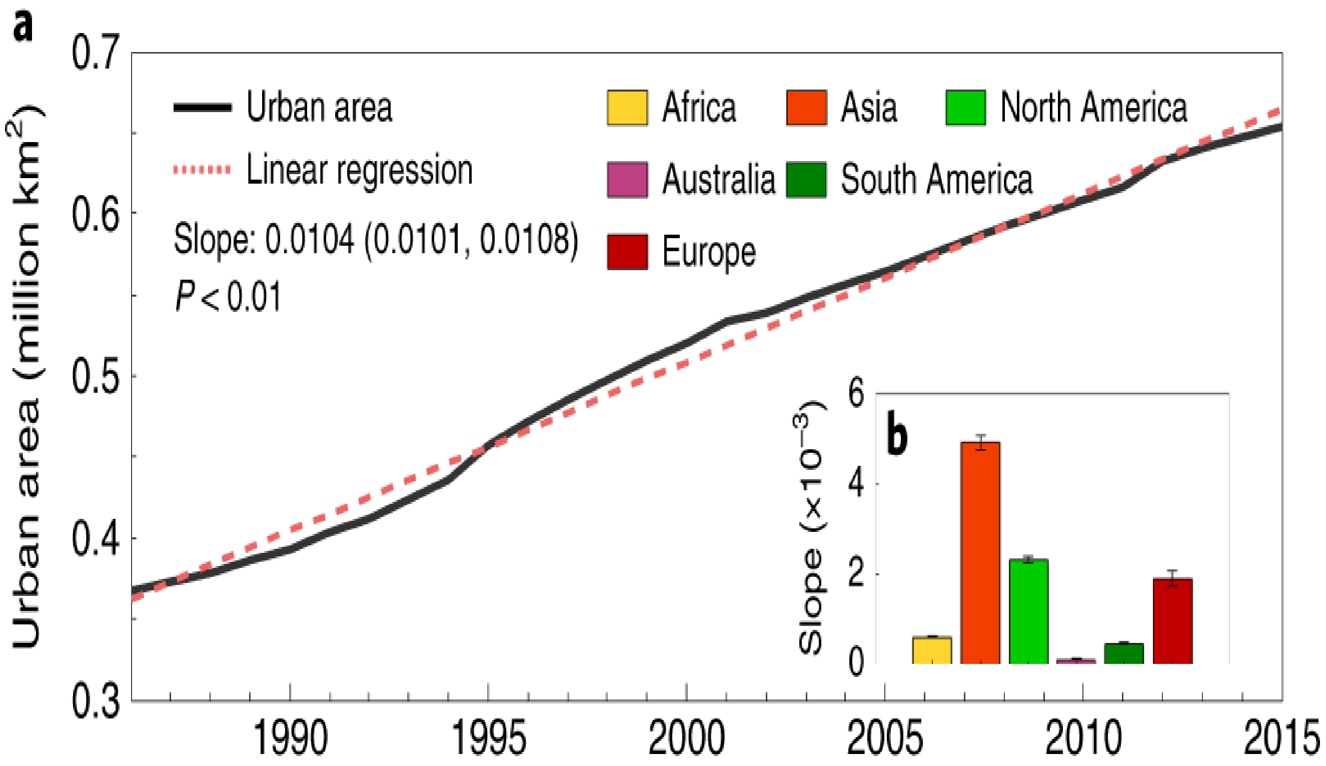
Urban area dynamics during 1985– 2015 at the global and continent scales.



Liu et al. *Nat. Sustain.* (2020)


Photo Credit: National Geographic


Photo Credit: Ron Zalesny, USDA Forest Service


Photo Credit: CUNY Graduate Center

Phytoremediation

- Sustainable, cost-effective

  McCutcheon and Schnoor. Phytoremediation: Transformation and Control of Contaminants. (2003)
- Urban phytoremediation applications

  -Wastewater remediation

  Dimitriou and Aronsson. *Unasylva* (2005)

  -Air pollution control

  Podhajska et al. *Sustain. Cities Soc.* (2023)

