Material Flow: A Central Role for Wastes in Ecological Design

Paul Mankiewicz, Ph.D.
Executive Director
The Gaia Institute
Applied & Theoretical Biogeochemistry
www.gaia-inst.org

Energy Flows
Materials Flow
Systems Develop

➢Energy flows into and out of the biosphere, within and between organisms and their surroundings, where each energy transfer leaves the system measurably less capable of performing work;

➢ Material are moved by interactions of the hydrosphere, atmosphere, and lithosphere, as well as the activities of organisms and ecosystems. Specific essential elements normally available in low or limiting concentrations have led to more closed loop material flows, or material cycles, of those elements required by life;

➢ Food chains/food webs, constrained and ordered by the flow of matter and energy, grow and develop to facilitate the capture and dissipation of energy with the uptake and conservation of essential elements

Additional Levels Can Hold and Keep Energy in an Ecosystem

124 6. The Description

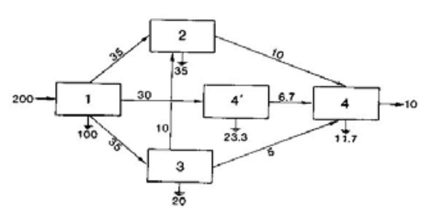
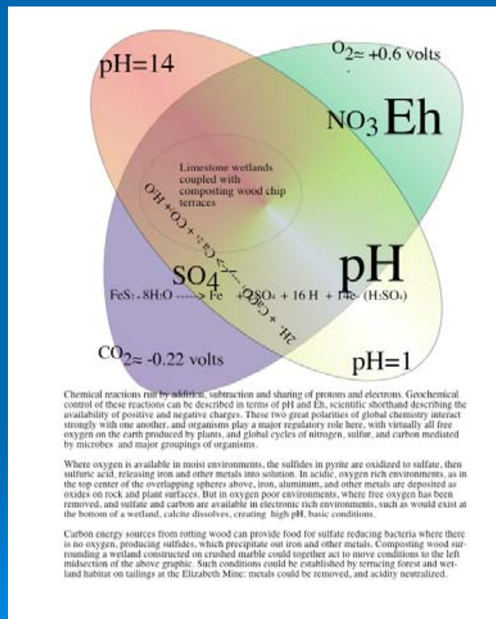


FIGURE 6.11. A modification of the network in Figure 6.9 created by splitting component 4 into two separate nodes.

Partitioning a component can increase the energy or material flow in the system



Energy Flows- human beings now control between 30% and 40% of the net primary productivity on earth

Material Flows- construction, mining and other human earth moving processes are now estimated to have surpassed glaciers, rivers, and other natural processes in terms of quantities of materials moved each year.

Systems Develop- What are the implications for biodiversity, ecological productivity, and ecosystem services (environmental quality maintenance) where one species controls much of biosphere material and process?

Material Flows:

New York City produces 13,000 tons of residential garbage each day;

NYC consumes about 1.2 billion gallons of water each day, and discharges a like amount of wastewater to Long Island Sound, the Hudson, East, and Harlem Rivers, and Jamaica Bay

The City produces somewhere between 12,000 and 15,000 tons of construction and demolition debris each day

Every inch of runoff from the 307 square miles of the City moves about 5 billion gallons of stormwater into receiving waters

The combined sewer system discharges about 27 billion gallons of untreated wastewater into estuaries surrounding New York

To maintain the Port of New York and New Jersey, approximately 6 million cubic yards of material a years needs to be dredged from channels and pierheads

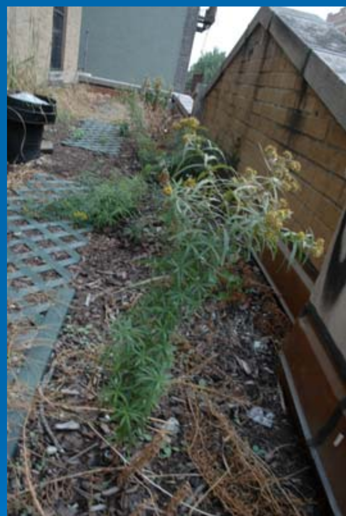
Material Flows:

New York City Garbage:

2,500 tons of organic waste each day;

Between 600 and 1,200 cubic yards per day of waste styrofoam;

About 2,000 tons of glass each day



- Plants on a 300 square foot roof at the St. Simon Stock Convent
- Detail of trellis walkway planted with path rush

- St. Simon Stock Grammar School-East View
- South View, past weather station
- Plants are growing on about 30 cubic yards of recycled expanded polystyrene, and 5 cubic yards of composted organics and mulch.

