

#### Leaf Island <sup>TM</sup> ~ Scaling Ecology into Urban Regeneration

By incorporating the urban waste stream in modular aquifers & soils, the material cycle of cities are used to support the work of plant communities, layering vegetation along roadway corridors and over vertical walls & city roofs. In this way, Leaf Island processes scale the ecology of exchange by building with the growth & development of living forms, regulating local climate in the process (see slide 5).

Leaf Island's work adapts the physical features of public & private properties to serve as scaffolding for ecological development. Dense plant cover supplied with water eliminates urban heat island, diminishing local peak load & energy use. Leaf Island technologies scale back operating costs of the built environment.



for Sustainable

Urban Development

#### Urban Planning Design WINNER

New York Access Cities Open Innovation Call on Air Pollution and Urban Heat Island Effect, an international competition sponsored by seven NYC agencies and numerous private investors Contact

Joshua Harrison Strategic Partnerships

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## New York City needs green infrastructure.

Home to 8 million people & growing, no cost-effective solutions as of yet have emerged to address: Combined Sewer Overflow, Urban Heat Island, Air Pollution, Biodiversity Loss, Increasing Energy Costs, Adaptive Re-Use of a Massive Waste Stream, Flooding.

By building ecological capacities back into the fabric of the City, Leaf Island aims to change this.





82% of the US lives in cities. By 2050, the UN estimates two thirds of the earth's population will be urban.

#### Urban density leads to ecological concerns

- Urban Heat Island Effect
- Polluted Waterways

- Air Pollution
- Stormwater Runoff
- Waste-stream Products

- Food Insecurity
- Environmental Injustice
- Climate Change

Leaf Island brings practical solutions to meet emerging crises with cost-effective strategies & firmly grounded technologies



### Leaf Island Effect

Reducing the Urban Heat Island Effect (UHI)

Vegetation layers canopy, understory & ground cover to multiply the living surface over the City, a branching, living architecture layering leaves in multi-layered volumes. As leaf surface area reaches & exceeds three times landscape footprint, the lower shade leaves always run cooler than their surroundings, heat energy taken away in masses of cool water vapor, a denser atmosphere, dropping to fill streets, sidewalks, & urban canyons below.

Upper leaves radiate heat; lower leaf layers evaporate water, cooling the air. Leaf Island products & modules are designed and integrated to effectively & efficiently capture, hold, and deliver water to support the essential, central work of plants on land, cooling the surroundings, in the process of capturing carbon.



Properly scaled, this fundamental feature of land plant biophysics reverses Urban Heat Island





#### Leaf Island Effect

#### Reducing/reversing Urban Heat Island

#### **Schlierin Photography Energy Partitioning in real-time:**

rising sensible heat to the left; cool air masses dropping from evaporative heat loss to the right



### Rn = H + G + LE + R + P

- (Rn) = total radiation load on an area
  (H) = sensible heat
  (G) = heat moved into air, soil and water
  (LE) = evaporative heat loss
  (R) = respiration
- $(\mathbf{P}) = \text{photosynthesis}$



### Visualizing the Reach of Urban Heat Island Reduction

Evapotranspiration of <sup>1</sup>/<sub>4</sub> inch over 224 ft<sup>2</sup> produces 1 ton of air conditioning,

~ the quantity of energy/needed to cool 400  $ft^2$ 

A Leaf Area Index of about 3 over 224 ft<sup>2</sup> of vegetation produces cools 400 ft<sup>2</sup>



#### Visualizing the Significant Reach of Urban Heat Island Reduction



### Linda Tool Green Roof

163 Dwight St, Brooklyn, NY

- 12,000 ft<sup>2</sup> green roof
- 19,700 ft<sup>2</sup> cooled to ambient temperature
- 120,000 ft <sup>2</sup> cooled by 2 3 degrees
- 300,000 ft <sup>3</sup> cool, clean vapor produced each warm - season day



# LEAF

### Leaf Island Effect

**Reducing Air Pollution** 

Land plants partition energy flow: hot air rising/cool air sinking. Adaptive geometry thus entrains atmospheric flow, moving pollutants into contact with plant surfaces & microbiomes. Supplied with water and nutrients, these biogeochemical filters grow & develop in the landscapes where we live and work.