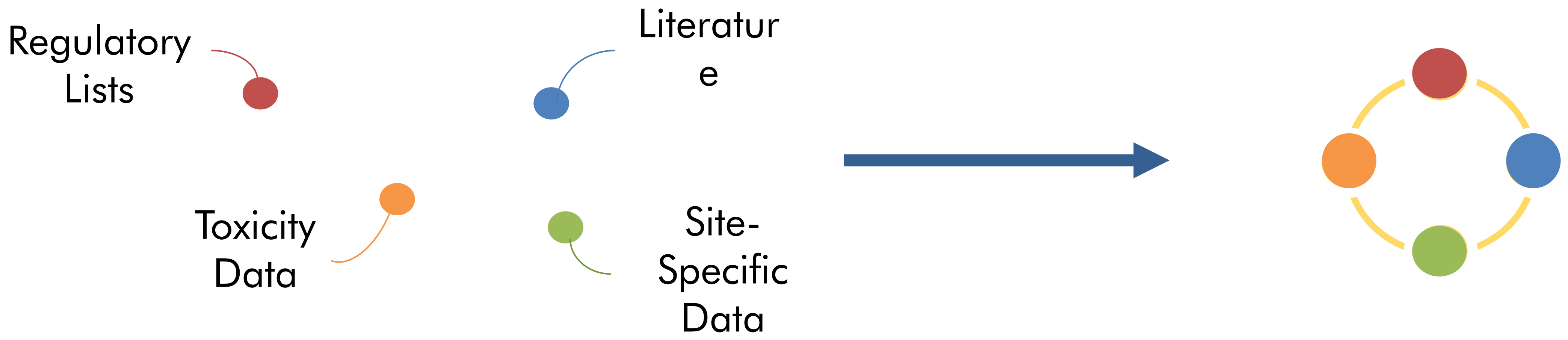
  -Soil reclamation

  Guidi Nissim and Labrecque. *Urban For. Urban Green.* (2021)
- Effectively identifying and prioritizing pollutants to target is critical for designing successful systems

The Problem: Fragmented Approaches to Identifying and Prioritizing Contaminants

- Phytoremediation studies focus on remediation of **small number of contaminants** (e.g., Cd, As, benzene, toluene)
- An approach for comprehensively identifying priority pollutants to target with phytoremediation efforts is urgently needed

Fragmented Approaches — Standardized Approaches



Objectives

Develop a standardized method for pollutant identification and prioritization

- Integrate a global metabolomics approach with toxicity profiling

Use the developed approach to identify and prioritize pollutants in landfill leachate and contaminated groundwater

Objective 1: Develop Standardized Method

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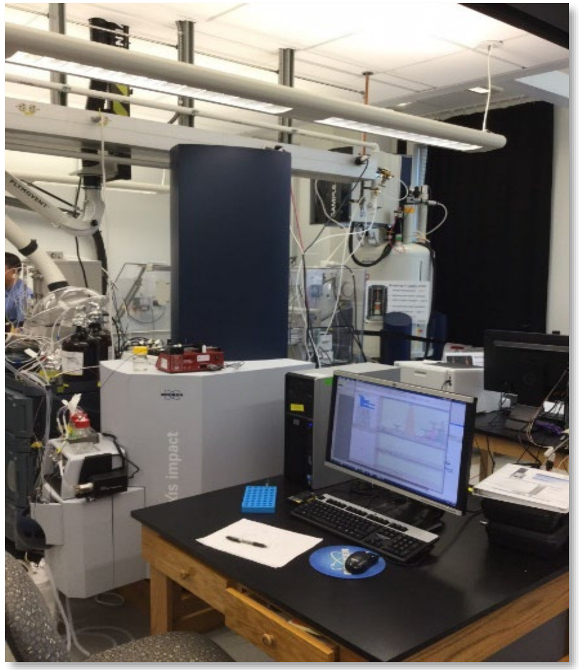
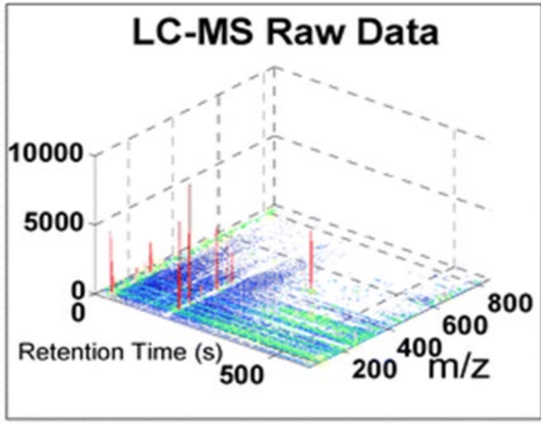
Washington DC, 2023

