3a Sediment Trapping to Control Coastal Erosion

Strategy

Erosion threatens critical habitat and cultural resources. Although erosion is a natural process, climate change impacts are likely to increase erosion rates. Installing small-scale sediment traps in erosion-prone areas could increase accretion rates and slow erosion. This option considers techniques to address erosion in tidal wetlands and sandy beaches.

Tidal Wetlands

Gateway has used large-scale permeable fabrics (geotextiles) to rebuild wetlands; these techniques have proven successful yet costly (Vadino, 2006). In the Jamaica Bay Watershed Protection Plan (2007), the New York City Department of Environmental Protection (DEP) proposes using sediment-filled biodegradable geotextile tubes filled with sand or dredge material to continue preserving wetlands (DEP, 2009).

Gateway could use small, biodegradable pre-seeded geotextile tubes, as well as filtration enhanced devices (FEDs) to recreate wetland and eroded coast. FEDs are similar to geotextile tubes, but are generally filled with straw instead of sand. This makes FEDs easier to transport and install, but less resistant to wave action. FEDs and geotextile tubes enhance wetland development by increasing accretion rates, slowing erosion and spurring plant colonization. Both of these techniques have proven more useful when pre-seeded or plugged with seedlings; the most common plant for seeding is smooth cordgrass (*Spartina alterniflora*; Marterne, 2006).

Certain strategies can improve sediment traps' success rate, lowering costs. Strategically placing sediment traps reduces labor and capital costs. Using sediment mapping tools or observation can determine optimal locations. Utilizing stone anchors, rather than stakes, can help increase strength, ensuring installations can withstand wave and tidal actions. Using recycled burlap bags made from natural fiber can also reduce costs; fibers such as kenaf or jute may prove more durable (DEP, 2009).

Sandy Beach

Using scrap brushwood can help create erosion barriers around dunes. Partnerships with New York City could potentially provide a low-cost source for materials such as discarded Christmas trees and brush. This technique involves constructing low fences of brush in rows, or shaving and burying portions of Christmas tree trunks in the ground. Sediment builds up until it eventually buries the treetop or brush fence. In washed-out areas, the trees are laid horizontally and the branches cause sediment to deposit. The accumulated sediment provides footholds for re-vegetation. Overtime, the scrap brushwood becomes part of the re-vegetation process, leaving behind nutrients as it decays (EURIS, 2009).

Benefits

- Using natural and biodegradable materials contributes to sustainability.
- Small geotextile and FED tubes are easier to install than large tubes.

Challenges

- Projects may require review from the Army Corps of Engineers and/or the USGS.
- Materials may weather quickly.

3b Strategic Land Acquisition & Partnerships

Strategy
Gateway can expand habitat and buffer zones through strategic land acquisition and partnerships.

Description
Expanding Gateway's buffer zones through strategic land acquisition and partnerships could help relieve some of the pressure on Gateway's ecological resources. Unlike many National Parks, Gateway lacks the necessary buffer zones to lessen the impacts of climate change, particularly sea level rise. Unbounded beaches are able to adapt to storms, waves and currents by going through natural regeneration cycles. However, urban development confines Gateway's coastline (Schlacher, 2007). Small increases in sea levels typically result in increased erosion, decreasing available habitat (Voice, Harvey and Walsh, 2006, 45-46). Purchasing adjoining lands and critical habitat areas, and building partnerships focused on land management and conservation can provide additional buffer space to Gateway's ecosystems and species.

As the current General Management Plan notes, Congress permits acquisition of prime shoreline areas using federal funds (Gateway National Recreation Area, 1979). Many NPS parks have recently proposed legislation to expand their boundaries (Holleman, 2009; Duffy, 2009). Gateway currently has a map of available areas bordering park lands. Gateway could examine any changes to land ownership or availability in the area, update the map, and begin to identify and prioritize those parcels which offer the greatest potential benefits to reduce ecosystem vulnerability. Gateway could then coordinate land acquisitions with partners and with the National Park Service. For natural areas not available for purchase, Gateway can partner with land owners to create conservation programs and corridors between core areas owned by different parties.