Ecology and Economics: the Problem in Front of Us

3.2 Describing Flow Networks 33

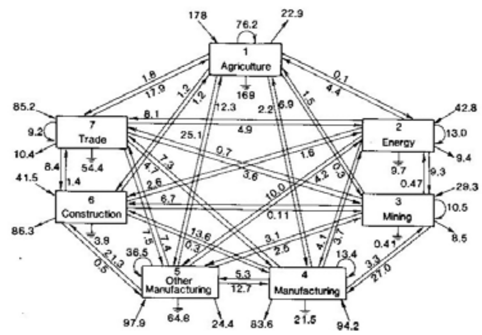


FIGURE 3.3. Cash flows among the sectors of the Polish economy (in millions of zlotys) during 1962. Exogenous inputs and outputs represent foreign trade. Ground symbols are used to represent consumer demand.

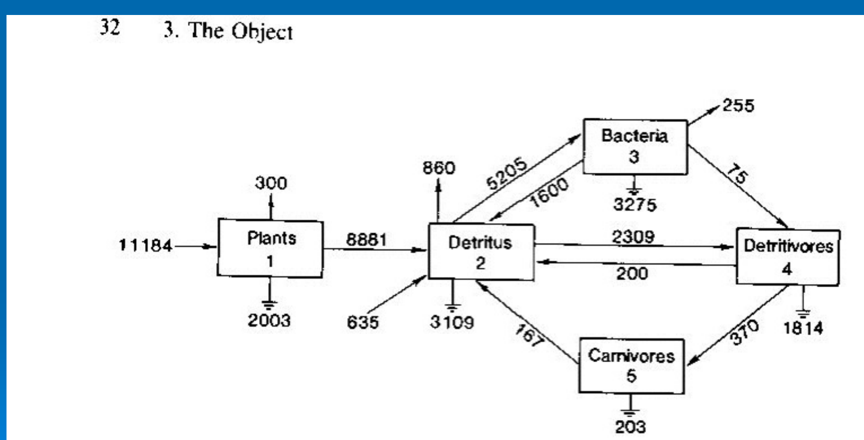
Energy Flows
Materials Cycle
Systems Develop
(& in New York)
Money Talks

Energy Balance Equation

- Q* (Net All-Wave Radiation) =

Q_H (Sensible Heat) + Q_E (Latent Heat) + Q_G ("Subsurface" Heat)

Ecology and Economics: the Problem in Front of Us



Additional Levels Can Provided Emergent Properties which can Hold and Keep Energy in an Ecosystem

124 6. The Description

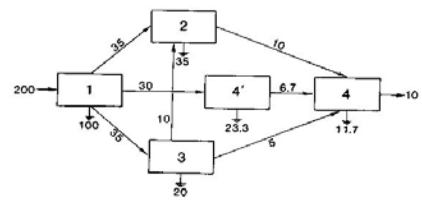


FIGURE 6.11. A modification of the network in Figure 6.9 created by splitting component 4 into two separate nodes.

Partitioning a component, or adding a link can increase energy or material flow in the system

Material Flows in NYC

- Residential Waste: 12,000 tons per day
- Drinking Water: 1,200,000,000 gallons per day
- Stormwater runoff: 5,000,000,000 gallon/in runoff

Material Flows:

New York City produces 13,000 tons of residential garbage each day;