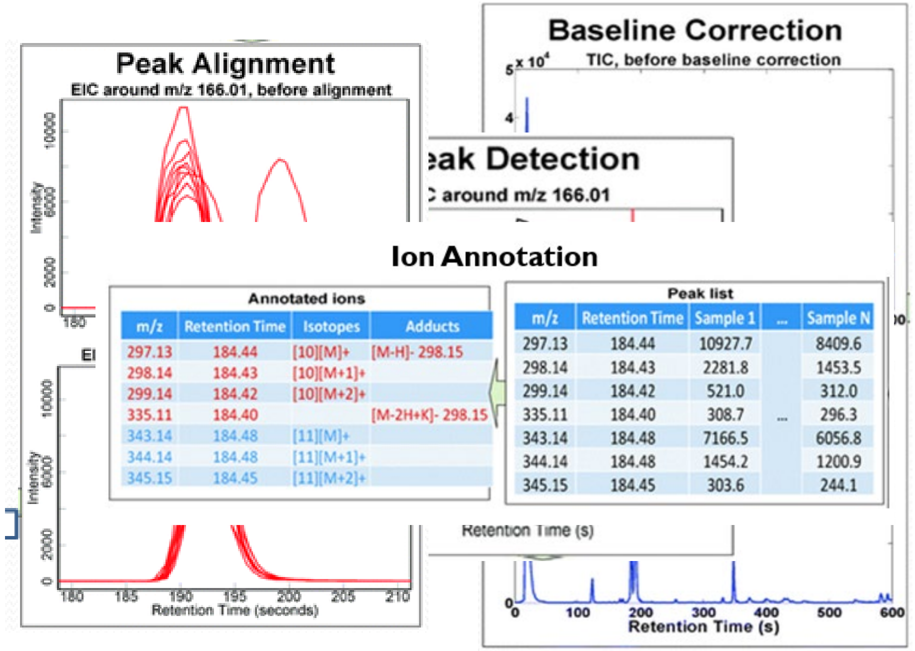
Step 1: Global Profiling Approach



UHPLC High-Resolution Mass Spectrometer



XCMS Online

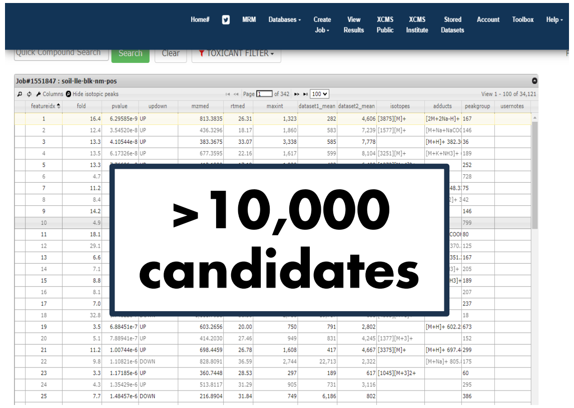


Annotated ions

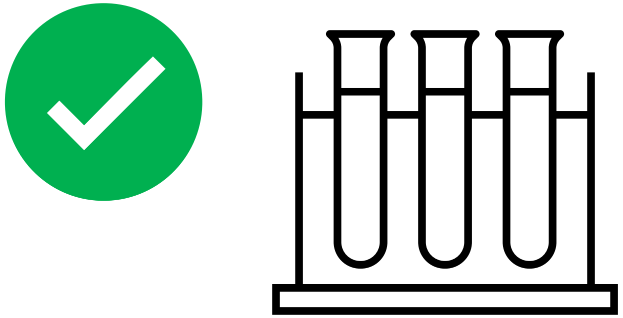
m/z	Retention Time	Isotopes	Adducts
297.13	184.44	[10][M]+	[M-H]- 298.15
298.14	184.43	[10][M+1]+	
299.14	184.42	[10][M+2]+	
335.11	184.40		[M-2H+K]- 298.15
343.14	184.48	[11][M]+	
344.14	184.48	[11][M+1]+	
345.15	184.45	[11][M+2]+	

