ECOLOGICAL OBJECTIVES

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INTRODUCTION

Ecosystem management and restoration planning should proceed from the identification of desired ecosystem conditions, which have been modified based on economic, social and political constraints (Kern, 1992). The ideal or target ecological conditions are not necessarily based on historical, pre-development conditions, but on a new equilibrium condition that supports a functional, ecologically intact system (Manci, 1989). In pristine river systems, for example, the dynamic processes of flooding, erosion, sediment deposition, and large wood falling and collecting in the river create habitat and associated biological diversity. Since these processes are not all achievable within an urban system, those ecological functions and values that are likely to be recovered in the Bronx River watershed must be identified. Setting specific objectives or targets is an important step in prioritizing restoration, management efforts, and resources.

An ecologically functional system is sustainable over time and resilient to external stresses. These characteristics are indicated by self-perpetuating native populations of flora and fauna and minimal threats to the system, as achieved through stabilization or reduction of invasive species populations (Parrish et al., 2003). In fragmented, highly urban and disturbed systems such as the Bronx River, relatively few populations or systems have the potential to be entirely self-sustainable. Instead, a suitable level of management and maintenance should be identified that might be considered acceptable to protect and sustain them.

Ecological Objectives for the Bronx River

In the Bronx River watershed, landforms, in-stream structures and vegetation have been so altered that most of the characteristics of a healthy river can never be fully replicated. Instead, a more realistic objective is to increase the number and lengths of river reaches where the conditions of a functional ecologically intact river are met. In general, restoration work should aim to create a river ecosystem that:

- Conveys the water flow and sediment it receives without resulting in excessive erosion or deposition
- Is a continuous network allowing unimpeded water and sediment transport as well as fish and wildlife passage throughout
- Allows groundwater exchange in the channel and floodwater exchange, retention and infiltration in the floodplain and on upland slopes within the watershed
- Supports riverbank vegetation and heterogeneous bedforms such as pools and riffles to provide varied habitat for fish and wildlife
- Supports aquatic communities that are not impaired by the quality of the water within the river

Ecological Objectives for the Watershed

Objectives for the Bronx River watershed, or the landscape surrounding and draining into the river, include identifying, establishing and maintaining ecologically beneficial characteristics in the urban landscape. Undisturbed (unpaved and relatively uncompacted), vegetated soil, for example, permits infiltration and storage of storm water, and recharge to the river and groundwater. Vegetative communities of almost any kind have some value in reducing ambient temperatures and protecting soil in an urban environment. The vegetation community can provide additional ecological functions, such as perpetuating floristic biological diversity, habitat for native fauna and soil conservation and enrichment. The degree to which these functions are present within a patch of vegetation depends on factors intrinsic to the patch (e.g. the current species composition and structure and the frequency and degree of disturbance) as well as various landscape factors (e.g. the size, shape and degree of connectivity to other vegetated areas). Ideally, the landscape surrounding the Bronx River should contain flora and fauna that are not only predominantly native, but also contains both pollution-sensitive and pollution-tolerant species.

Performance standards for ecological objectives

Whenever possible, ecological objectives should include quantifiable parameters or indicators that can be measured to evaluate success. Quantifiable objectives can help set priorities, drive the implementation of management plans and provide performance standards against which to assess the effectiveness and efficiency of restoration and management efforts (Parrish et al., 2003). Using performance standards to assess progress also encourages the implementation of adaptive management — if objectives are not met, management and restoration approaches should be re-assessed and adjusted to better reach stated goals. Alternatively, the performance standards themselves may need to be adjusted or changed to better reflect what is possible and important to achieve.

Quantifiable parameters include indicators of significant ecosystem attributes, such as the presence of focal species, native species regeneration or stream channel stability. Many ecosystem attributes, however, are difficult or costly to measure or there may be insufficient baseline data to develop a meaningful quantitative performance standard for them. In these cases, a qualitative standard can serve to guide restoration and conservation projects. While some ecological attributes improve quickly in response to a single restoration project other attributes may need to be monitored over a period of months or years to identify trends (Haynes and Moore, 1988).