Goals
- Lessen coastal habitat loss from sea-level rise.
- Buffer existing park areas, offsetting the effects of fragmentation.
- Expand coastal habitat, allowing for natural coastal migration.
- Link natural areas, aiding species through migration corridors and providing footholds for some species.

Benefits

- Halting development on land adjacent to the park through conservation partnerships.
- Converting marginal land in the New York Harbor area into valuable, usable park space.
- Building upon existing core missions of groups such as Sustainable South Bronx, Hudson River Park Alliance, and Environmental Defense Fund.
- Preserving or reclaiming non-federal lands in coordination with NPS and in support of Gateway needs via non-traditional land partnerships (Hamin, 2001).

Challenges

- Much land available for acquisition is altered and may be degraded requiring expensive restoration.
- Roads and parkways encircle much of Gateway, presenting hard barriers to expansion.
- Adjacent land is either private property or property of New York City. The City may be reluctant to cede developed land to Gateway.
- High land value in New York City area presents high cost of acquisition.
- Acquisition of land not immediately adjoining parkland may present further management and maintenance challenges given limited resources.

Current Efforts

Multiple state and city agencies are currently working to preserve open space in and around Gateway. Two examples include the New York State Open Space Conservation Plan (OSCP) and the Environmental Protection Fund (EPF) Local Waterfront Revitalization Program. The EPF Local Waterfront Revitalization Program goals include:

- Identifying areas in danger of flood impacts.
- Establishing zoning laws to protect these areas from development.
- Aiding local government and non-profit acquisition of priority coastal properties.

The OSCP actively supports climate change adaptation by:

- Facilitating intergovernmental land transfers and connections between urban greenways and parks.
- Developing tools with NYS Department of Transportation (DOT) that aid in integrating aquatic conservation objectives into road planning, which could also benefit in creating corridors.

Gateway could work with OSCP and EPF, as well as other partners, to identify land it wishes to acquire, prioritize lands that the EPF may not conserve on its own, and/or suggest lands for the EPF to protect. See Appendix D. Land Acquisition & Partnerships for a list of potential organizational partners.

3C Increasing Habitat Connectivity

Strategy

Increasing connectivity in Gateway through wildlife corridors can assist wildlife in adapting to climate change. Gateway can focus on both increasing connectivity within the park and identifying partners to increase regional connectivity.

Description

Wildlife corridors are strips of land linking intact patches of core habitat to one another. Corridors allow plant and animal species to travel between habitat patches, assisting gene flow and new site colonization (Primack, 2004). Wildlife corridors should be robust in order to buffer climatic impacts and provide sufficient habitat for species survival (BRANCH, 2007).

Developing successful corridors programs typically involves:

- Planting diverse vegetation to provide shelter and food for animals.
- Restoring core habitat, as corridors cannot substitute for core habitats.
- Selecting indicator species that share characteristics with many other species moving through the corridor.
- Monitoring new colonization to measure the corridor's effectiveness (Queensland, 2002, p. 16-17).

Goals

This strategy can help species adapt to climate change impacts including:

- Range shifts due to temperature and precipitation changes.
- Habitat alteration as a result of sea level rise.
- Combined effects from climate change impacts and anthropogenic habitat fragmentation and deterioration.

Within Gateway, managers can evaluate the current use of available land to identify potential areas where habitat connectivity could be increased. While there is not a lot of unused land at Gateway, corridors can be creatively developed along roads or through other developed areas. In Gateway, the species that are likely to become isolated include turtles and amphibians. Even species with low mobility, such as salamanders, are able to use natural corridors, such as wet fissures, during severe droughts to reach other suitable habitats. Human-made corridors that provide suitable habitat are likely to be effective in supporting species' adaptation under climate change (Tumlison et al., 1997). Wildlife corridors can ease movement of Gateway's reptiles and amphibians by providing critical habitat connections.

Benefits

- Enhancing genetic diversity, thereby increasing species resilience.
- Preventing species isolation as habitat space decreases and becomes fragmented.
- Increasing food availability.
- Assisting low mobility and extremely climate sensitive species.
- Providing natural spaces and easing animal sightings for park visitors.

