

The Gaia Institute

The work of the Gaia Institute couples ecological engineering and restoration with the integration of human communities in natural systems. While much environmental engineering has the worthy aim of minimizing harm, the Gaia Institute explores, through research and development, design and construction, how human activities and waste products can be treated to increase ecological productivity, biodiversity, environmental quality, and economic well being.

Presentation by:
Paul Mankiewicz PhD.
The Gaia Institute

Lightweight Soil for Urban Rooftops

Sustainability



Lightweight Soil for Urban Rooftops

Two Measures of Sustainability

- Increase in Ecological Productivity
- Increase in Biodiversity

Lightweight Soil for Urban Rooftops

New York City	322 square miles
Manhattan	24 square miles
Bronx	44 square miles
Queens	112 square miles
Brooklyn	82 square miles
Staten Island	60 square miles

Lightweight Soil for Urban Rooftops

Dutch Settlers paid \$24 for all of Manhattan
\$1 per square mile

Lightweight Soil for Urban Rooftops

Thermodynamics of buildings

$$t_{\varepsilon} = \tau_o + \alpha / h_o - [\tau - \varepsilon \Delta R / h_o]$$

Where:

T_{ε} = Sol-Air Temperature

τ_o = Outdoor Temperature

α = absorptance of the surface

h_o = heat transfer coefficient

I_t = solar radiation

ε = emittance of the surface

ΔR = difference between incident radiation incoming

$$Q_a = e \sigma T_1^4 + (T_1 - T_a) H + L + P$$

Where:

Q_a = amount of radiation absorbed

e = emissivity of leaf (tendency to radiate heat)

σ = Boltzmann constant for blackbody radiation

T_1 = leaf surface temperature

T_a = air temperature

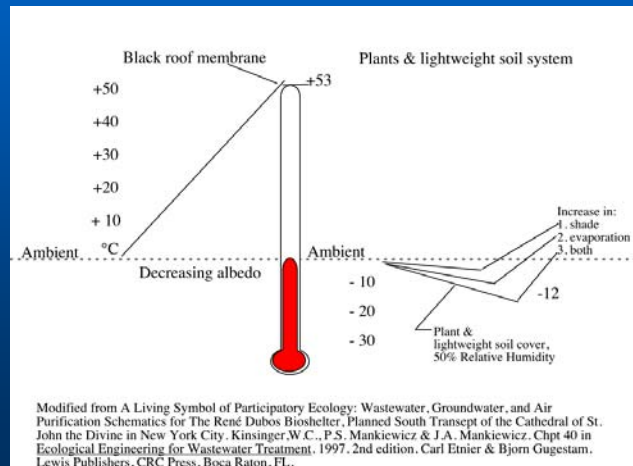
H = convection coefficient

L = heat of evaporation, about 580 cal/gram water

E = amount of water evaporated by leaf

P = photosynthesis

Lightweight Soil for Urban Rooftops



Lightweight Soil for Urban Rooftops



Lightweight Soil for Urban Rooftops



Lightweight Soil for Urban Rooftops



Lightweight Soil for Urban Rooftops

	Area in square miles	Quantity of water In an inch of runoff In cubic feet	Quantity of water in an inch of runoff in gallons	Grey water applied Over NYC, ½ of 1.2 billion gallons in inches per day
Bronx	44	764,611,584	5,719,294,648	
Brooklyn	82	1,424,957,952	10,658,685,481	
Manhattan	24	417,060,864	3,119,615,263	
Queens	112	1,946,284,032	14,558,204,559	
Staten Island	60	1,042,652,160	7,799,038,157	
Total	322	5,595,566,592	41,854,838,108	.11

Capturing one tenth of the runoff noted above could eliminate a tenth to a third of CSO discharges dependent on exact locations of water removal.

Applying the grey water noted in the right column to landscapes around NYC would double the total water input to approximately 80 inches per year.

Lightweight Soil for Urban Rooftops



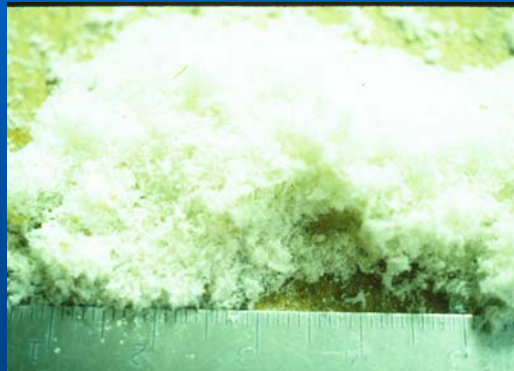
Lightweight Soil for Urban Rooftops



Expanded polystyrene blocks (EPS) or other forms of recycled EPS, are one starting component.

Blocks, packing materials, 'peanuts', cups, and other forms of expanded polystyrene can be shredded by a number of kinds of standard equipment, from planers to hammer-mills to certain kinds of paper shredders.