Increasingly dense vegetation is effective at filtering PM<sub>2.5</sub> by greatly increasing particle deposition rates (**10-30x faster**), and reducing ozone, nitrogen dioxide, carbon monoxide, and sulphur dioxide through gas exchange in the process.

Dense leaf cover integrated into urban landscapes, adjacent to pollutant sources, works to optimally remove PM2.5.



### We give flat surfaces volume.

Building multi-layered vegetation into green infrastructure, ecological potentials are optimized. This method works for all such surfaces: green roofs, green walls and street-level green infrastructure



## GaiaSoil TM

Patented, innovative ultra-lightweight soil medium.

Exclusively manufactured by Leaf Island.

GaiaSoil supports our suite of modular and infinitely scalable green technologies.



GaiaSoil EUltra -

Ultra lightweight green roof with a 30 - year warranty. Provides up to 33% in heating and cooling savings.

**Used For:** ≈40 sq. miles of rooftop in NYC

GaiaSoil ∃ Floating Wetland



Above-ground, zerodischarge stormwater capture system that is used to reclaim undeveloped underpasses.

**Used For:** 700 miles of underpass in NYC

Ready to Build

**Patent:** US 6,946,496 B2

**EcoBarrier EVegetated** 

**Bike Lane Protection** 

Stormwater System

Bike lane protection system

that mitigates air pollution

and is 95% effective at

stormwater uptake.

Used For: 1.250 miles of

bicycle lanes in NYC

**Pilot Project** 

BlueBlocks E Filter Coastline Protection + CSO Treatment System



Coastline protection system that mitigates storm surges, scales to uptake &clean hundreds of thousands of gallons of Combined Sewage Overflow, and filters millions of gallons in waterways daily.

**Used For:** 520 miles of coastline in NYC

**Pilot Project** 

**Lightest Green Roof Medium on the Market.** 1/5<sup>th</sup> the weight of top-selling alternatives

**Only Green Roof Medium That Insulates.** R-value four-fold greater than top competitors' products

Sourced & Manufactured from Recycled Styrofoam. Removes Styrofoam from waste stream & landfills

**Unbeatable Growing Capacity**. High aeration results in 40-60% faster growth

Endlessly Reliable. Does not degrade or compress over time

#### Trellis∃Green Wall System



Lightweight, modular and low maintenance green wall that can be utilized on virtually any vertical surface to reduce the Urban Heat Is land Effect, insulate buildings and capture air pollutants.

**Used For:** 3000 sq. miles of vertical space in NYC

**Pilot Project** 

Ready to Build

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### Leaf Island's integrated approach for roofs, walls, streets & coastlines.





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### Costs savings increase with replication

- Streamlined permitting, design & engineering process
- Local manufacturing decreasing shipping costs
- Installation familiarity and favorable pricing from local general contractors
- Bulk rates on materials
- Less uncertainty with planning & logistics

	GaiaSoil	Rooflite™ Intensive 700	LiveRoof™ Engineered Growing Medium	Metro D-Lite™ Green Roof Engineered Soil Media	Boughton™ Semi- Intensive 2	
Weight (unsaturated)	10-12 lb/ft³	40-55 lb/ft³	58-62 lb/ft³	~60 lb/ft³	62 lb/ft³	
Weight (saturated)	28-34 lb/ft³	70-80 lb/ft³	86-94 lb/ft³	70-80 lb/ft³	82 lb/ft³	
Water Holding Capacity (% of Dry Weight)	150-240%	27-100%	39-62%	16-33%	32%	
Bulk Density (dry)	0.13-0.28 g/cm³	0.64-0.88 g/cm³	.9299 g/cm³	.96 g/cm³	.99 g/cm³	

## GaiaSoil Specs.

Ultra-lightweight growing medium Made from recycled Styrofoam

#### **R-Values for Common Materials at 1" Thickness**



#### GaiaSoil Green Roofs vs. Competitive Green Roofs



Soil Depth	6-12 inches	4-12 inches	2-4 inches	
Max. Saturated Weight	16-32 lbs./SF	30-90 lbs./SF	15-30 lbs./SF	
Avg. Total Cost	\$30/SF	\$30-50/SF	\$15-25/SF	
Warranty	30 years	30 yearsVaries by Manufacturer		
Maintenance	Low High		Low	
Plants Supported	All Native Varieties	All Native Varieties	Sedum	
% Buildings Supported	90%	40%	98%	
Uses Recycled Materials?	Yes	No	No	
Insulation (R-Value)	11-22R	2-6R	1-2R	

