Green Infrastructure and Air Quality

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U.S. EPA

ADVANCE

A U.S. Environmental Protection Agency Program

Today's Presentation

- What is green infrastructure?
- How can green infrastructure benefit your community?
- How does green infrastructure improve air quality and resiliency to climate change?
- Applications of green infrastructure and emission reductions
  - EPA's Ozone and PM Advance participants
  - Estimating benefits of green roofs in Kansas City, MO
- Green infrastructure resources for air quality regulators

What is Green Infrastructure?

- Green infrastructure uses plants, soils and nature itself to manage stormwater and create healthier urban environments. Communities can create or preserve existing vegetated areas to protect their waterways and increase resiliency during heavy precipitation events.

- Green infrastructure practices are used to complement gray infrastructure – pipes, storage facilities and treatment systems.

Which Green Infrastructure Approaches Improve Air Quality?

- Green roofs
- Green alleys and streets
  - Rain gardens, bioswales and planter boxes
- Urban tree canopy
- Land conservation
- Waterway buffers

How Can Green Infrastructure Benefit Your Community?

Environmental Benefits

- Reduces polluted runoff entering waterways
- Conserves and enhances local water supplies
- Reduces combined sewer overflows (CSO)
- Builds resiliency - helps reduce localized flooding
- Improves air quality
- Climate mitigation
- Reduces urban heat island

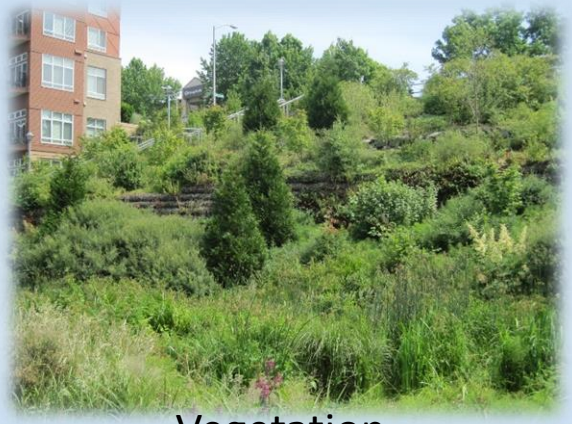
Economic Benefits

- Strengthens local economy
- Creates green jobs
- Revitalizes neighborhoods
- Reduces building energy usage
- Reduces gray infrastructure costs
- Lowers water treatment and management costs

Social and Health Benefits

- Neighborhoods are healthier and safer
- Enhances pedestrian safety
- Promotes more outdoor activity, walking and biking
- Improves people's general well-being
- Avoided health effects from heat and smog

How Does Green Infrastructure Improve Air Quality?



Vegetation

Vegetation provides shade and increases evapotranspiration in atmosphere*

Lowers ambient temperatures near surfaces (peak summer days)

Reduces photochemical reaction rates of ozone

Reduces building electricity usage – lowering demand for electricity generation

Creates more vegetative surface area to remove air pollutants

Leaves intercept particulate pollutants **($PM_{2.5}$)**

Leaf stomata absorb gaseous pollutants **(ozone)**

*Fallmann et al. *Secondary effects of urban heat island mitigation measures on air quality*. Atmospheric Environment, November 2015

How Much Air Pollution Are Trees in the U.S. Removing?

U.S. tree cover removed the following amount of air pollutants in 2010:

Pollutant	Removal Range in Short Tons*
NO_2	1,098 to 1,925
Ozone (O_3)	8,063 to 20,372
$PM_{2.5}$	105 to 1,716
SO_2	641 to 1,529
Total	9,911 to 25,542

Estimated human health benefits ranged from $1.5 billion to $13 billion in 2010

Pollution removal equated to less than 1% of total U.S. emissions

Reference: Nowak et al. *Tree and forest effect on air quality and human health in the United States*. Journal of Environmental Pollution, May 2014.

* Note: the journal article reports benefits in metric tons.

Potential Adverse Impacts from Volatile Organic Compounds (VOCs)

Assess the Ozone Forming Potential of Trees In Your Region

Table 1: Examples of VOC Emissions from Trees in the Los Angeles Climate [45]

Common Name	Genus and Species	Ozone-Forming Potential		
		L	M	H
Oaks				
White Oak	*Quercus alba*		✓	
Oregon White Oak	*Quercus garryana*			✓
Scrub Oak	*Quercus laevis*		✓	
Valley Oak	*Quercus lobata*		✓	
Pines				
Sand Pine	*Pinus clausa*			✓
Red Pine	*Pinus densiflora*	✓		
Longleaf Pine	*Pinus palustris*		✓	
Maples				
Red Maple	*Acer rubrum*	✓		
Silver Maple	*Acer floridanum*	✓		
Citrus				
Lisbon Lemon	*Citrus limon*		✓	
Meyer Lemon	*Citrus limon 'Meyer'*	✓		
Valencia Orange	*Citrus sinensis 'Valencia'*	✓		