ATTRIBUTES AND INDICATORS

Here, the attributes and indicators of an ecologically functional Bronx River corridor are discussed. Though many of these characteristics are inter-related, they are discussed under the following headings: water quality, hydrology/storm water management, channel stability, in-stream and riparian habitat, riparian vegetation, benthic macroinvertebrates, fish, and birds. A general goal is set for each and the ecological significance of the associated attributes is described. Relevant indicators and commonly used measures or regulatory standards are presented, if they exist, as are the challenges to establishing performance standards, if they do not.

In the tables that follow, the attributes and associated performance standards with quantitative measures are listed first. “Very good” is typically an ideal condition for an undisturbed river and watershed, rather than an assessment relative to an urban stream. In practice, “Good” may be the objective for a given attribute on the Bronx River. For most attributes, evidence that there is a positive trend, or at least not negative trend, in performance measures may be as important as achieving a “Good” ranking. Measurement methods are discussed briefly to provide some understanding of the level of effort required to conduct the monitoring to apply performance standards. At the end of each section, the current conditions, based on the proposed performance standards, are summarized.

Below, the attributes and performance standards that are most important to the Bronx River are summarized based on their significance in reflecting ecological conditions and function and their ability to be monitored given anticipated resources.

WATER QUALITY

Goal: To improve water quality for public health and recreational benefits and to support sensitive life stages of aquatic organisms

Significance and standards

Improvements in water quality are necessary both to increase recreational access to the river and improve ecological health. Although several metrics can be used to evaluate water quality, dissolved oxygen (DO) and fecal coliform are the two of greatest interest in the Bronx River. They are used by state and federal agencies to regulate water quality to protect human health and the environment {TABLE IV.1}. The concentration of fecal coliform bacteria is an indicator of human and animal waste discharge into water and is used to establish permitted recreational uses of the river. Combined sewer overflows (CSOs) discharge a mix of sewage and storm water, both containing fecal coliform, when heavy rainfall overloads the sewage system. High levels of fecal bacteria are linked to pathogens that can cause illness in humans, so public health standards have been developed to determine whether the water is safe for swimming, fishing and boating.

Since healthy aquatic flora and fauna require a minimum level of DO, the river's capacity to sustain life is limited when oxygen is scarce. High fecal coliform counts are also linked to increased biochemical oxygen demand in the river and decreased DO levels. Biological indicators that are directly impacted by DO levels are also important and are discussed in further detail in following sections.

TABLE IV.1: Conditions and performance standards for Water Quality, based on New York State Surface Water Quality Standards (Schmidt et al., 1981)

Poor	• DO concentrations below the survival threshold for most aquatic organisms for more than one week in parts of the river • Monthly geometric mean fecal coliform and monthly geometric mean total coliform counts only suitable for secondary contact with water and fishing; coliform counts adequate for fish propagation and survival
Fair	• DO concentrations below levels required for growth by most aquatic organisms for more than one week • Monthly geometric mean fecal coliform counts and monthly median total coliform counts suitable for primary and secondary contact with water and fishing; coliform counts are adequate for fish propagation and survival
Good	• DO concentrations above levels required for growth by most aquatic organisms year-round • Monthly geometric mean fecal coliform counts and monthly median total coliform counts suitable for primary and secondary contact with water and fishing; coliform counts are adequate for fish propagation and survival
Very Good	• DO concentration levels greater than 7 mg/l year-round • Monthly median total coliform counts suitable for commercial shellfishing, primary and secondary contact with water, and fishing; coliform counts are adequate for fish propagation and survival

Measurement methods

Standard protocols exist to provide a quantitative determination of many parameters of interest. Adequate measurements require moderate (i.e. temperature and pH) or high (i.e. bacteria and nutrients) level of effort. Field methods, as well as location and frequency of sampling, depend on the objectives of the sampling (Behar et al., 2000).

Current condition: FAIR

Monitoring indicates that the Bronx River currently experiences periods of low DO levels (hypoxia) that may have adverse effects on sensitive organisms and on juvenile life stages. The hypoxic conditions (below 4.8 mg/l DO) do not seem to persist for long periods and tend to be limited to impoundments and areas near CSOs. The primary sources of fecal coliform bacteria are CSOs after rain events, waste from wildlife and domestic animals and illegal sewage discharges through storm sewer hookups.