Challenges

- Requires monitoring the movement of species throughout the park.
- Determining whether movements are due to climate change or other factors will be difficult.
- Expanding corridors and habitat connectivity beyond Gateway boundaries will be crucial for long-term species migration but is dependent on the participation of other land-holding organizations.

In the long term, climate change will force species to migrate beyond the boundaries of Gateway. Because the heavily developed landscape surrounding Gateway does not allow for easy migration through the region, habitat connectivity outside of Gateway is a major challenge. While Gateway cannot influence the potential corridors outside of the park, it can consider partnering with other public and private organizations to try to increase regional habitat connectivity or promote the protection of lands that do or could serve as corridors (see Adaptation Strategy 3b. Strategic Land Acquisition & Partnerships).

3d Improving Water Quality

Strategy

Gateway could establish a water quality program in conjunction with its long term climate change planning initiatives, with a focus on Jamaica Bay. Water quality relates to climate change adaptation because poor water quality reduces ecosystem resilience. Climate change will also worsen the drivers behind water quality problems at the park.

Description

Pollution is the major source of water quality problems at Gateway. Gateway can address pollution in three ways: reducing pollution within the park, working with New York to reduce external pollution and implementing projects to improve the water quality.

1. Reducing Pollution within the Park

To address water quality internally, Gateway could focus on decreasing runoff from paved surfaces within park boundaries. Precipitation runoff from paved surfaces carries pollutants such as heavy metals, chemicals and motor oil into open water sources (EPA, 2008). Creating vegetation buffer zones that slow water and collect polluted sediments before they reach the Bay can help reduce runoff from the many paved surfaces in and around Gateway. Where buffer strips are not an option, Gateway could consider infrastructure changes such as pervious pavements on parking lots. This pavement allows water to flow into the ground (Hirschman et al., 2007). Areas where Gateway can focus to reduce runoff include the parking lot near Jacob Riis Beach and Canarsie Pier. Gateway can also consider partnering with landowners adjacent to the Bay to reduce runoff, including the US Coast Guard, US Navy Reserve and JFK Airport.

Benefits

- Gateway can improve corridors within park boundaries, or can attempt to involve outside partners.
- Buffer strips that slow and filter runoff might also serve as habitat.

Challenges

- Many areas where buffer strips might be most useful are outside of NPS jurisdiction.
- Replacing concrete with pervious pavement can be expensive.

2. Reducing External Water Quality Problems

Nitrogen pollution from the New York City wastewater system is a second target area to reduce water quality problems. Approximately 70% of New York's sewer network is part of a Combined Sewage Overflow (CSO) system that frequently discharges untreated waste into Jamaica Bay (NYC DEP, 2007). The Bay relies on treated wastewater effluent for freshwater, but excessive nutrients in untreated water undermine efforts to restore the Bay. The Jamaica Bay task force is currently working with New York to address nitrogen pollution. Gateway could bring a new focus to this partnership, emphasizing how sewage overflows into the Bay are also a climate change issue because:

- Climate change will likely cause an increase in extreme precipitation events, exacerbating the current wastewater overflow problem.

- Nitrogen pollution could decrease the success of other climate change adaptation measures.
- Temperature increases could increase the likelihood and size of algae blooms, worsening eutrophication events.

Benefits	Challenges
• The relationship between Gateway and the New York is already established. • Reducing nitrogen pollution will have significant benefits to ecosystems.	• The scale and cost of reducing sewage overflow makes progress difficult and unlikely to occur quickly.

3. Implementing Projects to Improve Water Quality

In addition to reducing water pollution, Gateway can take actions to remedy some of the existing pollution. One option is restoring oyster beds in Jamaica Bay. Oysters naturally filter water sediment and micro-algae, and eastern oysters (*Crassostrea virginica*) are native to New York's waters (see Box 14. The Importance of Oysters). Gateway is currently exploring options for eastern oyster restoration in Jamaica Bay (Frame, 2008); these projects can be continued as part of a climate change adaptation strategy.

Benefits	Challenges
• Gateway may act internally or work with partners such as the NY/NJ Baykeepers. • Oysters also provide food for other aquatic species (Frame, 2008).	• Diseases limited past restoration projects and will likely threaten future attempts (Frame, 2008). • Large-scale oyster bed projects might maximize filtration capacity, but could be considered aquaculture which is contrary to NPS policy.

