V. STRATEGIES AND TECHNIQUES FOR ENHANCEMENT

Like an English Garden, which is planned to be a place of beauty as it develops over the years through various stages in the life cycles of the plants in the landscape, all strategies that aim to incorporate ecological systems must encourage and plan for their growth and change through time. Rich soils are one necessary component to such planning, but we must also recognize that soils may need to be periodically enriched to support increasing or changing needs of the plant and animal communities they support.

In a world where open space, passive recreation, sports and playgrounds are packed into one park, means need to be found to make sure that parkland can still act as the "lungs of the city" while allowing space for exercise, enjoyment and solitude. The methods and means for integrating different park uses to mutual benefit through the techniques of ecological restoration and engineering are given below.

Ecosystem growth and development

The plant communities in and around the twin lakes have developed to their present state largely over the past three decades. Nutrient, water holding, and seed source limitations are probably the main inhibitors of further growth and development on the land. This leaves a large number of landscaping opportunities to enhance biodiversity and ecosystem services along virtually every linear foot of roadway, degraded soil system, turf grass, and lake edges.

Today, the structure of the natural systems reflects the uniformity of the lakes. This is especially so since the plant communities were reduced to minimal diversity through the period of clearing and building, and then left to develop, on their own, so to speak, without any systematic reintroductions from neighboring areas. Beyond wind blown and bird-distributed seed inputs, little has been done to restore the original species composition or native plant communities on the site.

In general, where there are no immigrations of plants to a site, marginal populations will disappear, displaced by invasive weeds, with seeds continually entering the site from surrounding weed populations. Nor have there been any large imports of biomass in the form of organic matter, compost[i], which would increase the scale of the biogeochemical filter and primary water holding capacitor: the humus that supports plant and ecosystem growth and development.

The future plans for Flushing Meadows-Corona Park should incorporate the methods described below if the park environment is to be substantially improved. These can be implemented one at a time or as part of a master plan, but each will begin to have a positive impact on the park itself.

Wetlands in series

Wetlands have measured capacities to remove toxins and pollutants[ii]. Typical, well-documented removal capacities for single wetlands are given in the table below.

Summary of North American Wetland Treatment Systems
Operational Performance: Surface Flow

	Concentration (mg/l)			*Mass (kg/ha/d) b*		
Parameter	**In**	**Out**	**Eff.%**	**Load**	**Rem**	**Eff.%**
BOD (5 day)	30.3	8	74	7.2	5.1	71
TSS (total suspended solids)	45.6	13.5	70	10.4	7	63
NH4-N	4.88	2.23	54	0.93	0.35	38
No2+NO3-N	5.56	2.15	61	0.8	0.4	51
Organic nitrogen	3.45	1.85	46	0.9	0.51	56
TKN- (Tot kjeldahl nitrogen)	7.6	4.31	43	2.2	1.03	47
TN- (Total nitrogen)	9.03	4.27	53	1.94	1.06	55
ORTHO-P	1.75	1.11	37	0.29	0.12	41
Total P	3.78	1.62	57	0.5	0.17	34

Kadlek and Knight: Treatment Wetlands, CRC Press, p 731 .

These values are for single wetlands. Coupled wetlands, and wetland plus soil buffer systems act to multiply removal efficiencies. In most cases, these capacities are described in terms of quantities of pollutants removed per area of wetland per unit time, and in terms of the ratio or percentage of removal, input concentration divided by output concentration.