HYDROLOGY

Goal: To increase connectivity between the Bronx River and its historic floodplain, to promote storm water infiltration and to reduce peak storm water flows

Significance and standards

Urban development increases impervious area in the watershed, creating a "flashy" hydrologic regime in which more storm water runoff is transported to the river channel more rapidly. The highest flood flows (measured as the annual peak discharge) become higher, and the low (base) flow can become lower. In addition, the volume of runoff after a storm is higher and passes through the stream system more quickly. Typically, degradation of the natural stream biota is observed in watersheds with impervious area of 10 percent or greater (Booth and Reinelt, 1993). Imperviousness in the Bronx River watershed is greater than 60 percent.

Despite well-documented hydrologic impacts of development, quantifying the level of hydrologic disturbance is often difficult because continuous historic flow records are usually unavailable. Even when historic and on-going monitoring data is available, identifying a target for hydrologic restoration may still remain difficult for several reasons. First, an understanding of the most biologically or morphologically significant hydrologic parameters is lacking for restoration. Second, reversing landscape changes caused by development is usually not feasible in an urban environment. Third, metrics such as peak discharge vary annually and are not sensitive to individual, localized restoration projects. Finally, in highly urban areas, the watershed can be ecologically uncoupled from the river. In Bronx County a combined sewer system conveys most storm water to discharge points downstream in the estuary, making hydrologic restoration even more difficult to measure.

Although quantifying the target can be difficult, hydrologic disturbance can be reversed or at the very least mitigated, and it is important to do so. Restoration attempts will never be entirely successful without addressing the causal factors of disturbance. Reversal of hydrological disturbances is achieved through incremental alterations to the volumes and areas of detention and infiltration of storm water. Over time these incremental changes can lead to measurable increases in base flow and decreases in the frequency and volume of discharges through CSOs and other indicators of hydrologic disturbance.

TABLE IV.2: Conditions and Performance Standards for Hydrology	
Poor	• Little or no floodplain available for flood retention • Annual peak flows significantly greater than pre-development conditions • No storm water best management practices implemented • Substantial implementation of storm water best management practices requires major reconstruction • High imperviousness (>40%), with development increasing
Fair	• Some historic floodplain available for flood retention • Annual peak flows not increasing over the long term • Some storm water best management practices implemented • Some potential for implementation of storm water best management practices • High imperviousness (>40%), but development has stabilized
Good	• Much of historic floodplain available for flood retention • Annual peak flows decreasing • Frequent implementation of storm water best management practices • Great potential for implementation of storm water best management practices
Very Good	• Maximum possible area of floodplain available for flood retention • Annual peak flows similar to pre-development historic conditions • Aggressive implementation of storm water best management practices • Measurable increases in storm water infiltration and retention

Measurement methods

Continuous surface water monitoring conducted by the U.S. Geological Survey (USGS) is the ideal source of data for evaluating hydrologic conditions. However, because it is primarily useful for assessing long-term trends, not incremental changes, it is not practical for assessing progress towards meeting goals. Another option is to monitor changes in watershed conditions that affect the in-stream hydrologic regime (e.g. the amount of impervious area or floodplain and storm water retention area or number of best management practices). Monitoring should occur on a site-by-site basis, by measuring the volume of storm precipitation, runoff captured and area of impervious surface converted to pervious surface at the site.

Current condition: POOR

Peak annual flows at the USGS stream gauge at Bronxville have increased since the 1940s with increased development in the watershed (USGS, 2005). Recent one-year storm hydrographs show a higher peak and shorter duration than fifty years ago, which means that more runoff is conveyed to the channel over a shorter period of time. Land development has created frequent flashy flows and low ground water recharge. Very little active floodplain or pervious area remains in the watershed of the Bronx River to absorb precipitation and storm runoff.

CHANNEL STABILITY

Goal: To establish or maintain channel stability

Significance and standards

Channel stability refers to the ability of a river system to convey water and sediment from upstream through a reach without excessive sediment deposition or bank erosion. Although rivers are dynamic systems, healthy rivers also maintain a degree of stability. A stable bank is thoroughly rooted by native plants, exhibits stable undercut (overhanging banks), and is dominated by soil or bedrock rather than artificial armor. Signs of bank erosion or channel sedimentation should be interpreted within the context of the local geology as well as where they are found in a reach, within the system, and in relation to other structures.