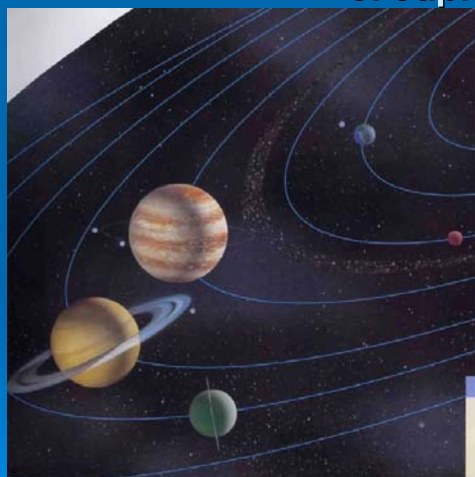
NYC consumes about 1.2 billion gallons of water each day, and discharges a like amount of wastewater to Long Island Sound, the Hudson, East, and Harlem Rivers, and Jamaica Bay

The City of New York produces somewhere between 12 and 15,000 tons of construction and demolition debris each day

Material Flows in NYC

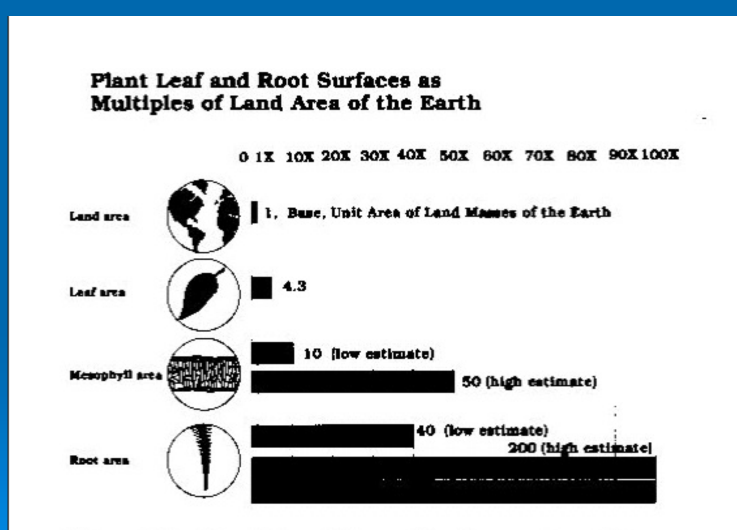
- Residential Waste at ≈ $100/ ton & 12,000 tons per day = $1,200,000 per day
- Drinking Water: at $1.50/100 gallons for 1,200,000,000 gallons per day = $18,000,000 per day
- Stormwater runoff: treated in WWTP at ≈ $1.50/ 100 gal. For 5,000,000,000 gallon/in runoff ≈ $80,000,000 per inch of stormwater

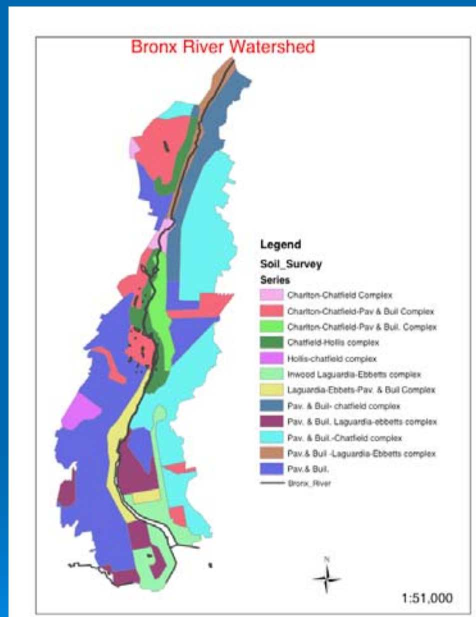
According to Vernadsky, Life on Earth has Increased the Planetary Surface to the Scale of Jupiter