Box 14. The Importance of Oysters

Oyster reefs extended 350 miles from Sandy Hook northward when Henry Hudson first arrived in 1609, but populations declined dramatically around the turn of the 19th Century due to overharvesting, pollution, disease and siltation (NY/NJ Baykeeper, 2005). Oysters are keystone species that cleanse the water. Oysters, such as the native eastern oyster (*Crassostrea virginica*), play a vital role in maintaining a healthy estuary ecosystem. The New York Department of Environmental Protection (2007) notes that a single mature oyster can filter approximately 2.5 gallons of water per hour (35 gallons a day) and can remove approximately 20% of the nitrogen it consumes.

Oysters grow in colonies forming reefs, which provides important habitat for fish and other aquatic species. Oysters provide habitat for biofoulers, which cling to the hard shells of oysters or surrounding substrate to make up a uniquely rich microecosystem (Raj, 2008). The realization that oysters are vital to ecosystem function has led to a series of oyster restoration programs. In 2005, volunteers with the New York/New Jersey Baykeeper participated in oyster gardening, using remote sensing to restore oyster populations near the Sandy Hook Unit. The Department of Environmental Protection has also implemented the Oyster and Eel Grass Restoration Pilot Study (DEP, 2007).

3e Adaptive Restoration

Strategy

Gateway is currently implementing salt marsh restoration projects. Climate change will further damage salt marsh habitat; as a result, restoration is a major adaptation effort. In addition to current projects, Gateway can consider focusing on several smaller, modular projects. The smaller sites are essentially tests sites to attempt a variety of techniques, in order to understand best practices.

Description

Climate change will make Gateway's ecosystems, particularly salt marshes, increasingly vulnerable. Salt marshes provide a wide range of environmental services, including water filtration, storm surge protection and critical habitat. Salt marshes are one of the most difficult ecosystems to protect in the face of climate change for many reasons:

- Salt marsh is highly vulnerable to sea level rise.
- Nitrogen loading and turbidity hinder salt marsh vegetation development.
- Salt marsh is already disappearing and is difficult to recreate once lost.

Salt marsh is integral to coastal adaptation. Without maintaining salt marsh ecosystems, protecting many species that inhabit Gateway, either permanently or during migration, may be impossible. In the face of human stressors and sea level rise, Gateway's inter-tidal wetlands will vanish by 2025 without drastic human intervention (Lloyd, 2006).

In partnership with USACE, NYCDEP and NYDEC, Gateway has restored 40 acres of salt marsh at Elders Point East using dredge material. Gateway is duplicating this successful project to restore 25 acres at Elders Point West and 30 acres at Yellow Bar Hassock. Given the rapid rate of salt marsh loss, totaling 63% since 1951, these projects are essential for maintaining this critical habitat but may not be able to keep up with loss (Gateway et at., 2007).

An option for Gateway as they continue salt marsh restoration in the future is an adaptive restoration, taking the following approach to uncover best practices:

- Creating small, test project sites to pilot different techniques.
- Inter-planting a variety of native species to improve mature wetland habitat formation.
- Monitoring and recording how and why different methods work to improve future projects' success.
- Using larger upfront costs to decrease costs in the long term, when projects are expanded.
- Collaborating with other restoration projects to understand new techniques and best practices (Zedler, 2003).

Benefits

- Building upon previous success; past projects indicate that this is a feasible option for adapting to climate change.
- Decreasing costs through best practice utilization.
- Preserving salt marsh not only improves habitat but is also a more cost-effective barrier to storm events than "hard" engineered solutions.

Challenges

- Increasing maintenance costs due to sea level rise acceleration if more efficient restoration techniques are not found.
- Restoring sites may eventually prove futile due to sea level rise and other stressors.
- Funding may become more difficulut to access since project funding often require a life span of 30 years (USEPA, 2009).

4a Protecting Cultural Resources

Strategy
Physically reinforce cultural resources to protect them against sea level rise, saltwater incursion, and erosion. Where reinforcements are impractical, consider relocation.