The opportunities offered at Flushing Meadows allow a dual approach to utilizing these pollution removal abilities:

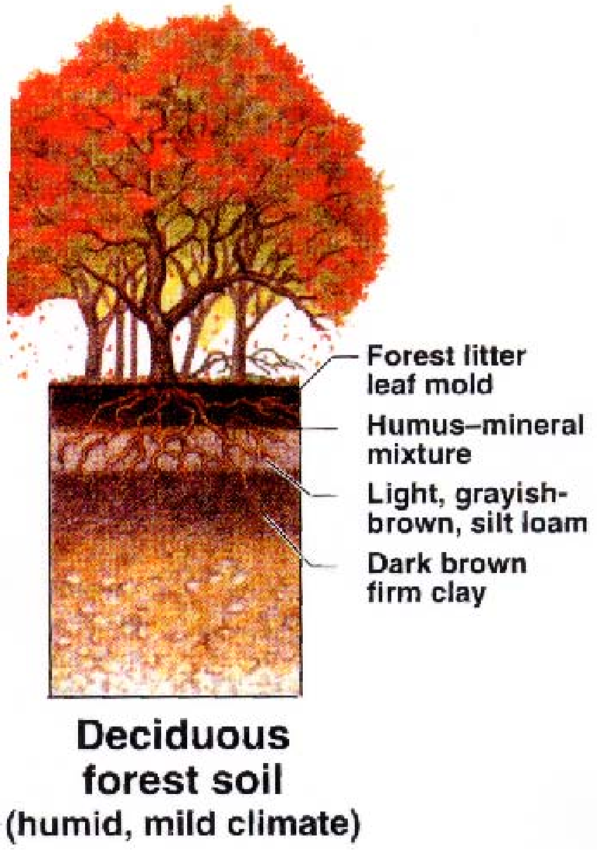
1. By measuring loads or input quantities around the twin lakes, it becomes possible to use potential loadings to specify the area and configuration of wetlands required to remove 50%, 90%, or 99% of these inputs.

2. By taking the known values for lake eutrophication, it is possible to determine how large a wetland (and soil buffer) complex would be needed to remove specific quantities of pollutants and sustain water quality in the lakes.

In practice, integrating both of these approaches will make it possible to create a testable, verifiable framework for ecological engineering of natural systems to meet water quality goals in Flushing Meadows.

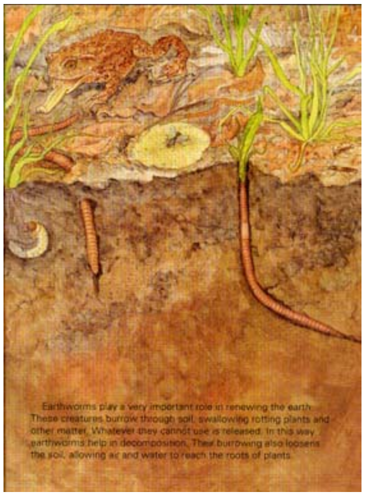
Increasing biomass to improve soil quality

As moist surfaces, plant leaves filter particulates from the air. Below ground, plants are even more active. Beneath a dense coverage of forest vegetation, a “rhizosphere,” or root zone, literally weaves itself together. More than two linear miles of fine roots can be found beneath every square yard of forest soil, along with billions to trillions of microbes associated with these plant roots and the physical-chemical environment of the soil[iii].



Tree roots, worms, and burrowing animals all keep the soil porous, rich, and supportive of life through maintenance of an organic layer.
Schmid, E. 1994. The Living Earth. North-South Books. (above)
Miller, J.E. 2000. Living in the Environment. 11th ed. Brooks/Cole.

Macro-pores are created in soil by roots and burrowing animals. Root hairs and microbes together elaborate an immense surface area of some ten square feet of biological surface beneath a single square foot of landscape[iv]. The porous, air-filled sponge-like soil so created below the forest floor is ecologically engineered by the activities of organisms to support their further growth and development. These same features positioned around human built infrastructure can purify water and air, and incorporate runoff in groundwater and nutrient-rich sediments in soils and plants so as to increase local ecological productivity and biodiversity.



Earthworms play a very important role in renewing the earth. These creatures burrow through soil, swallowing rotting plants and other matter. Whatever they cannot use is released. In this way earthworms help in decomposition. Their burrowing also loosens the soil, allowing air and water to reach the roots of plants.