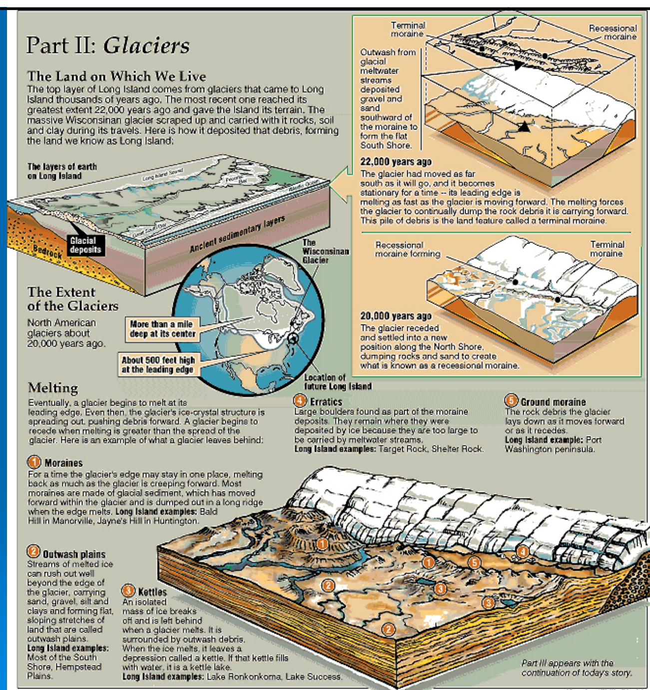
- Ecosystem growth and development increases biomass and energy transfer (Unlanowicz)
- Biotic surfaces increase catalytic or free energy lowering capacity (Kaufman)
- Earth R= 4,000mi
- 2×10^{8} sq.mi
- Jupiter R=45,000mi
- 2.5×10^{10} sq.mi.

Plant Surface Area



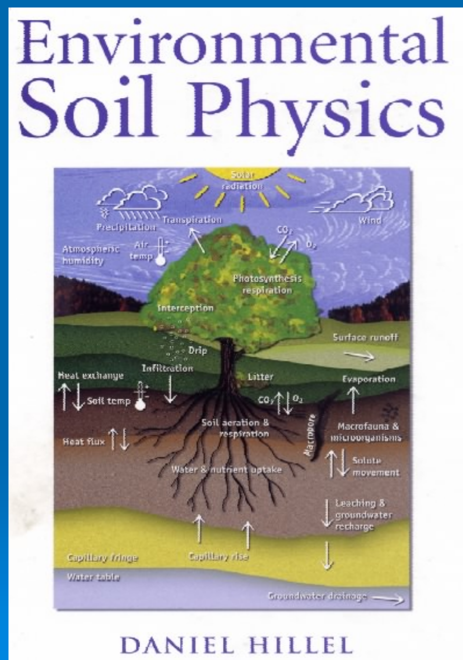


Bronx River Watershed Soil Survey,
New York City Soil & Water Conservation District



Glacial History

North of Staten Island, many of the physical properties of the surface and subsurface of the environment have been established or highly modified by glacial history



Physical Processes Regulated by Plant-Soil Interactions

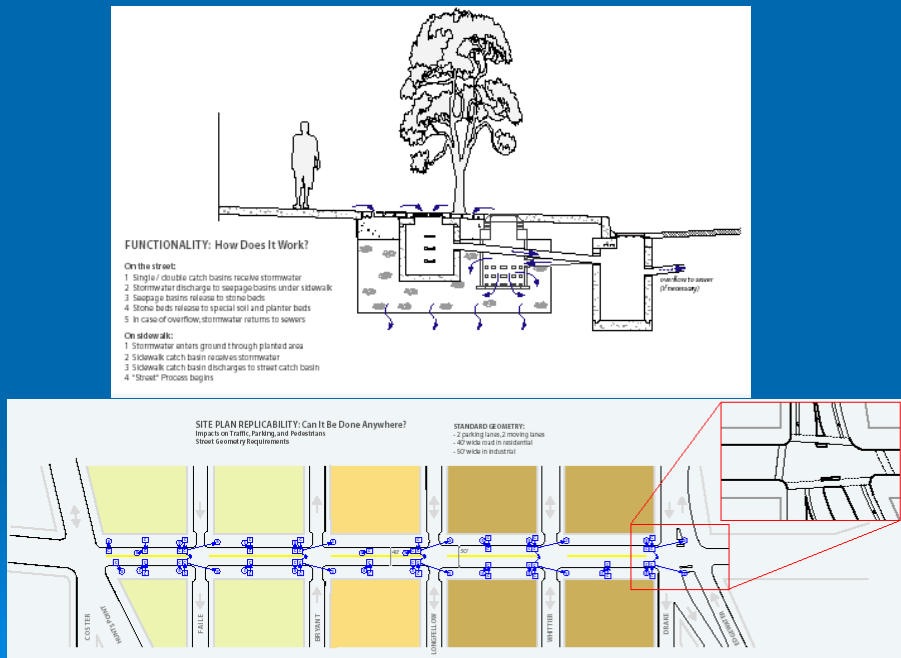
Soil Water holding-capacity regulates ecosystem growth and development. It is regulated by:

Infiltration
Macropores
Capillarity

CSX & Hugo Neu, Edgewater Avenue

Lafayette St. Corridor
"Before"

Lafayette St. Corridor "After", capable of capturing ≈ 450,000 gallons of water (ten year storm)



East New York, Brooklyn

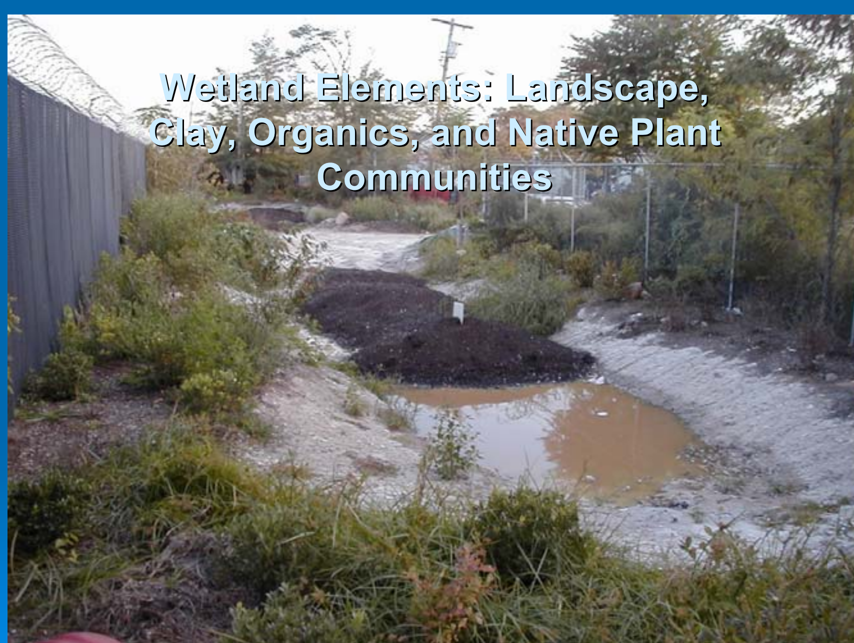
- Soil buffer and wetland construction for stormwater treatment from Command Bus Depot Parking lot and NYC Street.

ENY BEFORE & AFTER

BEFORE:
compacted urban wasteland, ragweed patch adjacent to a bus depot, infilration rate < 1/8”/hr.

AFTER:
stormwater capture park, infiltration rate 12” - 24”/hr.

Wetland Elements: Landscape, Clay, Organics, and Native Plant Communities



Bobcat mixing clay & subsoils

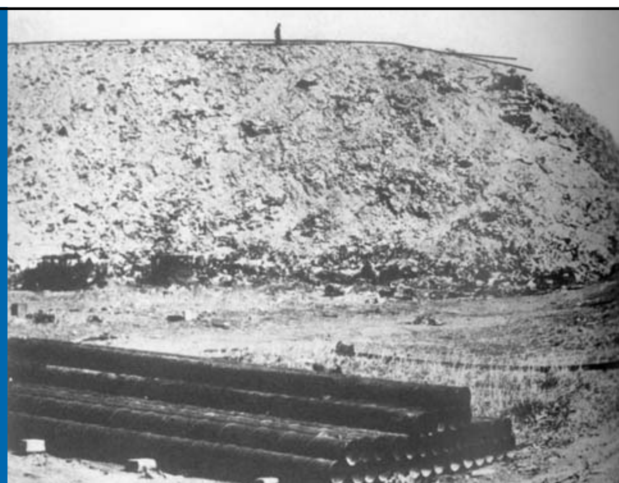
Increasing biomass to improve infiltration