Excessive bank erosion is indicated by erosion along banks in a straight reach as well as beneath tree roots at the lower bank or outside a river bend. Other indicators of excessive erosion include high banks that cannot be flooded annually, exposed bridge abutments, vertical, eroded, crumbling or sloughing banks, recently exposed tree roots, and the absence of native vegetation rooted along the water line. A bank supporting native vegetation is one that is thoroughly rooted by native plants, exhibits stable undercut or overhanging banks, and is dominated by natural landforms such as soil or bedrock rather than artificial armor (Barbour et al., 1999).

Excessive sedimentation is characterized by the deposition of more material into a channel reach than can be transported out of the reach over time. Sedimentation usually occurs on the downstream side of a bar or on a point bar on the inside of a river bend. If sedimentation occurs across the whole channel, the channel will widen and become shallow. These signs of channel instability occur along a continuum. Indications of bank erosion or channel sedimentation must be interpreted with regard to local geology, position in the stream reach and overall stream system, and proximity to structures.

TABLE IV.3: Conditions and Performance Standards for Channel Stability

Poor	• Few parts of bank support native vegetation • All reaches exhibit excessive sedimentation or erosion • Banks held only by hard points • Channel is straightened or dammed in most reaches
Fair	• Some parts of bank support native vegetation • Most reaches exhibit excessive sedimentation or erosion • Channel is straightened or dammed in some reaches
Good	• Many parts of bank support native vegetation • Few sites exhibit excessive sedimentation or erosion • Few sections of channel are straightened or dammed
Very Good	• Most parts of bank support native vegetation to water line • No signs of excessive sedimentation or erosion • Natural channel configuration

Measurement methods

It is relatively easy to observe and describe stability conditions qualitatively within a reach. Both erosion and sedimentation can also be quantified at a given site using surveying, permanent bench-marks and tools such as erosion pins (Harrelson et al., 1994). The channel width and depth at a given location can be compared to a stable reach on the same river or regional stream widths and

depths at comparable drainage areas as a means of identifying erosion or sedimentation problems. Some of the indicators identified for assessing in-stream habitat (below) can also serve as indicators of channel stability.

Current condition: POOR to FAIR

Conditions vary from poor to fair in the freshwater reaches of the Bronx River. In the very low-gradient reaches, much of the channel has been straightened, banks are often steep and high, the channel bed is covered with fine sediment and frequently re-mobilized, and fine sediment accumulates rapidly on the bars. In the impounded reaches, the number of bars are increasing and the channel is becoming shallower. Banks are largely artificially armored (and therefore stable) in the tidal and estuarine reaches of the Bronx River and are mostly unarmored throughout the freshwater reaches.

IN-STREAM HABITAT

Goal: To conserve and increase in-stream and bank habitat for fish, benthic invertebrates, reptiles and other wildlife

Significance and standards

Excessive erosion and sedimentation, a flashy or urban hydrologic regime, and human activity such as floodplain development and channel straightening and clearing, can reduce or obliterate important channel features. These features include:

- Diffuse flow energy as well as varied flow depth and substrate
- Habitat for algae and micro-organisms (food for invertebrates and fish)
- Shelter for fish and aquatic organisms from direct sunlight
- Areas of refuge from predators and high water flow
- Breeding sites for fish
- Features that serve as markers for territorial or migratory species
- Grade controls on the channel bed to help stabilize banks

Habitat conditions vary depending on location in the river system and which species are of concern. Typical parameters of interest include cover availability (quantity and quality) in the channel, embeddedness (the degree to which the larger substrate on the bed is buried in fine sediment), flow and channel bed variability, riparian vegetation, and degree of bank armoring. One of the more quantifiable parameters in lowland streams for which sufficient data has been collected is the frequency of pools (Scholz and Booth, 2001). Pools are areas of local depressions with a depth (or residual pool depth) significantly deeper than the surrounding streambed. For a stream the size of the Bronx River, pools with residual pool depth greater than 2.5 feet are ideally found every five to seven channel widths in low-gradient, sand-bedded reaches and every three to five channel widths in steep-gradient, cobble-bedded reaches (Leopold, 1964).

Large woody debris (LWD) is another feature that has significance for cover, flow variability and stability that can also be readily quantified (Kaufman and Robinson, 1997; Beechie and Sibley, 1997). The size of wood that will have a structural influence on the channel varies by stream size, but for the Bronx River any piece of wood larger than 10cm in diameter and longer than 1m in length can be considered LWD.