Peak list

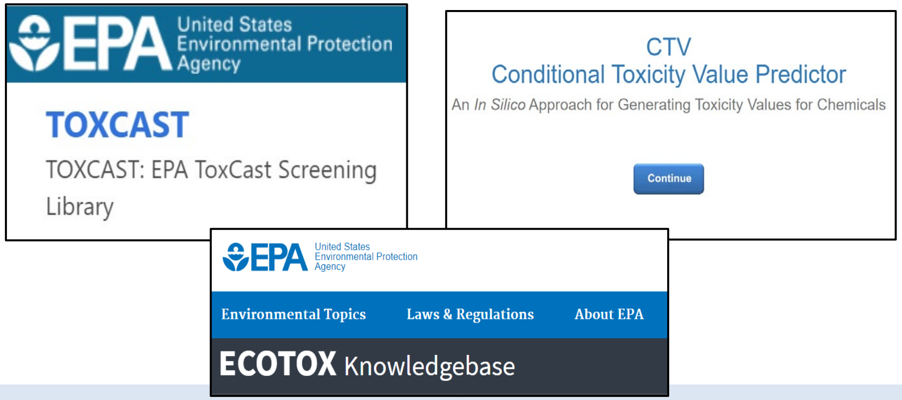
m/z	Retention Time	Sample 1	...	Sample N
297.13	184.44	10927.7		8409.6
298.14	184.43	2281.8		1453.5
299.14	184.42	521.0		312.0
335.11	184.40	308.7	...	296.3
343.14	184.48	7166.5		6056.8
344.14	184.48	1454.2		1200.9
345.15	184.45	303.6		244.1



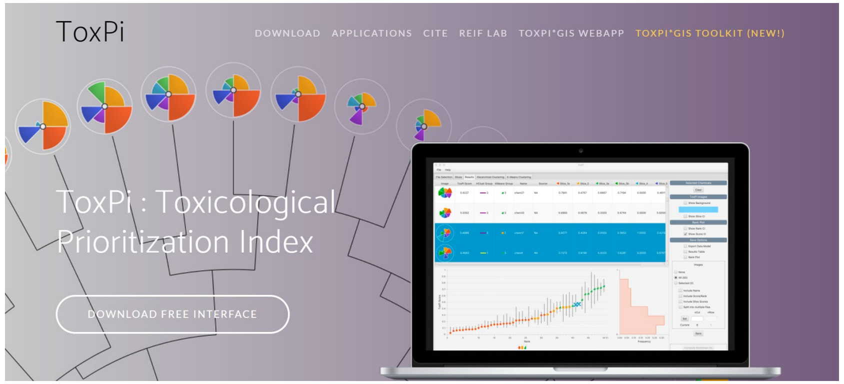
Step 2: Prioritize Contaminants



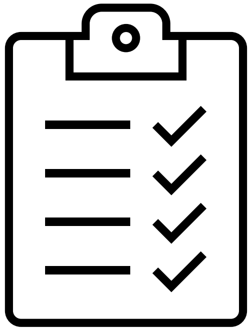
1. Identify contaminants using global metabolomics approach