Controlling Erosion

One year ago, the cover of *BioCycle: Journal of Composting and Organics Recycling* read: "Controlling erosion: Why compost and composted mulch are winning the battle to stem erosion and revegetate even the toughest of scarred slopes"[v]. The reason for the optimism regarding the seemingly intractable problem of increasing erosion around impacted landscape lies in results of more than five years of testing composted organics as a cost-effective means to bring highways into compliance with water quality regulations. While Flushing Meadows faces exactly this difficulty, it is seriously compounded by thousands of visitors and multiple land use, disturbance, and compaction problems within the park. All of this has translated into erosion and runoff, increased sedimentation in the lakes and decreased water-holding capacity on the land. While pathways, desire lines, connections between park entry, parking zones and use destinations will need to be integrated into any soil rebuilding and revegetation program, the key element to restoring ecological systems in the park is integrating park use with the addition of organic matter, humus, which can be cost effectively incorporated to increase biomass and biodiversity by diminishing or eliminating erosion and compaction.

Compaction and subsequent erosion
prevent the establishment of
permanent, healthy ground cover.

Increasing biomass to improve infiltration

Potentials for ecological engineering are set by local and regional hydrology and geology, together with land use and modifications of these by human activity. In Flushing Meadows, of glacially deposited materials provide a highly porous subsurface environment allowing for high stormwater infiltration rates. Urban fill covering the meadow, by contrast, has, in many areas, become compacted. Prior work of the Gaia Institute suggests that infiltration rates into urban fill can be multiplied by adding thick compost with shrub plantings, which can greatly increase water flow into the subsoil and groundwater.

For example, a community of blueberries and other shrubs planted on a foot and a half of compost over construction and demolition debris, increased infiltration rates of an inch or less per hour to between one and two feet per hour – more than enough to absorb the rate of rainfall produced by Hurricane Floyd.

Plantings on compacted soil next to a foundation with negligible infiltration have come to support vines twenty to thirty feet long. Through ongoing mulching with compost and wood chips, a strong organic horizon has developed, with multiple worm burrows (≥50 per square foot) and infiltration rates of several inches per hour.

Such relatively simple ecological engineering steps could transform infiltration and water holding capacity in and around Flushing Meadows. The addition of a new soil layer will start the natural processes of incorporating the compacted ash and cinder substrate back into the cycle of water and nutrient flows.

Within months, this 18" thick topsoil layer (pictured above) had produced a healthy rhizosphere on top of heavily compacted construction debris. The infiltration rate of the soil was also increased dramatically. This project, by the Gaia Institute, continues to be monitored for its on-going effectiveness. The photograph at left shows the macropores which formed at the edge of the boulder, in the left corner, which was rolled back to take this 'snapshot' of below ground activity. The quarter placed at center left for scale shows that roots and worm borrows have reached a scale of 1/8" to 1/4", providing for rapid infiltration, and the dark humus in the picture providing high water holding and moisture retention capacity.

Ecologically engineered surfaces

Ecologically engineered surface and subsurface features, from wetlands, ponds and creeks to porous gravel or wood chip paths and parking lot foundations, are needed to connect upslope water sources with water holding and conducting areas to bypass and eliminate overland seeps and erosion rills and gullies. This can be accomplished by integrating water conveyance and water holding landscape features to diminish wetness around road and path foundations, which should also decrease damage to park infrastructure and reduce potential liability.

The difference between urban runoff problems and habitat lies in sustainable natural structures. A mallard and her ducklings can just be seen in the dark shade at center right in the photo at right, under the grassy overhang. Eighteen months ago, this wetland was a blacktopped path. Constructed largely by school children, interns, and community members working with the Gaia Institute and the NYC Parks Department, this former asphalt surface now contains a coverage of 22 native species, with about 300 individuals shoots and 170 colonies.

Design can turn a runoff and erosion problem into a valuable landscape feature, as in the wetland (below) constructed by the Gaia Institue and NYC Parks, which increases biodiversity while enhancing environmental quality.

One method for creating stormwater treatment and edge stabilization is with timbers for terracing and eastern white cedar plantings (below right).