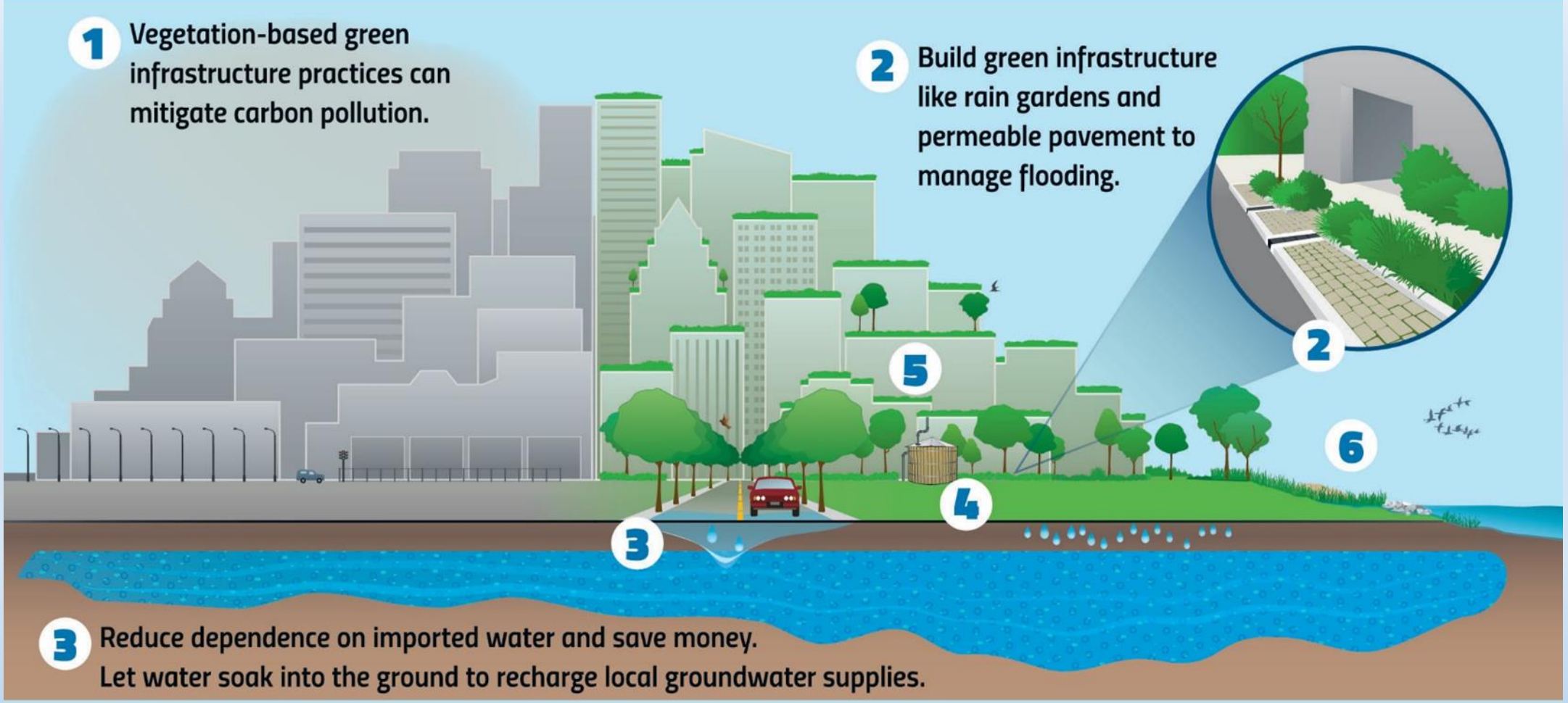
U.S. EPA, Heat Island Compendium, Chapter 2

Nine Tree Genera With Highest Isoprene Emission Rate

- Beefwood (*Casuarina spp.*)
- *Eucalyptus spp.*
- Sweetgum (*Liquidambar spp.*)
- Black gum (*Nyssa spp.)*
- Sycamore (*Plantanus spp.*)
- Poplar (*Populus spp.)*
- Oak (*Quercus spp.*)
- Black Locust (*Robinia spp.*)
- Willow (*Salix spp.*)

USDA, The Effect of Urban Trees. 2002

Green Infrastructure Builds Resiliency



4 Keep water local. Capture runoff in cisterns and rain barrels to reduce municipal water use.

5 Plant trees and green roofs to mitigate the urban heat island effect.

6 Use living shorelines, buffers, dunes and marsh restoration to reduce the impact of storm surges.

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Green Infrastructure Projects in EPA's Advance Program

Green infrastructure program in Advance Path Forward*

Note: *This is EPA's best assessment of Advance Paths Forward that currently include green Infrastructure projects.