2a. Collect toxicity data from public databases



2b. Integrate data using ToxPi

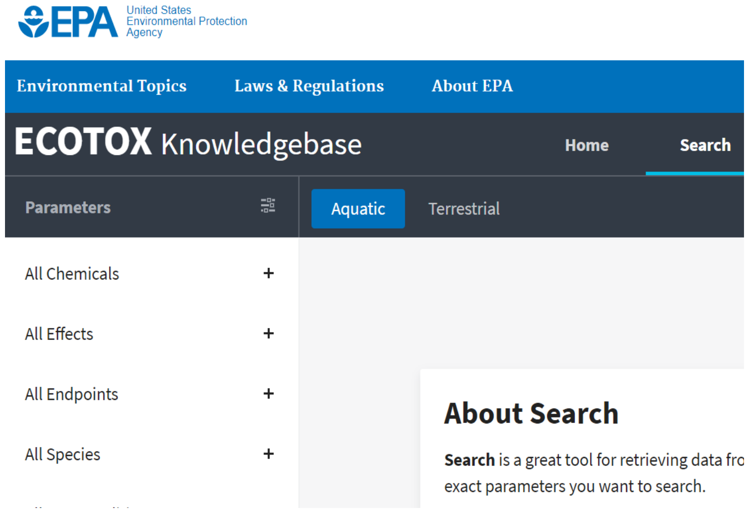


2c. Prioritize contaminants to target with remediation activities

2a. Collect Toxicity Data from Public Databases

ECOTOX database

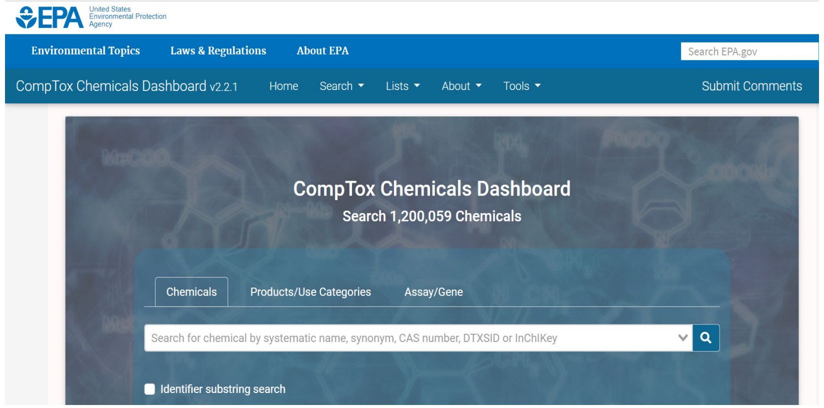
In vivo toxicity data from plants, animals



https://cfpub.epa.gov/ecotox/

CompTox Chemicals Dashboard

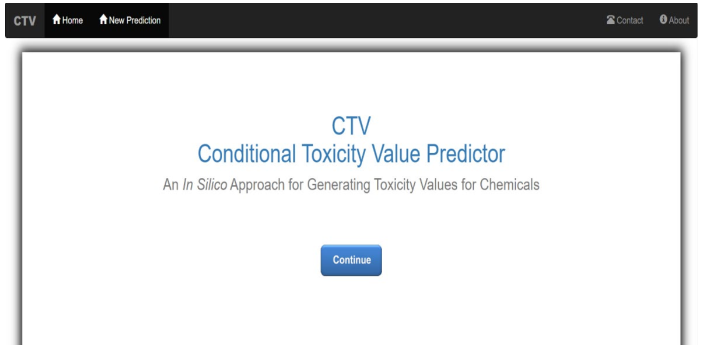
In vitro assay toxicity data



https://comptox.epa.gov/dashboard/

Conditional Toxicity Value (CTV) predictor

Model-based *in silico* approach, generates quantitative predictions for human toxicity values



https://toxvalue.org/6-CTV/Cover.php

2b. Integrate Data using ToxPi

Toxicological Prioritization Index (ToxPi)

- Integrates multiple sources of data into one **dimensionless index score**
- Generates a toxicity profile for each compound
- Users have ability to add different weighting schemes to data sources

Example

	(EC50) +	(AC50) +	(% Active Assays) +	(Cancer Potency) = Toxicity Score
Scheme 1.	(0.25)	(0.25)	(0.25)	(0.25)
Scheme 2.	(0.10)	(0.10)	(0.30)	(0.50)

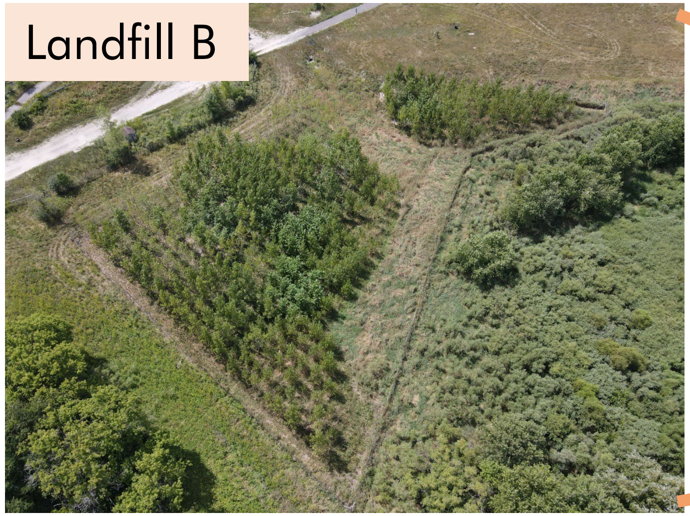
Rogers et al. 2021. *J. Environ. Manage.*

Objective 2: Identify and Prioritize Pollutants from Landfill Field Studies

Landfill Field Studies

- Commercial landfill that operated between 1976-1986
- **Population served:** ~39,000
- **Population demographics:** mixture of rural towns and one small city
- **Acres:** 17
- **Wastes handled:** fly ash, garbage, demolition, refuse, wood matter

- Municipal landfill that operated circa 1970-1990
- **Population served:** ~32,000
- **Population demographics:** mixture of rural towns and one small city
- **Acres:** 46
- **Wastes handled:** demolition, garbage, refuse, wood matter



Wisconsin, USA

State Cartographer's Office. University of Wisconsin – Madison.