TABLE IV.4: Conditions and Performance Standards for Habitat Features	
Poor	• Few parts of bank support native vegetation • Most parts of bank armored or channelized • Pools absent • LWD absent • Floodplain entirely developed, filled or abandoned
Fair	• Some parts of bank support native vegetation • Many parts bank armored or channelized • Pools rarely present • LWD rarely present • Floodplain partially developed, filled or abandoned
Good	• Many parts of bank support native vegetation • Some parts of bank armored or channelized • Pools sometimes present • LWD sometimes present • Floodplain partially undeveloped, unfilled or active
Very Good	• Most parts of bank support native vegetation • Few parts of bank armored or channelized • Pools present where expected • LWD present where expected • Floodplain predominantly undeveloped and active

Measurement methods

Habitat conditions can be evaluated quantitatively or qualitatively using a number of measures with varying levels of effort. Most measures involve low to moderate effort, but are most effective for describing existing conditions rather than assessing trends or setting priorities. Habitat data that is reliable, species-specific and replicable despite flow and site variability is much more time-consuming to collect and interpret. Information on habitat conditions can also be obtained from the measures discussed under Channel Stability above.

Current condition: POOR to FAIR

Conditions along the Bronx River vary from poor to predominantly fair in the freshwater reaches where there are areas of active, undeveloped floodplain and there is some large wood in the channel and native trees on the banks. In the tidal reaches, conditions are mostly poor due to channel straightening, filled floodplains, bank armor and sparse native vegetation.

RIPARIAN VEGETATION

Goal: To reduce the spread of invasive species and increase populations of native vegetation for improved habitat conditions and storm water retention

Significance and standards

Invasive exotic plants such as Japanese knotweed (*Polygonum cuspadatum*), Oriental bittersweet (*Celastrus orbiculatus*) and other vines are one of the most visible threats to ecological integrity on the Bronx River. Invasive species change the structure of the riparian community, reducing the abundance and diversity of native species and decreasing habitat diversity. Along the Bronx River, invasive species also reduce the number of shade trees over the water, the extent of woody roots that stabilize the bank and the amount of LWD in the river.

A variety of metrics, including the presence or prevalence of rare or sensitive plant species, regeneration of native species and prevalence of invasive species, can be used to evaluate the condition of the vegetation community. Although there are no standards for these metrics, they are often used to evaluate change or trends from a baseline condition or to a specific or assumed reference condition. The presence and distribution of rare plants can help determine the degree of disturbance in an area and whether protection or management approaches are effective. The regeneration of native species, survival of native plantings and presence of invasive species are also important measures of management success and long-term viability of restoration programs. NYS DEC has included in their permit requirements that 85 percent of the native plants installed in a restoration project are alive after five years (Larson, 2006). In addition, increased vegetative cover increases storm water holding capacity of the landscape.

The rationale behind conserving and enhancing the native diversity of plants along the Bronx River is to maximize biological and physical habitat diversity for both the vegetation and the animals it supports. One approach towards this goal is to re-establish native plant community assemblages that were once predominant along the riparian corridor. Because floodplain forests are so variable and diverse, however, a broader emphasis is placed in the Bronx River on native species suited to a floodplain and on the heterogeneous local conditions created by centuries of disturbance, rather than a specific target community composition. In other words, the appropriate vegetation goal for the Bronx River is establishing native floodplain species suitable to local conditions instead of replicating historical plant communities.

The proposed targets are based on attributes commonly monitored at restoration sites. Goals for controlling invasive species still need to be established for individual restoration sites and the entire river corridor. The rankings below should also be refined based on reference sites in the watershed, comparisons to similar, but less impacted rivers, and values in the literature. Finally, realistic expectations for management and maintenance to protect and sustain native plant communities need to be factored into vegetation community goals.