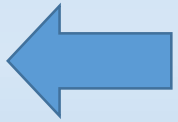
Application: EPA Estimates Green Roof Impacts in Kansas City, MO

Project Goal

- Analyze avoided emissions and other environmental effects for an illustrative green roof scenario
- Describe a replicable methodology, identify available tools and outcomes

EPA estimated green roof impacts in Kansas City related to:

- Building electricity savings; associated emissions and health benefits from the electric power sector
- Heat flux changes - transfer of heat between a building's exterior and surrounding atmosphere
- Stormwater net run-off impacts from rooftop



Today's Focus

Replicable Methodology for Projecting Green Roof Installations in 2020

Step 1. Gather Green Roof Data

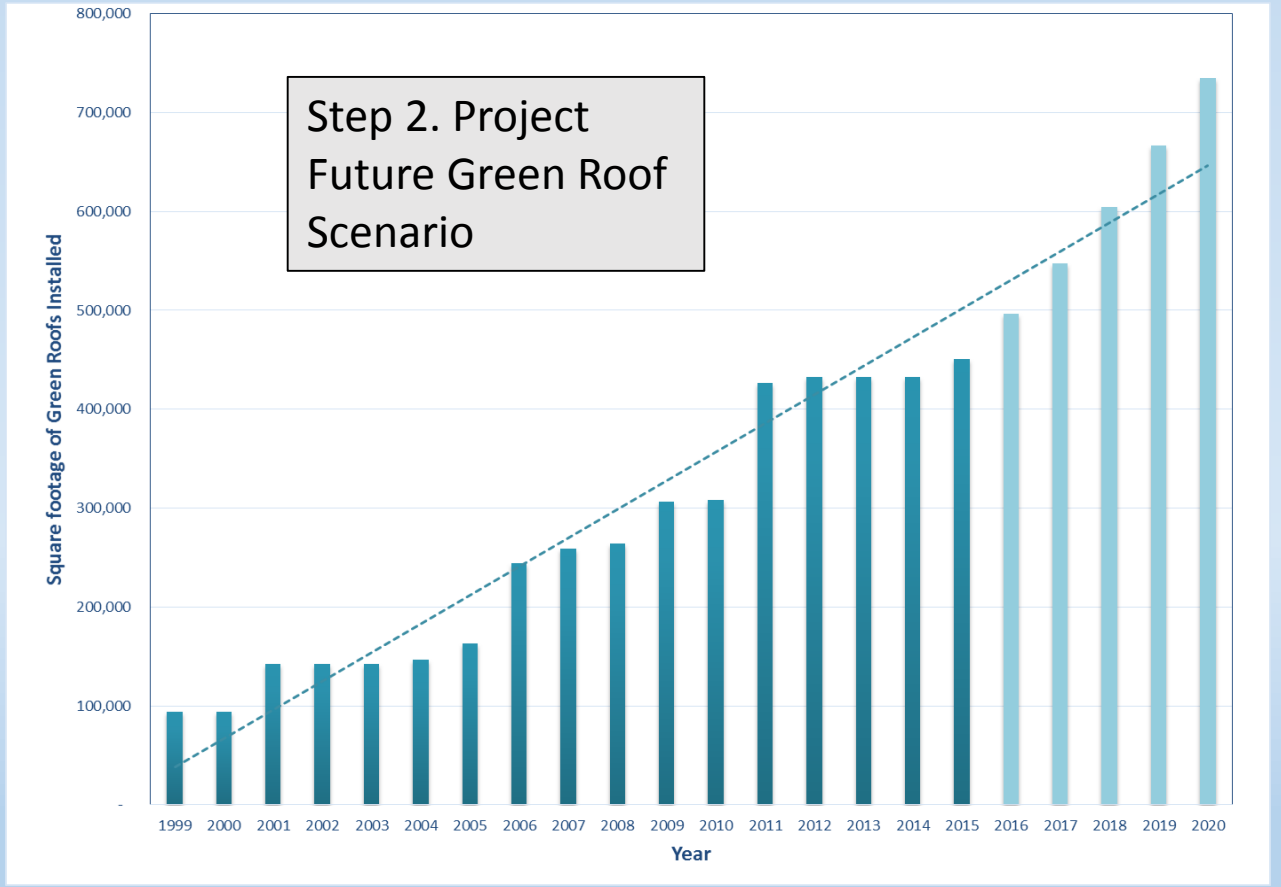
Survey Kansas City's Existing Green Roof Installations (ft^2)