Information gathered from Brrts on the Web:
https://dnr.Wisconsin.gov/topic/Brownfields/botw.html

Results: Features Identified

Forward Searching

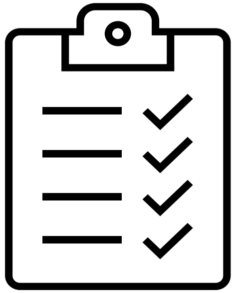
List of contaminants from the literature (n = 150)

↓

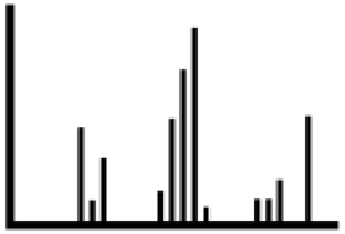
Search HRMS data in XCMS Online

↓

Putatively identify candidates (n = 21)



List of Contaminants



HRMS Data

Reverse Searching

Identify features in HRMS data using XCMS Online (n > 90,000)

↓

Narrow Down List (relative peak intensities, retention time, available CASRN)

↓

Putatively identify candidates (n = 909)

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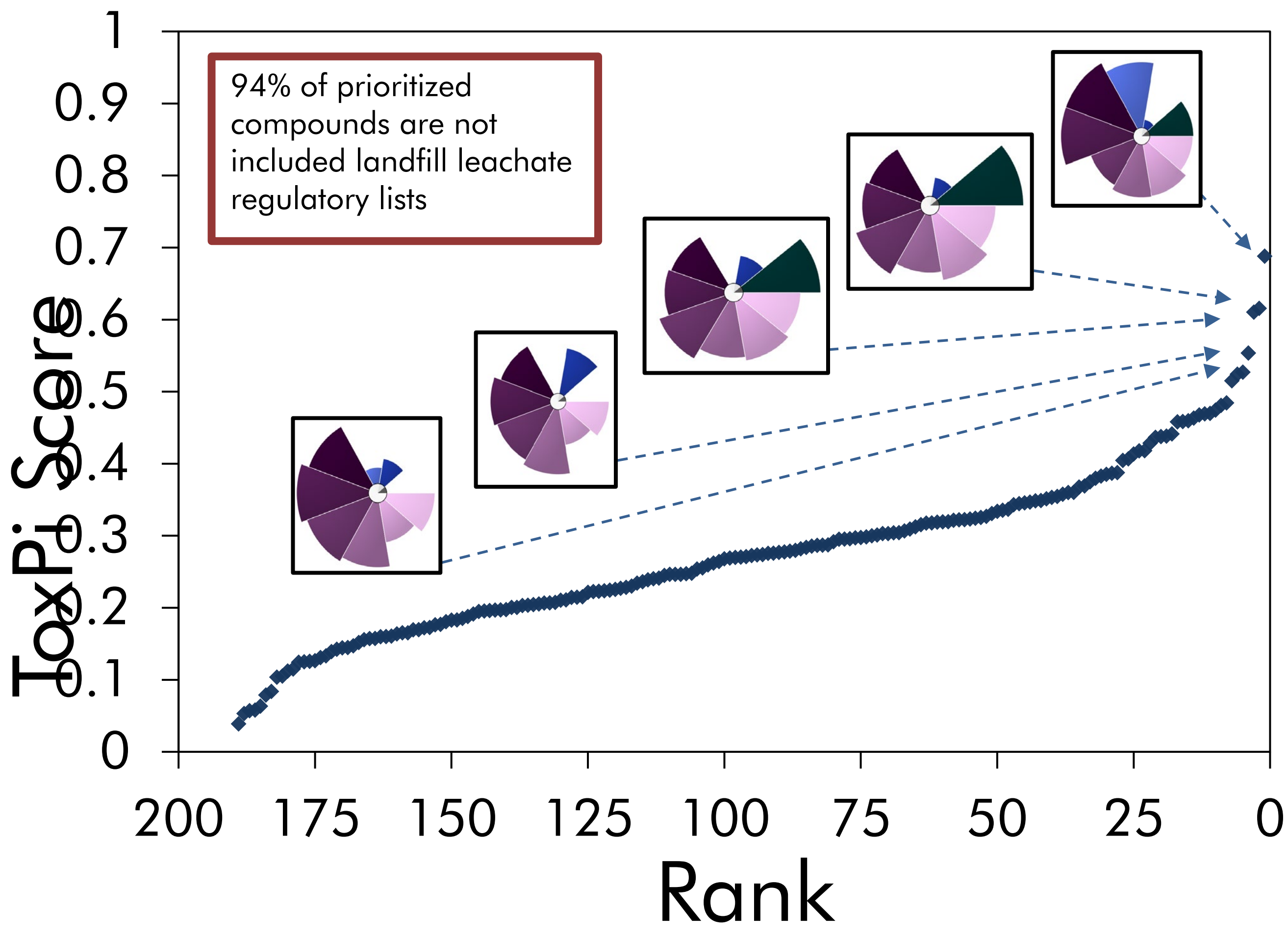
Results: Ranked Contaminants

