Barnegat Bay National Estuary Program
Science and Technical Advisory Committee

Sustaining Soil Health in the Barnegat Bay Watershed

Introduction

The need to reduce nutrient inputs to aquatic ecosystems to protect drinking-water supplies and reduce eutrophication is widely recognized throughout the United States. In support of the Barnegat Bay National Estuary Program's 2008-2011 Strategic Planning priority to address the causes (*e.g.*, nutrient loading) and symptoms (*e.g.*, brown tides, declining eelgrass populations) of eutrophication in the Barnegat Bay, the BBNEP's Science and Technical Advisory Committee (STAC) developed a consensus statement on the justification of reducing nitrogen (N) and phosphorous (P) loadings from applied fertilizer to lawns and other turf areas to protect water resources in the Barnegat Bay watershed. This initiative to reduce N and P through fertilizer ordinances emphasized the importance of other initiatives to improve water quality throughout the watershed. Research has shown that phosphorous and nitrogen loadings can be reduced through filtration and, adsorption, and through sustaining healthy soils, microbial processes are effectively enhanced to reduce nutrient loadings (1).

Soil Porosity, Soil Disturbances, and Water Flows

Approximately 80% of the coarse textured soils within the Barnegat Bay watershed are classified as sands, sandy loams, or loamy sands (2). Most of the natural soils in the watershed are covered with woody vegetation and have minimal organic matter content. Both available water capacity and nutrient holding capacity are very low. The soil's acid nature limits the uptake of the many nutrients needed for plant growth; not surprisingly, some of these nutrients are components of fertilizers. These naturally occurring soils maintain an interconnected system of small, medium, and large pores equal to as much as half the soil's total volume.

Due to their porous nature, most undisturbed soils throughout the Barnegat Bay watershed infiltrate rainwater year round at a high rate. A 100-year storm event in Ocean County is 9.5 inches in a 24 hour period. Undisturbed soils can absorb nearly all of the rainfall from a 100-year storm without any surface water runoff. Investigations by United States Geological Survey (USGS) have confirmed that a high percentage (81% South Branch Metedeconk to 93% Westecunk Creek) of total stream flow within the watershed comes from groundwater that is recharged by infiltration. Therefore, maintaining infiltration of rainwater is essential to sustaining stream base flow and as well as minimizing stormwater (3).

Commonplace human activities associated with development of the landscape often disturb soil features and overall soil health. For example, clearing and grading natural areas can severely compact soil which reduces soil health. Severe compaction of soil reduces the ability to absorb the rainwater, increases surface ponding, and produces poor turf, shrub and tree growth. The Ocean County Parks Department has experienced increasing difficulty managing turf areas, and some athletic fields have continual soggy turf, restricting use. Moreover, turf often succumbs to drought more quickly since less rainwater is absorbed by compacted soil. The effects of soil compaction are also seen on agricultural lands. Farmers are being forced to subsoil lands to maintain productivity and reduce increasingly accelerated runoff and increased soil erosion in order to maintain productivity. The U.S. Forest Service has investigated the longevity of soil compaction and the rate of soil recovery following forest harvesting practices. Numerous U.S. Forest Service studies have shown that once compacted, forest soils may take decades to return to pre-disturbance levels. They also concluded freeze and thaw cycles are not effective in ameliorating the impacts of soil compaction (4).

Unfortunately, average base flows in streams continue to decline in many streams throughout the watershed, whereas, the frequency and magnitude of flash stormwater flow events are increasing. Increased stormwater runoff results increases surface water flows and accelerates in-stream erosion and sedimentation problems. The Ocean County Engineering Department has expressed concern that accelerated runoff volume from developed areas, including areas with disturbed soils, is causing increasing flooding events, and that existing culverts and

storm drains may need to be improved. Increased runoff also results in the need for greater storage capacity in stormwater basins, which requires additional landscape disturbance and costs for development projects, and has other adverse impacts (e.g., pesticide treatment to minimize transmission of West Nile virus for poorly draining stormwater basins). Stormwater management has significant economic consequences that will increasingly impact Ocean County in the future if not properly addressed.

Soil Health and Bay Impacts

Soil compaction affects the bay by affecting the quantity and quality of waters reaching the bay. In addition to causing a variety of problems on the land (*e.g.*, poor plant growth, localized flooding), these compacted soils contribute to a complexity or stormwater and nutrient management problems that deleteriously impact the bay. Of great concern is the risk of severely compacted soil increasing stormwater runoff, which carries away soil, nutrients, and other contaminants to the nearest stream and ultimately the bay. Applied fertilizers are used more efficiently in healthy soils, reducing the need for fertilization. Unfortunately, homeowners treat symptoms of poor plant growth by over-fertilizing their landscapes, and applying large amounts of nitrogen and phosphate containing fertilizers as well as continual application of herbicides, fungicides and insecticides. These actions do not correct soil health problems, typically they mask the problems. Low organic matter content and compaction of soil reduce water storage and restrict plant root growth; thus many lawns, shrubs, and trees have difficulty growing without irrigation. Landscape irrigation adds to domestic consumption of limited fresh water supplies in the watershed. Improvement of soil health throughout the watershed would ultimately decrease stormwater runoff and improve water quality in the bay.