Estimate compound average growth rate (1999-2015)

Apply historical growth rate to future years %/yr

Project future green roof installations (ft^2) by 2020

Method to Project Green Roof Growth in Kansas City, MO



Green Roof Installations and Projected Growth in Kansas City 1999-2020

Quantitative Steps and Tools to Estimate Impacts and Benefits of Green Roofs

Step 3. Run tools to calculate impacts

Enter Green Roof Surface Area (ft^2)

RUN: Green Roof Energy Calculator
Green Building Research Laboratory

Estimate Run-off Reductions, Heat Flux, and Electricity Cost Savings

Estimate Building Electricity Savings

Power Plant Avoided Emissions
NOx, SO_2 and CO_2

Monetized Benefits
Dollar value of health effects and climate benefits

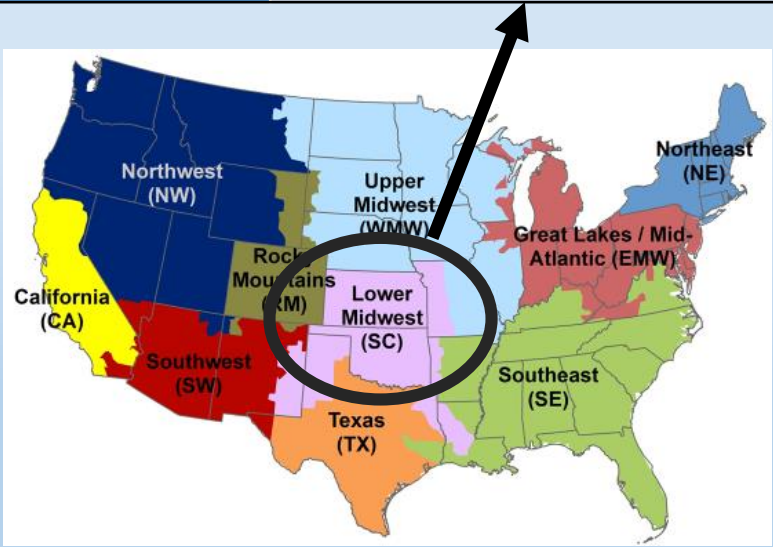
Estimated Electricity Savings and Storm Water Benefits from Green Roof Adoption in Kansas City, MO

EPA used the Green Roof Energy Calculator to estimate the benefits of adding 734,826 ft^2 of green roofs in Kansas City by 2020:

Type of Benefit	Estimate
Electricity Savings	601,502 KWhs
Electricity Cost Savings	$41,587
Stormwater run-off reduction	29 inches per year

Estimated Avoided Emissions at Power Plants from Green Roof Adoption in Kansas City, MO

Air Pollutant	Total Annual avoided air pollutant emissions in 2020 (annual)
SO_2 (lbs)	2,600 lbs
NO_x (lbs)	1,800 lbs
CO_2 (tons)	1,100 tons



EPA's AVERT regions

Geographic location	AVOIDED AIR POLLUTANTS IN 2020		
County, State	SO2 (lbs)	NO_x (lbs)	CO2 (tons)
Platte, Kansas	3	7	17
Pottawatomie County, Kansas	107	115	121
Sedgwick, Kansas	-	44	11
Shawnee, Kansas	46	8	9
Wyandotte County, Kansas	80	12	10
Greene County, Missouri	64	33	24
Henry, Missouri	157	55	28
Jackson County, Missouri	149	71	35
Scott, Missouri	64	39	14

Green Infrastructure – Air Quality Resources

Research and evidence-based papers:

- Green Roofs Research On Lowering Building Electricity Demand
  - The Benefits and Challenges of Green Roofs on Public Buildings
- Air Quality Research

Tools:

- U.S. Forest Service i-Tree Tool Tools and analysis on AQ , environmental and economic benefits
- Green Roof Energy Calculator Green Roofs for Healthy Cities, Portland State University and Toronto jointly launched this tool.
- Green Infrastructure Modeling Toolkit this link has the five most popular EPA Green Infrastructure tools to help communities evaluate and manage urban water runoff.

Resources:

Tools and Lessons Learned from EPA's Green Infrastructure Technical Assistance Projects

Green Infrastructure and Climate Change: Collaborating to Improve Community Resiliency

Funding Opportunities for Green Infrastructure

EPA's Urban Heat Island Compendium

THANK YOU!

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