Distribution dot plot of ToxPi scores for 189 leachate and groundwater contaminants

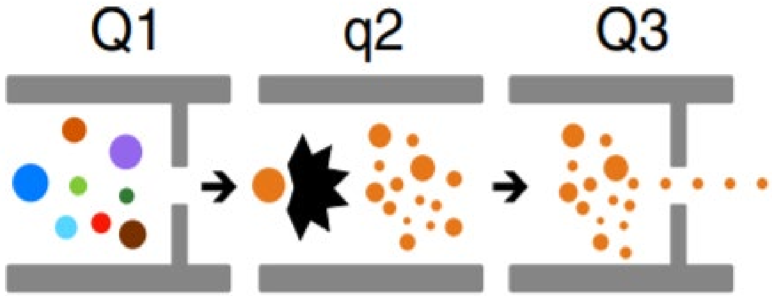


Top 10 leachate contaminants according to ToxPi analysis

Rank	Name	Uses/Sources	Health Impacts
1	Clotrimazole	pharmaceutical	potential endocrine disruptor
2	Benzo[ghi]perylene	industrial byproduct	not classified
3	Indeno[1,2,3-cd]pyrene	industrial byproduct	animal carcinogen; possible human carcinogen
4	Flurandrenolide	pharmaceutical	damage to heart, liver, kidneys, muscles
5	Fluoxymesterone	pharmaceutical	liver damage, high blood pressure
6	Canrenone	pharmaceutical	possible carcinogen; organ damage; toxic to aquatic life
7	Ajmaline	pharmaceutical	damage to cardiopulmonary system
8	Clomipramine	pharmaceutical	behavioral effects; possible aquatic toxicity
9	Benz[a]anthracene	asphalt, fossil fuels, vehicle exhaust, wood and soot smoke	possible carcinogen
10	Chlorprothixene	pharmaceutical	toxic to aquatic life

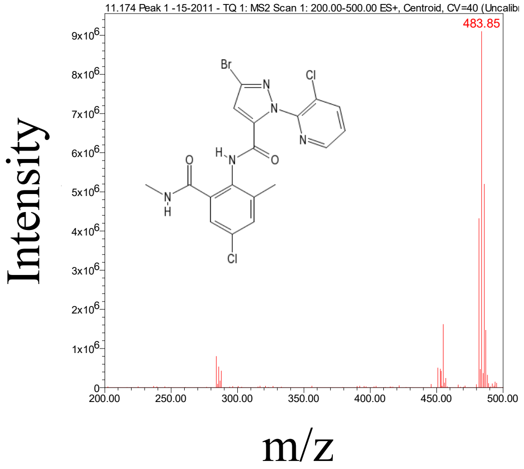
Next Steps: Confirm and Quantify Contaminants Using Targeted Analysis

Waters Xevo LCMSMS

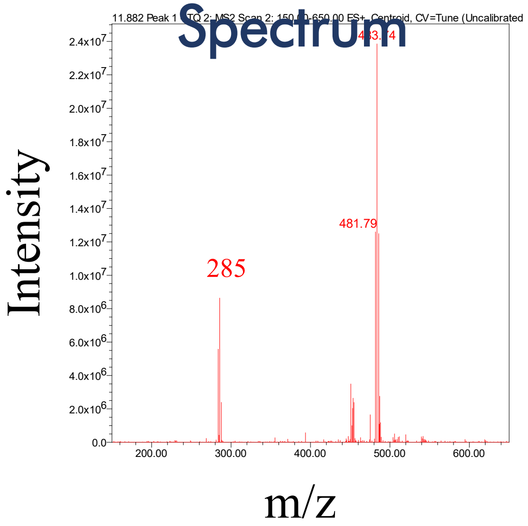


Domingo-Almenara et al. *Nat. Methods.* (2018)