Coupling recreational areas with natural filters

The single most important area for water purification may be directly adjacent to infrastructure, since impervious surfaces are sources of stormwater runoff, and often, of air pollution. Parking lot, path, and road edges can be designed to capture and biogeochemically filter stormwater, an approach that has documented success at an increasing number of sites[vi]. As the robustness of scientific backing grows, together with pressures to capture stormwater and surface pollutants, municipalities and agencies responsible for the impacts of infrastructure around the country and the world are turning towards vegetated soil buffers and wetlands to capture precipitation before it creates erosion and pollution problems. By treating water near where it falls, this approach has the added advantage of minimizing runoff, and, therefore, the size of detention basins such as the $300 million sewage tank under construction in Flushing. If several linear miles of roadway edges had been coupled with water capturing green buffers, this project might have been scaled down or made unnecessary. In any case, diverting as much stormwater as possible from the treatment plant will greatly increase its efficiency in removing pollutants from Flushing Bay.
A critical element in improving ecosystem services in Flushing Meadows-Corona Park is the coupling of active recreation areas with ecological enhancement. Specifically, the recreational amenities in the park could become functional components of the ecosystem, as described:

1. ***Triassic and Jurassic Parks:*** These areas are now surrounded by standard fencing, pathway infrastructure, and turf grass. With directed effort, these wonderfully imaginative playscapes could be surrounded with organisms that are direct descendants of plants that were alive during the age of dinosaurs. Wetlands and moist soil buffers could be created around Triassic and Jurassic Parks to provide habitat for horsetails, clubmosses, and ferns, with full-scale models of the Triassic and Jurassic ancestors of these living relics. Small children and their parents could come to see how the wastes of the dinosaur age were cleaned up by plants and wetlands between 245 and 144 million years ago, just as our own wastes and non-point pollutants can be removed by well designed wetlands and soil buffers, using modern relatives of these ancient organisms.

2. ***Ball fields***: Because of the proximity of the land surface to the water table, the distance required for a recycle pump to move ground or lake water for irrigation through the root zone of the outfield grass is not great. A solar driven system could thus treat groundwater and/or lake water in the process of irrigating playing fields. Beyond allowing for much more intensive use and higher quality turf, the use of the fields as a water filter could demonstrate how active recreation uses like baseball and soccer could be coupled with the aims of improved environmental quality. Given the nutrient status of runoff and lake water, recycling lake or stormwater through turf grass could make fertilizer addition unnecessary.

3. ***Model airplane field:*** Here, the impervious area required could be coupled with thickly vegetated rich soil infiltration galleries at the edges, or potentially in "vegetated islands" to create a zero-discharge zone for stormwater runoff around the model airplane facilities, a worthy model for airports of all sizes.

Together, the constraints of existing infrastructure may be taken as a proper challenge to standard notions of park design. Ball fields can function to both support our best athletic efforts and to clean water. Specifically, the conflicting goals of good drainage to avoid flooding or ponding may be optimized so turf grass in playing field areas are not killed during times of drought, since good drainage puts grass cover at risk during low water periods. Scoreboards and subsurface ground water irrigation systems could be designed to run from energy generated by solar collectors, which could again be a project of local schools, colleges, little leagues, and other park users.

Theme parks such as Disney World and Busch Gardens have attempted to portray their activities in an environmentally forward-looking context, with advanced natural water treatment facilities and similar programs. Triassic and Jurassic playgrounds could be supported to grow into functional and educational features, demonstrating how natural systems have recycled wastes in the long term, and how the living relatives of ancient organisms are still at work in the modern world, supporting human populations, much as their ancestors supported and contributed to life in the Triassic and Jurassic periods.

Transforming the ratio of soil and wetland filters to match inputs

Soils and wetlands filter or sequester pollutants and nutrients in different ways. The size and distribution of these natural buffers in and around a lake is usually a matter of geological history, but human modifications of the landscape have changed virtually all the surface features around Flushing Meadows. Because of this, the ratio of meadows, shrublands, forests and wetlands to stormwater inputs and lake volume is an accident of recent history. Restoration efforts, however, could change watershed and lake characteristics to better serve water quality and biodiversity goals.