Issues and Opportunities

The health of the Barnegat Bay ecosystem depends on our ability to improve and maintain the essential physical, chemical and biological soil functions in the watershed. Effective soil management is vital to sustaining fresh water flow and reducing nutrient inputs, both of which need to be widely understood to better manage future growth throughout the watershed. NJDEP efforts to encourage the use of Best Management Practices (BMPs), (5), along with Ocean County initiatives to purchase additional open space, offer opportunities to help prevent or reduce stormwater runoff and nutrient inputs. However, there are no existing rules/guidelines to implement soil restoration practices on developed and developing lands. The USDA-Natural Resource Conservation Service (NRCS) defines healthy soils as able to perform these critical functions: effective cycling of nutrients; minimizing runoff and erosion; absorbing and filtering excess nutrients; maximizing water-holding capacity, and providing a healthy root system within natural or managed ecosystem boundaries to sustain plant and animal productivity; maintaining or enhancing water and air quality; and supporting human health and habitation (6). To retain soil porosity on sands and loamy sands, NRCS recommends an ideal bulk density of less than 1.60g/cm3 (6). Field measurements by the Ocean County Soil Conservation District and USDA-NRCS documented the impact of soil compaction as measured by increased in bulk density, declining infiltration and increased runoff (7). Heavy equipment typically used to clear, cut, bulldoze, scrape, transport and fill, most notably, entire development sites, compacts the soils, leaving insufficient pore space. This disrupts vital soil processes, including water infiltration. The topsoil of disturbed sites is typically removed and placed in large stockpiles for extended periods, which typically disrupts or destroys the soil's biology. Such manipulation of topsoil also greatly reduces organic matter. Beneficial organisms are diminished and the aggregation of soil particles is severely impacted. When topsoil is returned to these developed sites biological activity has been greatly reduced creating a difficult environment for the homeowner or property manager attempting to grow turf and healthy, attractive landscaping.

Current Actions

The U.S. Environmental Protection Agency strives to implement various actions that could help minimize anthropogenic effects and build science-based approaches to better manage ecological resources wisely. In a 1999 research report, EPA confirmed a widespread problem of decreased infiltration due to disturbed soil

conditions and recommended a potential solution: the use of soil amendments with compost (8). A USDA, NRCS study confirmed that sandy soil is most affected by compaction (9).

In Chapter 7 of the Hydrologic Soil Groups in the National Engineering Handbook (NEH), the USDA-Natural Resources Conservation Service (NRCS) notes that as a result of construction and land disturbance activities, the soil profile is altered from its natural state, and *the listed* soil hydrologic group assignments can no longer be applied. Pursuant to the National Engineering Handbook, the NJ-NRCS and OCSCD have developed recommendations based upon on-site investigations to determine the correct hydrologic soil group.

The Ocean County Planning Board has been leading a partnership of the Ocean County Road Department, Ocean County Engineering Department, NJDEP, OCSCD, and USDA-NRCS to restore soil health in several stormwater management basins (10). The information learned, protocols, and demonstrations developed by this partnership may have applicability throughout the state.

Assistance/Actions Needed

The STAC has confirmed current nutrient loadings into Barnegat Bay are contributing to the bay's eutrophication and therefore unsustainable. Investigations by the Washington Organic Recycling Center in King County, Washington have confirmed that healthy soils directly contribute to healthier water resources. These studies demonstrated the connection between soil and water as well as the benefits of restoring urban soils to improve hydrologic conditions for salmon habitat. These findings helped formulated a coalition that led to development of soil restoration guidelines to create healthy soil habitat as a critical component of salmon recovery (11). These guidelines could serve as a model to improve water quality in the Barnegat Bay watershed and support the growth and restoration of clams, eelgrass and other species sensitive to water quality. Despite some success in reducing sediment loadings and related non-point sources (NPS) through Chapter 251, the New Jersey Soil Erosion and Sediment Control Act 1975, and the recent adoption of stormwater BMPs through NJDEP Stormwater Regulations, efforts to date have neither ensured the sustainability of soil functions nor prevented the accompanying loss of ecosystem services.

Many contractors have insufficient training about the long-term economic and environmental impacts and need to understand: (1) how applying soil quality practices can reduce construction costs, and (2) how these practices can reduce long-term maintenance costs for irrigation, fertilizer and stormwater infrastructure.

The STAC recognizes that BMP guidelines need to include measures that sustain and/or restore soil health to maintain the natural hydrologic balance of the land that is being developed. The STAC concludes that when we apply BMPs to reduce the volume of stormwater runoff, we also reduce nutrient loadings entering Barnegat Bay. The following actions will assist in leading efforts to sustain soil health in the Barnegat Bay watershed.