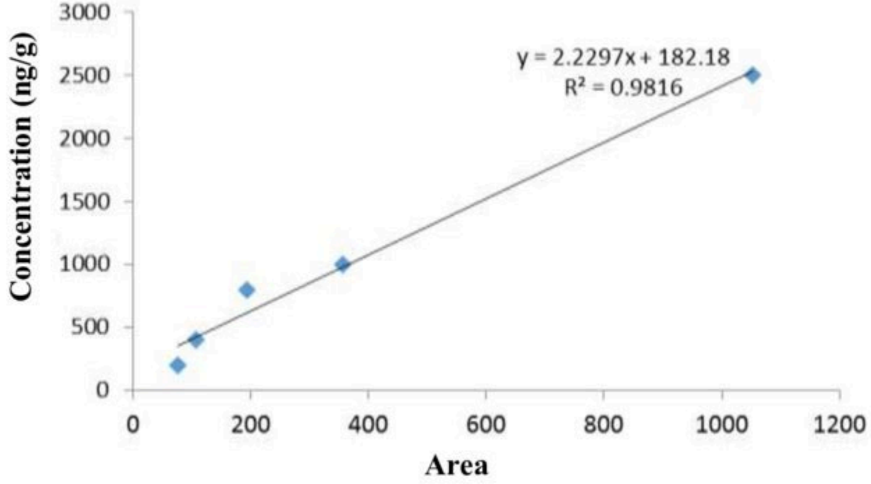
Example MS Spectrum



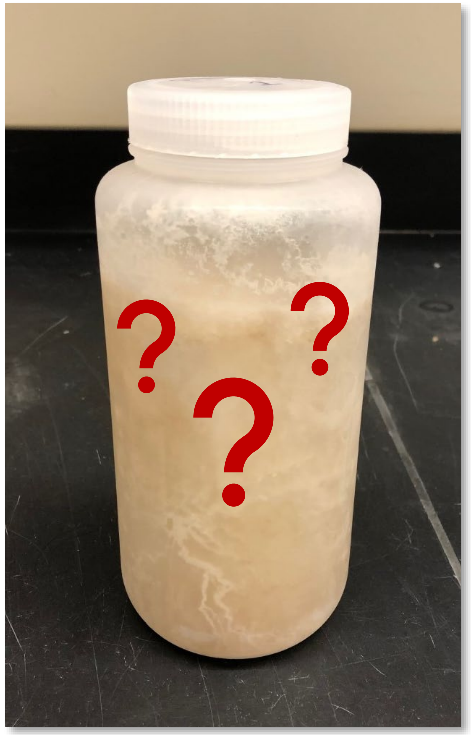
Example MSMS Spectrum



Example Calibration Curve

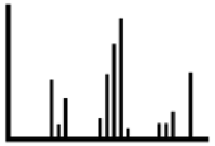


Vision for Future Applications



Sample from Contaminated Site

HRMS Data



+

Toxicity Data

+

Community Priorities

Prioritized Contaminants

Rank	ToxPi Score	Name
1	0.5867	Atropine methyl bromide
2	0.5846	Fluorene
3	0.5546	Butylate
4	0.5527	Fluoxymesterone
5	0.5488	Pyrilamine
6	0.5449	Octylonium bromide
7	0.5201	3-Methyl-1,2-cyclohexanedione
8	0.5077	Benz[a]anthracene
9	0.4944	Dimethametryn
10	0.4943	DL-α-Lipoic Acid
11	0.4937	4-Biphenylamine
12	0.4928	Tulobuterol hydrochloride
13	0.4772	9-Hydroxyrisperidone
14	0.4771	Acarbose (Glucobay)
15	0.4714	Tropisetron
16	0.4708	raclopride
17	0.4680	Benzofuran
18	0.4646	Eletriptan
19	0.4616	Quinocide
20	0.4541	Felodipine

Design Phytoremediation Systems

Thank You!

Funding

Great Lakes RESTORATION

USDA Forest Service U S Department of Agriculture

The Center for Agroforestry University of Missouri

Collaboration

University of Missouri

- Chung-Ho Lin
- Mohamed Bayati
- Shu-Yu Hsu
- Zhentian Lei

USDA Forest Service

- Ron Zalesny
- Ryan Vinhal

Support

WM WASTE MANAGEMENT

GAD GREAT AMERICAN DISPOSAL 906-774-9006

GFL GREEN FOR LIFE environmental

Thank you

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CEUs

Session 1.5: Breathless: How urban forests and trees can contribute to the reduction of air, water and soil pollution

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PP-23-3559

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