Lightweight Soil for Urban Rooftops



Shredded EPS

Expanded polystyrene can be finely shredded to create a capillary matrix for holding water. The material shown above was produced by shredding Styrofoam blocks

Lightweight Soil for Urban Rooftops



Shredded EPS fragment

The small scale of the capillary matrix formed by finely shredded expanded polystyrene acts to hold water and resist water loss.

Lightweight Soil for Urban Rooftops



EPS, water, clay, and other components before mixing

Lightweight soil can be made at a number of different scales, as pictures here in quarter cubic yard cement mixer. A batch can be made in about ten minutes.

Lightweight Soil for Urban Rooftops.

Finished mix of different sizes

Clumps or clusters at various scales are formed in the process of mixing the components of the lightweight soil.



Lightweight Soil for Urban Rooftops



Cast blocks of lightweight soil

The lightweight soil and compost matrix can be cast into regular blocks or tiles, and fitted to sections of rooftops or decks.

Lightweight Soil for Urban Rooftops



Earth casting with reinforced mesh

The lightweight soil can be earth cast and formed around reinforcing mesh to increase strength and for ease of transport.

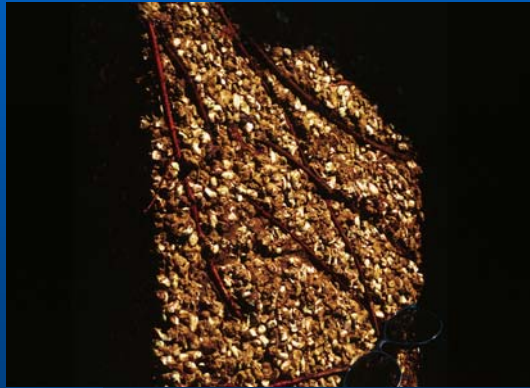
Lightweight Soil for Urban Rooftops



Examples of earth cast soils

Earth cast lightweight soil forms are shown here. Small amounts of cementitious materials may be used to increase cohesive qualities of the materials and to make more permanent, 'free standing' forms.

Lightweight Soil for Urban Rooftops



Earth cast planter

The lightweight soil and compost matrix can be made into irregularly shaped forms to serve as planters and/or sculptural features.

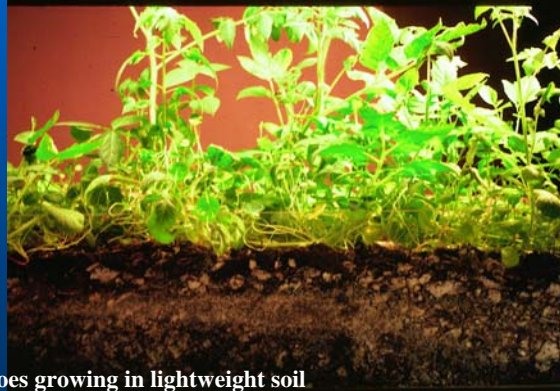
Lightweight Soil for Urban Rooftops



Lettuce and flowers growing in light weight soil.

Hyacinths, lettuce, and nasturtiums are shown in this picture of the 1991 exhibit in the Earth Bay of the Cathedral of St. John the Divine in Manhattan. This picture shows the 'soil horizons' of the light weight soil, with the organic layer of humus at the top, and the complex matrix of expanded polystyrene, compost, and other natural materials.

Lightweight Soil for Urban Rooftops



Tomatoes growing in lightweight soil

Tomatoes, shown here, are another commercial crop which has been grown in the lightweight soil. This photograph was also taken at the exhibit on rooftop agriculture at the Cathedral of St. John the Divine.

Lightweight Soil for Urban Rooftops



Red Pines in rooftop planters

Red pines planted in lightweight soil on a rooftop in the West Village of New York City. The redwood planters were chosen by the owner for aesthetic appeal rather than low weight

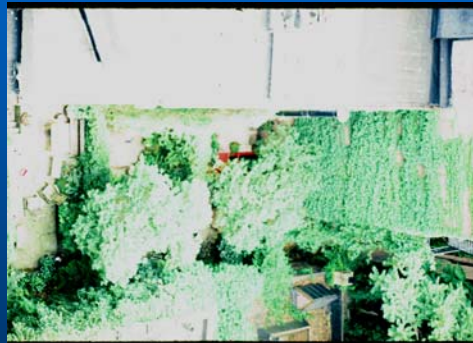
Lightweight Soil for Urban Rooftops



Red Pine root ball of lightweight soil

The red pine pictured above was grown on a rooftop for about three years in a redwood planter in lightweight soil. The tree plus root and soil ball weigh less than 200 pounds.

Lightweight Soil for Urban Rooftops



Various vines covering wall surface

These photographs of plantings installed by The Gaia Institute show how plantings may be used to cover surfaces, thus increasing air purification and decreasing the thermal loads and heat storage on the build environment.

Lightweight Soil for Urban Rooftops

Grapevine in rooftop planters

Vines can be grown in containers, adding shading, fruit production, and wind barriers to the rooftop environment. The 6'X2' galvanized container weighed less than 200 pounds filled with fully saturated lightweight soil.



Lightweight Soil for Urban Rooftops



Lightweight Soil for Urban Rooftops



Lightweight Soil for Urban Rooftops