ISLAND

LEAF

GaiaSoil Floating Wetlands vs. Competitive Stormwater Solutions



Average Total Capital Cost: \$35-45/SF Cost/Static Storage: \$3.5/gallon

+Capture 2-8 lbs./sq. meter of carbon annually +Not vulnerable to shallow water tables +Mitigate the Urban Heat Island Effect +Connect biodiversity corridors in urban areas +Reduce airborne particulates from nearby roads +Increase pedestrian traffic safety +Create opportunities for urban farming +Enrich the aesthetics of the cityscape Average Total Capital Cost: \$60-160/SF Cost/Static Storage: \$2-7/gallon

+Highest stormwater capacity relative to size-No ecological benefits

-If placed underground, costs increase dramatically-Maximum size limited-Shorter lifespan compared to green infrastructure

-Captured water must be discharged

-Requires additional components to uptake water

#### Average Total Capital Cost: \$40-65/SF Cost/Static Storage: \$14/gallon

+Capture 2 lbs./sq. meter of carbon annually
+Mitigate the Urban Heat Island Effect
+Connect biodiversity corridors in urban areas
+Reduce airborne particulates from nearby roads
+Enrich the aesthetics of the cityscape
-Requires costly excavation
-Limited by shallow water tables
-Limited by underground utilities



ast River Park Rendering Credit: NYCDDC

Sterile Coastline

PENDEPING DEPICTS 2015 MEAN HIGHER HIGH WATER

glass, brick, sand fr

structed from recycled

Frellis Green

GaiaSoil Floating

East River Park Rendering Credit: NYCDDC

Wetland

Design features a hillside configuration for a GaiaSoil Floating Wetland designed for Pratt Institute on Governors Island, with cross section included.

Rendering demonstrating eco - industrial retrofit concept for Bruckner Expressway Underpass in Bronx, NY

> Image modification differentiates Leaf Island's vision from that of present plan, multiplying the living coastline restoration

### Applying Leaf Island Technologies to Just $\frac{1}{4}$ of NYC



+ tens of millions saved annually on better health and wellness outcomes

+ hundreds of millions saved annually on lower social service reliance & taxable income from newly created jobs

+ path to peak load reduction providing protection against brown-outs by reducing energy demands during heat waves

+ new opportunities for hundreds of miles of newly created public & private spaces

Estimated \$4-6B total value annually



### **Green Infrastructure Benefits**

- Urban Heat Island Reduction
- Increases Air Pollution Reduction
- Increases Stormwater Mitigation
- Increases Biodiversity
- Protects Pollinators
- Decreases Food Insecurity
- Decreases Stress
- Provides Community Spaces
- Provides Recreational Spaces

- Providing Educational Opportunities for Public Schools
- Decreases Crime Rates
- Creates Jobs
- Expands Tax Base
- Decreases Reliance on Public Services
- Increased electricity efficiency and savings











### The Team

#### laor Bronz Head of Design Urban Soils Institute

Engineer bringing hydrological methods and models to quantification of stormwater mitigation to better evaluate, scale, manage and benefit our innovative products. Integrated analysis and direction informed through work with top innovators in Philadelphia & New York.

#### Dr. Paul S. Mankiewicz Lead Scientist Founder of the Gaia Institute

Innovator in industrial ecology & green infrastructure, with four decades of regenerative work grounded in wastes into - resources adaptations and across scientific disciplines, from ecosystem structure & development, to fluid dynamics.

#### Phoebe Mankiewicz Head of Research Yale CEA

Investigations at RPI & dissertation work at Yale CEA incorporates plant rhizosphere and microbiome development in ecologically engineered growth media designed to metabolize pollutants and enhance indoor environments.

#### **Michael Fishman Client & Development Advisor** Principal City Planner, Mott MacDonald

25 years managing design teams with public and private stakeholders on behalf of owners to deliver resilient programs from \$15k to \$2B.

lgor Bronz

Mankiewic Phoebe

Michael Fishman

Joshua Harrison

LEAF ISLAND

Joshua Harrison

Strategic Partnerships

Co-Director, Center for the Study of the Force Majeure at UC Santa Cruz

30 years experience in merging art and science to identify and envision climate focused

> Responses to land and water issues, challenges, opportunities