We know that the load of nitrate can be one to two parts per million in stormwater runoff, and also that wetlands and soils are capable of removing variable quantities, from part of a ton per acre per year in certain wetland environments, to tens of pounds per acre per year in productive soils[vii]. This allows an estimation of how large natural systems would need to be in order to remove pollutant loads.

If wetlands alone were used to remove nitrate (NO_3) it would be necessary to divide the total inputs by expected removal rates. The spreadsheet below shows minimal to maximal expected removal from wetlands, from a hundred pounds of NO_3 removal per acre per year to a ton and a half of NO_3 removal per acre per year.

Water input to 6 sq.mi watershed (In cu.ft.).	Water input (In pounds)	Nitrate mass loading (in pounds) (NO_3 concentration of 1 ppm)
167,270,400	10,437,672,960	10,438

Wetland acres to remove NO_3 load at 100 lbs./acre/yr	Wetland acres to remove NO_3 load at 1/2 tons/acre/yr	Wetland acres to remove NO_3 load at 1.5 tons/acre/yr.
104 acres	10 acres	3 acres

Increasing exposure to filter area

In the porous glacial materials on the hillslopes, inputs to groundwater could readily be increased by a factor of two or more, if more stormwater could be brought into contact with the porous material from the impervious surfaces. If, at the same time, lake sediments were removed by dredging, a large source of pollutants would be eliminated, increasing lake water quality in the process.

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[i] Not since the peat moss, mulch and topsoil brought in by Robert Moses for the 1939 Worlds Fair, and relatively smaller projects since, has any quantity of organic matter be brought into Flushing Meadows. See Moses, op cit.

[ii] Kadlek, R.H., & R.L. Knight, 1996. Treatment Wetlands, CRC Press, Lewis Publishers, Boca Raton, FL; Mitsch, W.J. & J.G. Gosselink. 3rd Ed. 2000. John Wiley & Sons, Inc. New York.

[iii] Wood, T.E. 1980. Biological and Chemical Control of Phosphorus Cycling in a Northern Hardwood Forest. Yale University Thesis. Jackson, R.B., H.A. Mooney and E. D. Schulze. 1997. A global budget for fine root biomass, surface area, and nutrient content. Proceedings of the National Academy of Sciences Vol. 94: 7362-7366.

[iv] Jackson et. al. 1997, above cite, provide data for temperate forests and other ecosystems in the global biosphere, indicating the immense global and local role of roots and the rhizosphere in global material cycles.

[v] BioCycle. January 2001. Vol. 42, No.1. Cover articles on pp 26-33. Earlier on the learning curve is an issue of BioCycle featuring “Compost on the Highway”, BioCycle. July 1997. Vol. 36, No.7: pp 75-80. “State Transportation Departments Expand Compost Use”.

[vi] The use of such natural systems to control stormwater and non-point pollution is documented in a number of scientific literatures, including solid waste recycling. Recent articles include two from BioCycle: Tyler, Ron. 2001. Compost filter berms and blankets take on the silt fence. BioCycle. January 2001: pp 26-31. Organics in Action: Composted Woody Materials Become Erosion Control Product, BioCycle. January 2001: pp 32-33.

[vii] Christ, M, Y. Zhang, G.E. Likens, & C.T. Driscoll. 1995. Nitrogen retention capacity of a northern hardwood forests under ammonium sulfate additions. Ecological Applications. 5(3) 1995. pp. 802-812; Groffman, PM, G. Howard, AJ. Gold, & WM. Nelson. 1996. Microbial nitrate processing in shallow groundwater in a riparian forest. Journal of Environmental Quality. 25: 1309-1316 (1996); Starr, JL., AM. Sadeghi, TB. Parkin, & JJ. Meisinger. 1996. Wetlands and Aquatic Processes: A tracer test to determine the fate of nitrate in shallow groundwater. Journal of Environmental Quality. 25:917-923 (1996).