Measures for evaluating health of the vegetative community include:

- Regeneration of native species by seed at the rate necessary for a self-sustaining population (rate of new plants reaching maturity more than or equal to death rate)
- Invasive species regenerating at a slower rate than native species
- Greater abundance and diversity of native aquatic and marine vegetation than currently exist
- Greater abundance of overhanging and submerged riparian vegetation than currently exist

TABLE IV.5: Conditions and Performance Standards for Vegetation	
Poor	• Absence of native tree cover in canopy layer of riparian areas • Absence of native plant cover in shrub and herbaceous layers of riparian areas • Rare or sensitive species absent • No native plant regeneration
Fair	• Some native tree cover in canopy layer of riparian areas • Some native plant cover in shrub and herbaceous layers of riparian areas • Few occurrences of rare or sensitive species • Isolated or inconsistent native plant regeneration
Good	• Abundant native tree cover in canopy layer of riparian areas • Abundant native plant cover in shrub and herbaceous layers of riparian areas • Some occurrences of rare or sensitive species • Consistent native plant regeneration
Very Good	• Mostly native tree cover in canopy layer of riparian areas • Mostly native plant cover in shrub and herbaceous layers of riparian areas • Common occurrence of sensitive species; rare species present as expected • Successful native plant regeneration, with plants at multiple ages

Measurement methods

Vegetation characteristics can be monitored using standard sampling methods depending on the size of the area and the parameter to be assessed. Randomly placed, permanent plots and subplots are typically used in reference sites or in project areas to evaluate the success of plantings, plant response to treatments or changes in control conditions. On a larger scale, mapping (or entitation) can be used to subdivide vegetation into recognizable entities or preliminary types with information such as the dominant species in each vegetation layer.

Current condition: POOR to FAIR

Invasive species currently dominate the vegetative community along the banks of much of the Bronx River and the survival of native plantings is typically less than 85 percent after 5 years. Moreover, there are few rare or sensitive species and native plant regeneration is poor. Although survival rate is low, native vegetation cover is increasing due to the invasive vegetation removal and native planting efforts.

MACROINVERTEBRATES

Goal: To increase the abundance and diversity of invertebrate and pollution-intolerant species in the Bronx River

Significance and standards

Benthic macroinvertebrates comprise a heterogeneous assemblage of animal groups that live in or on stream channel sediments or other bottom substrates in the aquatic environment. They are typically larger than 0.5mm and are primarily aquatic insect larvae, annelids (worms), mollusks, flatworms and crustaceans in freshwater systems or polychaetes, crustaceans and mollusks in estuarine systems. They are extremely useful as monitoring indicators since they are abundant and diverse, not artificially stocked, have short life cycles, are sensitive to subtle changes in water quality, play an important role in food webs, including larger wildlife, and are relatively sedentary. (Fore et al., 1996; Rosenbery and Resh, 1993; Vannote et al., 1980).

The NYS DEC assesses water quality in freshwater riffles using four types of benthic macroinvertebrate analysis: the Hilsenhoff biotic index measures the richness of pollution-sensitive groups (Ephemeroptera, Plecoptera, and Trichoptera), species richness, and the degree of similarity between the observed benthic community and an ideal community (Percent Model Affinity, or PMA). Higher species richness values (indicating increased diversity) and higher proportions of pollution-sensitive species such as mayfly, cadddisfly, stonefly and damselfly are associated with better water quality and less disturbance in the surrounding landscape. The exact values of these indices that are associated with the NYS DEC's water quality ratings vary according to sampling method and habitat type. Therefore, while table IV.6 lists the criteria that apply to samples taken from freshwater riffles using a kick sampling method, different criteria may be more appropriate for data obtained using a different sampling method. Furthermore, PMA is only used as a standard within freshwater riffles. In the name of consistency with the rest of this document the NYS DEC's rating of none impacted, slightly impacted, moderately impacted and severely impacted have been converted respectively to **very good**, **good**, **fair** and **poor**.