NYC 2012 Olympics

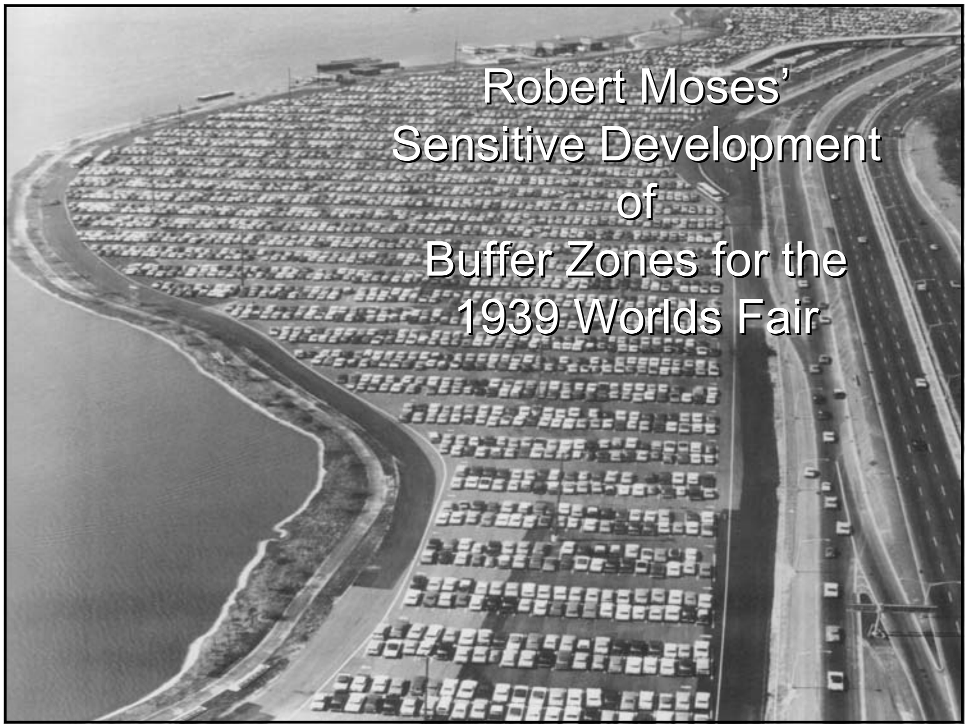
Flushing Meadow Lakes design for the 2,000 meter rowing course

Flushing Creek 1896

The large saltmarsh of Flushing Meadow gathered nutrients for about five thousand years until just after the turn of the last century



The great marsh was filled, in part by the Corona Ash Dump (above), run by Fishhooks McCarthy from the beginning of the 1900's through the 1930s, was famous for its grotesque presence on the landscape. The so-called "Mount Corona" was a mountain of garbage that reached nearly 100 feet high.



Approximately One and a half square mile of watershed Surrounding Flushing Meadow Will need to capture and/or infiltrate about three and a half million cubic feet of water to store each inch of runoff