Action Plan

Standards and Specifications

Outputs/Products	Outcomes
Improved management practices, and model soil standard to optimize soil physical, chemical, and biological functions to improve infiltration, water retention, aeration, and reduce water consumption.	Improved soil structure, reduction of surface runoff, nutrient loadings, erosion, and surface and groundwater contamination. Enhance soil sustainability and conservation of water resources.
BMP construction guidelines to sustain and restore soil health on disturbed lands and on agricultural lands.	Degraded soils become more productive and less likely to contribute to excess runoff and water quality degradation.

Tools

Outputs/Products	Outcomes
New methods and equipment to assess soil health	Increased understanding of the functional relationships between soil physical, biological and chemical processes. Development and piloting of a Soil Health Card and Soil Quality Test Kit to assess and monitor soil health
Research and recommend the best, most practical and cost effective measures to remediate degraded soil conditions.	Pilot cost effective mechanical methods to loosen soil and to incorporate organic materials (recommended amount, depth, application/incorporation techniques) to effectively restore infiltration.

Public Outreach

Outputs/Products	Outcomes
Develop, pilot and test construction guidelines, Soil Health Amendment Specifications and model Soil Health Ordinance to sustain and restore soil health.	OCSCD and OCPB to pilot soil health guidelines and soil restoration specifications on County projects to minimize soil compaction and restore soil physical and hydraulic properties to improve infiltration, water quality and reduce consumption. Evaluate guidelines for recommended period and revise techniques as needed. OCSCD to adopt model Soil Restoration Ordinance and apply to all land disturbances greater than 5,000 sq. ft.
Develop and implement Soil Health Certification Program for contractors, landscapers, and engineers to ensure that BMPs and stormwater practices are properly constructed to sustain soil physical, chemical and biological functions. Prepare inspection procedures and inspections forms as a basis for uniform inspections to evaluate soil conditions.	Contractors certified in sustaining soil health to retain fully functioning soils to reduce runoff, erosion and nutrient loadings. Pilot inspection procedures to ensure that stormwater BMPs function as designed.
Utilize public outreach and communication to encourage application of soil health practices and techniques.	Soil health fact sheets for homeowners, revised Homeowners' Guide and resource information. Homeowner demonstrations, Field Days at garden centers to demonstrate soil health techniques that protect water resources**.**

References

1. Lucas, William and Greenway, Margaret, Nutrient Retention in Vegetated and Nonvegetated Bioretention Mesocosms, Journal of Irrigation and Drainage Engineering, ASCE, September 2008.

2. Ocean County Soil Survey, USDA-Natural Resource Conservation Service. 1980

3. Gordon, A.D. 2004, Hydrology of the Unconfined Kirkwood-Cohansey Aquifer System, Forked River and Cedar, Oyster, Mill Westecunk, and Tuckerton Creek Basins and Adjacent Basins in the Southern Ocean County Area, N.J. 1998-1999; USGS Water Resources Investigations Report 03-4337.

Watt, M.K. Johnson, M.L., and Lacombe, P.J., 1994. Hydrology of the Unconfined Aquifer System, Toms River, Metedeconk River and Kettle Creek Basins, N.J., 1987-90: USGS Investigations Report 93-4110, 5pl.

4. U.S. Forest Service Handbook, FSH 2509.25-Watershed Conservation Practices Handbook: Amendment No. 2509.25-2006-2, May 2006.

5. Mullica River Watershed Stormwater Basin Assessment Project, NJ Pinelands Commission, September 2005;

6. USDA-NRCS Soil Quality Institute: http://soils.usda.gov/sqi/concepts.html

7. The Impact of Soil Disturbance During Construction on Bulk Density and Infiltration in Ocean County, NJ, Ocean County Soil Conservation District, USDA-Natural Resource Conservation Service, Schnabel Engineering. 2001.

8. USEPA, Office of Research and Development, December 1999, Infiltration through Disturbed Urban Soils and Compost-Amended Soil Effects on Runoff Quality and Quantity.

9. Urban Soil Compaction: Soil Quality-Urban Technical Note No. 2; USDA-NRCS, Soil Quality Institute, March 2000.
   Soil Compaction: Detection, Prevention and Alleviation, Technical Note 17; USDA-NRCS Soil Quality Institute, June 2003
   Protecting Urban Soil Quality: Examples of Landscape Codes for Specifications; Ann Lewandowski, USDA-NRCS

10. Final Report: Atlantic Coastal Watershed Management Grant; Stormwater Basin and Storm Drain Retrofitting Projects for the Barnegat Bay Watershed, Ocean County Planning Board. 2008.

11. Washington Organic Recycling Council, Guidelines and Resources for Implementing Soil Quality and Depth BMP T5.13 2009, *info@compostwashington.org*, www.soilsforsalmon.org, www.buildingsoil.org.