TABLE IV.6: Conditions and Performance Standards for Macroinvertebrates*

Poor	• Absence of pollution-sensitive macroinvertebratesand freshwater mussel species
Fair	• Presence of some pollution-sensitive macroinvertebrates and freshwater mussel species • Species richness low
Good	• Presence of many pollution-sensitive macroinvertebrates and freshwater mussel species • Species richness moderate
Very Good	• Presence of most pollution-sensitive macroinvertebrates and freshwater mussel species • Species richness high

*Based on NYS DEC classification of stream invertebrate communities

Measurement methods

Sampling by NRG has used the Hess sampling technique at all sites, but other methods of sampling may be more appropriate, particularly at locations where riffles are scarce and the water is deep. In addition, comparison to state standards would be more straightforward if kick sampling replaced Hess sampling in the future. Regardless of the method chosen, sampling generally requires low effort. On the other hand, the next step after sampling, sorting and identification of benthic invertebrates, requires significantly greater effort and requires the aid of a skilled taxonomist. The amount of effort spent on this step can be reduced considerably if NYS DEC standards are followed and a sub-sample of 100 is analyzed instead of the full sample from each site. In addition to the water quality indices discussed above and in other sections, benthic data can also be used to determine the probable sources of impacts. This can be done both through examination of the species present and by using NYS DEC protocols for Impact Source Determination.

Current condition: FAIR

Macroinvertebrate assessments conducted by the NYS DEC in 1998 and 2003 identified a site within the north Bronx part of the Bronx River as "moderately impacted" (NYS DEC, 2003). The assessment identified point source discharges, high sediment loads and high hydrologic variation as causes of degradation. NRG conducted additional studies near this site and at six other sites closer to the river mouth between 2002 and 2004 (U.S. EPA, 2005). The overall assessment at the seven sites was that the river was "moderately impacted" or in fair condition. However, individual sites varied from borderline moderately/slightly impacted to severely impacted and the major causes of degradation appear to vary along the river.

FISH

Goal: To increase the abundance and diversity of fish and shellfish in the Bronx River

Significance and standards

The fish community provides an integrated indicator of ecological health based on organisms that are affected by multiple environmental factors over their life span. To increase the health and abundance of the fish species already present in the river and to attract new species from upstream, habitats within the river and connectivity between habitats must be restored. Habitat such as floodplains, which are already a restoration priority, not only increase storm water retention in the system, but also provide excellent nursery grounds for fish and optimal environments for many invertebrates (Bayley, 1995). Reconnecting the floodplain with the river would increase fish populations both directly, by restoring nursery grounds, and indirectly, by increasing prey abundance and decreasing hydrologic variability.

The connection between the freshwater and estuarine reaches is also necessary so all fish can freely move up and down the entire river. This would not only increase the health and abundance of diadromous species like river herring (*Alosa pseudoherrengus* and *Alosa aestivalis*), striped bass (*Morone saxatilis*), blue crab (*Callinectes sapidus*), and American eel (*Anguilla rostrata*), which require both aquatic/estuarine and marine habitats to complete their life cycle, but is also necessary for resident species that are currently depleted in part due to habitat fragmentation. Habitat fragmentation reduces the amount of habitat accessible to each individual, limiting options for refugia, prey, and spawning, and divides populations, increasing the chance of extinction for each smaller population and decreasing genetic mixing.

A run of anadromous fish (those that spawn in freshwater and live their adult lives in saltwater) is the only component of the fish community that is obviously missing from the Bronx River. Connectivity would also take advantage of important habitat for the catadromous (spawns at sea and lives its adult life in freshwater) American eel, a species in such serious decline that the Atlantic States Marine Fisheries Commission is considering nominating it for the Endangered Species List (Kritzer, 2005). The eel population, already present in the river, would be expected to increase with improved connectivity.

Targets for the fish community could be based on Indices of Biological Integrity that have been developed since the 1980's and implemented by many states to monitor fish communities and assess the ecological health of rivers (Karr, 1981; NJDEP, 2000). Targets could also be based on the presence and abundance of pollution-sensitive species such as largemouth bass (*Micropterus salmoides*), redfin pickerel (*Esox americanus americanus*), yellow perch (*Perca flavescens*), and creek chub (*Semotilus atromaculatus*). Comparison to fish assemblages in other rivers in the region of similar size, but with less development could also be used. Although declines in species richness, local extirpation of sensitive species and decreases in abundance have been documented in fish communities due to urbanization, these metrics can only be expected to change over a long period as a result of cumulative improvements of habitat restoration and pollution-reduction efforts.