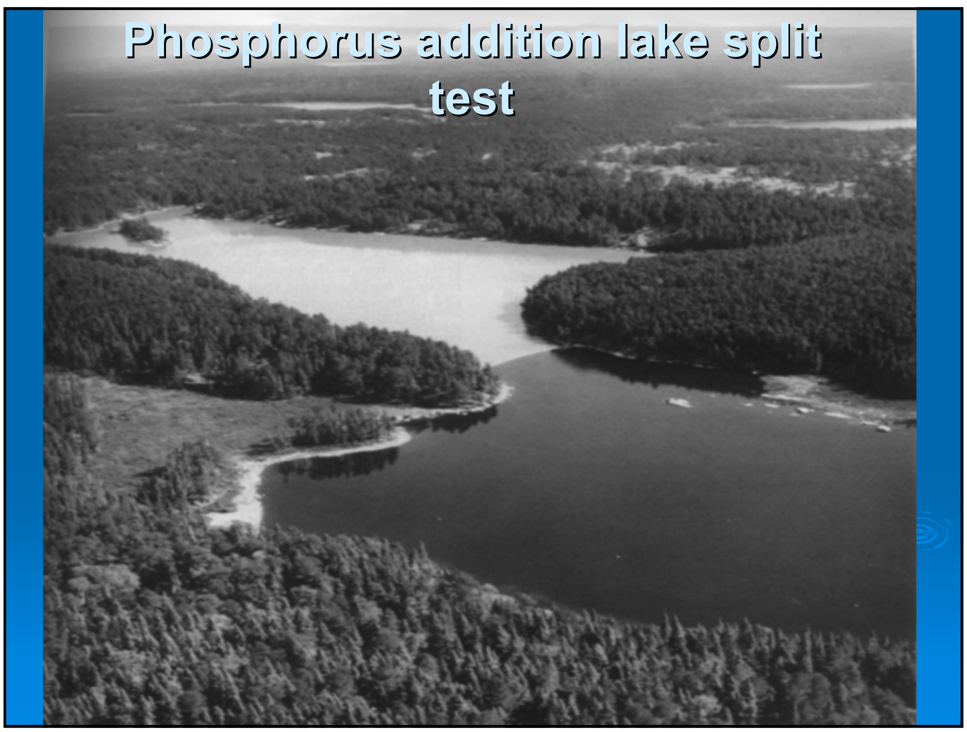
Existing Conditions and Problems

Good water is the life of terrestrial lanscapes. Three structural features of the twin lakes in Flushing Meadows negatively impact the quality and quantity of water:

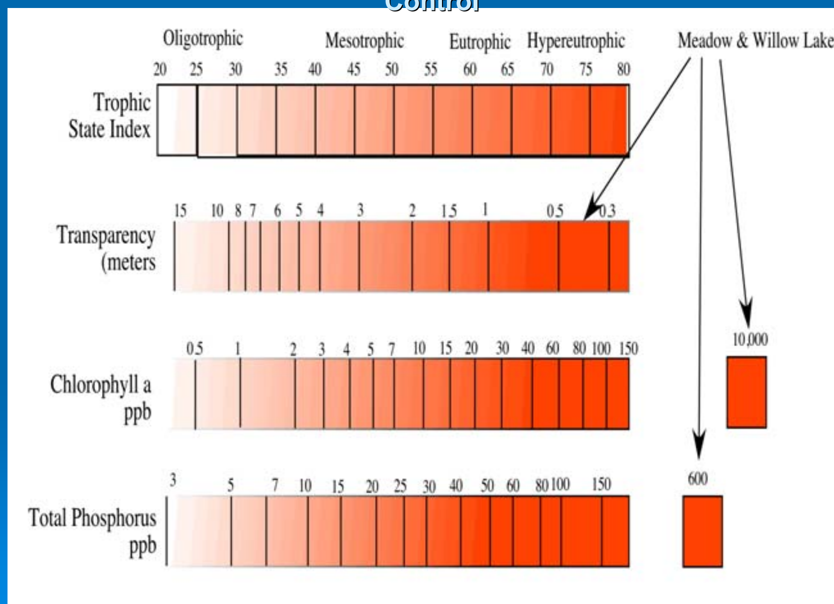
Ringed by roadways that cut the landscape off hydrologicaly from surrounding ecological communities, while discharging pollutants into the lakes, disturbing and disrupting habitat.

Stormwater is diverted out of the watershed. Less water flowing in means a reduced flushing rate in terms of throughput, as well as less water to support plant community growth.

High nutrient content in the underlying sediments from historic salt marsh is compounded in Meadow Lake by the grassy lake edge, attracting geese that deposit droppings and yet more nutrients to the water.

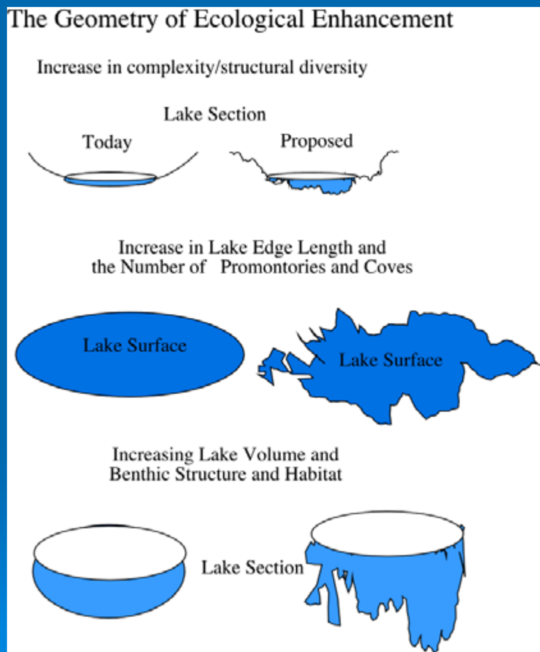


Eutrophication Indices-Hypereutrophic equals beyond Biotic Control



Principles Informing Ecological Design (Biogeochemical Enhancement)