TABLE IV.7: Conditions and Performance Standards for Fish*	
Poor	• Absence of pollution-sensitive fish species • No reaches passable by anadromous fish • Striped bass absent • Public health standards prohibit fish consumption
Fair	• Presence of some pollution-sensitive fish species • Some reaches passable by anadromous fish • Striped bass present, though scarce • Public health standards restrict consumption of eel and crabs
Good	• Presence of many pollution sensitive fish species • Many reaches passable by anadromous fish • Striped present in low numbers • Public health standards restrict consumption of striped bass
Very Good	• Presence of most pollution sensitive fish species • Most reaches passable by anadromous fish • Striped bass abundant • Public health standards allow unrestricted fish consumption

* Based on Index of Biotic Integrity (Karr 1981) modified for New Jersey by NJDEP and personal communication with Joe Rachlin

Measurement methods

Fish surveys can use various tools, such as creel census by interviewing people fishing, spot sampling various sections of the river using baited and unbaited traps, small 4' x 4' or 4' x 10' seine nets with 1/8th to 1/4 inch mesh, and small Fyke net sets deployed for three hours with mouth facing upstream. Larval fish can be sampled using either 500 micron mesh drift or plankton net sets.

In the Federal Channel of the estuary fish are typically sampled by sequential 10 minute tows using a modified shrimp net deployed from the stern end of an appropriate vessel at speeds not to exceed one knot. All sampled fish are identified to species, weighed to the nearest 0.5 gram, measured for standard length (tip of the snout to the end of the hypural plate), counted and released. These data can then be used to assess catch per unit effort, species richness, condition, diversity, and species evenness in addition to the above mentioned indices.

Current condition: FAIR

More than 30 species of fish have been collected in recent surveys, including several pollution-sensitive species (Schmidt and Samaritan, 1984; Larson et al, 2004). The current fish assemblage in the Bronx River, while representative of an urban system, is quite diverse and is similar to that found at Pelham Bay Park, a less degraded area. Although most of the expected species are present, they are found in low abundance.

The predominant species are tolerant of disturbed and polluted environments and the variability in species composition and abundances from year to year indicates system instability. For example, conditions in 2003, including high flows and dredging in the East River, resulted in extremely poor fish sampling results in the estuary, a finding that was very different from previous years (Rachlin, 2005). There are no fish species currently in the river that are ecologically detrimental and must be removed. The invasive common carp is found in such low numbers that it is unlikely to be a problem.

BIRDS

Goal: To increase the abundance and diversity of resident bird species and over-wintering waterfowl in the Bronx River corridor

Significance and standards

Avian community conditions and performance standards are based on the presence of bird species that occur in riparian areas in this region and are sensitive to habitat fragmentation and disturbance. Targets for species richness or species diversity indices could also be developed based on reference sites.

Along much of the Bronx River, the riparian forest is not wide enough to support a typical interior woodland bird community. Increasing the extent of unfragmented forest would be important for these species, but opportunities for reforestation are restricted in this urbanized watershed. An increase in the nesting abundance of sensitive species such as wood ducks (*Aix sponsa*) and pileated woodpecker (*Dryocopus pileatus*) could indicate an improved habitat along the river.

TABLE IV.8: Conditions and Performance Standards for Birds

Poor	• Absence of forest interior and disturbance-sensitive riparian species
Fair	• Few nesting forest interior and disturbance-sensitive riparian species • Species richness low
Good	• Some nesting forest interior and disturbance-sensitive riparian species • Species richness moderate
Very Good	• Many nesting forest interior and disturbance-sensitive riparian species • Species richness high

Measurement Methods

Bird surveys have been conducted by Chad Seewagen on Bronx Zoo property adjacent to the river and point counts conducted by NRG in the Bronx River Forest. Other lists of Bronx River birds have been generated through sightings by Chrissy Word at Drew Garden, the Bronx River Crew, NRG, the Bronx River BioBlitz and others. Although not formal studies, these latter sightings form an important data set of birds that have historically appeared in the Bronx River watershed.

Current condition: FAIR

The current bird community along the Bronx River is representative of an urbanized system. The number of resident species is lower than in less-developed riparian areas and forest interior species and species that are sensitive to habitat degradation are rare. More than 80 species have been observed along the Bronx River corridor throughout the year, but the resident community is dominated by generalist species.

Though described as fair overall with regard to its avian community, the Bronx River's small forest fragments do serve as habitat for breeding pairs of a diverse array of native birds. These species use the Bronx River for the range of habitat that it provides. By protecting existing fragments of habitat, these common species should remain common.