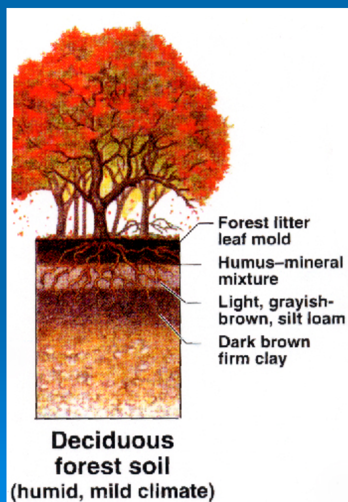
- ***Structural Diversity Can Increase Free Energy Lowering Capacity: Hypothesis: Ecosystem Growth and Development Moves Natural Systems Far from Thermodynamic Equilibrium***
- ***Hypothesis: The Evolution of Terrestrial Life Increased Land Surface Structural diversity.***
- ***The Biota Increased the Filter & Exchange Area of the Earths Surface. Life on Earth Has Changed the Hydroperiod of the Terrestrial Biosphere.***

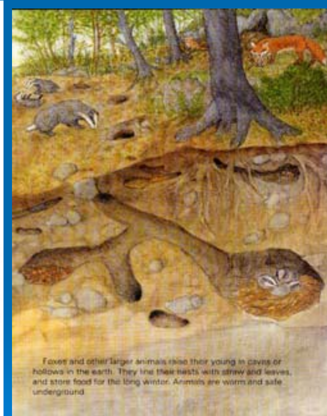


Fractalizing Edges

Controlling Erosion

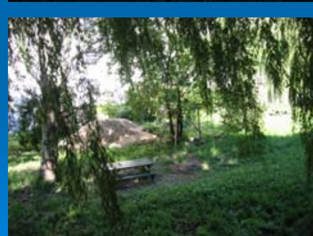
Increasing biomass to improve soil quality



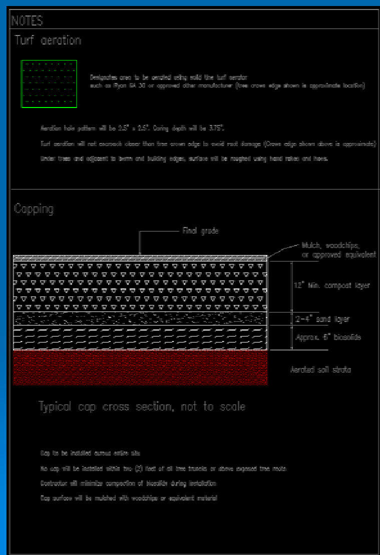


2000 Meter Rowing Course with Soil & Wetland Buffers

El Jardin del Paraiso



Lower East Side: El Jardin del Paraiso:
Stormwater capture and lead mitigation cap



- One foot of compost from NYC DOS and/or Green Thumb
- Two to several inches of clean sand or ground brick, concrete, & rock
- Several inches of composted NYC DEP biosolids
- Fill presently on site, left in place, unmodified

El Jardin del Paraiso

Penn & Fountain Ave Landfills

Pelham Bay Landfill

The sectional area of the Eastchester Creek/Hutchinson River estuary between the Pelham Bay landfill and Rodmans Neck from the Shore Road Bridge to the northerly bank of Turtle Cove would be decreased by a quarter to a third with a containment facility structured as shown. This would lead to relatively small changes in the structure of the currents here, with increases in Reynolds and Froude numbers ranging between about 20% and 70%. Flow changes in other areas of Eastchester Bay adjacent to the containment facility would be less significant.