Description
Climate change threatens the long-term viability of some of Gateway's important cultural resources through increases in erosion, saltwater incursion, and sea level rise. Unlike the 'soft approaches' available for ecosystem adaptation, cultural resources may require hard, or more engineering-intensive, solutions such as building sea walls and protecting buildings from increased weathering through building alterations.

In some cases, historic buildings and objects may need to be moved to higher ground. As in adaptation planning for ecosystems, adaptation planning for cultural and recreational resources may require new management strategies, and will depend heavily on physical adaptation of landscapes and structures. In addition, implementing hard approaches will likely vary from unit to unit at Gateway, since the cultural resources are quite different from site to site. Any changes must be in collaboration with the State Historic Preservation Officers in New York and New Jersey. For further information on non-climate factors affecting this approach, it may be helpful to consult two Department of the Interior publications: Moving Historic Buildings, by John Obed Curtis (1991) and the Historic Lighthouse Preservation Handbook (1997).

Goals
- Provide long-term physical protection for threatened cultural resources.
- Identify those resources most at-risk to changes in climate and sea level.
- Prioritize cultural resources requiring relocation.
- Identify potential sites for receiving relocated structures and landmarks.
- Avoid long-term recurring costs from insufficient soft measures (Schneiderman, 2003, 215-216).

Benefits
- Providing long-term physical protection of important historical and cultural landmarks. Properly planned and executed projects could last hundreds of years.

Challenges
- Requiring significant financial resources and long-term budgeting, planning and construction.
- Identifying suitable sites for relocating cultural buildings. Parkland is already at a premium; most potential sites will present some disadvantages.
- Significantly impacting the environment at both the new and old sites.

1. Sandy Hook Unit

From an adaptation perspective, maintaining Officer's Row may require relocating buildings or erecting sea walls. In the near-term, erosion control measures described previously can help slow the impacts of sea level rise. Documenting Fort Hancock, including its batteries, may be the only way to provide a historical record of these resources; full physical protection of the site may not be possible given the high cost. At this point, many of the guns and historic components associated with Fort Hancock have already been moved from the site; this may need to continue into the future.

A second possibility is to consider some of the harder options mentioned in Maryland Shorelines Online (2009). Projects in and around the Chesapeake Bay employ artificial barrier reefs and oyster reefs and shoreline sills to slow water energy impacting beach areas, thereby slowing erosion. Similar measures could be adopted off of Sandy Hook or Rockaway point. Artificial reefs offer additional benefits as aids to marine ecosystem development (Urbina, 2008).

2. Staten Island Unit

From an adaptation perspective, Battery Weed's sea walls could be improved, but this strategy is likely limited. Given current projected sea level rise within the next 40-90 years, this fortification is likely to face increasing inundation (see Figure 6. Elevation for Cultural Resources). Moving Battery Weed would be very expensive and logistically challenging. More feasible options would include careful documentation of the Battery or removal of a small section of the structure for preservation. Given the Battery's sturdy construction, it is also possible to leave it as is, and dedicate it as a monument to measure and teach sea level rise, as noted in the "Documenting Resources" option. The Battery would likely survive sustained saltwater incursion, and could be viewed from above as waters rise.

At Miller Field, sea walls could prevent erosion and guard against sea level rise. Since most of Miller Field is grassy land used for sports and recreation, there is also the potential for increasing the actual height of the area by adding more land. Due to the high costs associated with these measures, adopting soft erosion controls may present more economically viable options. Storm damage to Miller Field, while costly, can be repaired relatively simply, thus favoring the employment of softer measures.

3. Jamaica Bay Unit

Floyd Bennett Field faces similar problems of coastal erosion and sea level rise. It would be harder to re-elevate this field, due to historic buildings and runways as well as the grassland habitat. Efforts to protect against sea level rise and erosion are already being implemented. Gateway should consider incorporating sea level rise projections into planning long-term solutions for the field's waterfront.

4b Documenting Resources & Climate Change Education

Strategy

Gateway could design educational programs and tours in impacted sites to illustrate climate change impacts and inform visitors about actions they can take to mitigate climate change.

Description

In areas where Gateway can not feasibly protect resources from climate change impacts the park could create "living museums" as examples of local climate change effects. First-hand observations may provide a meaningful and intense exhibit of climate change and other synergistic stressors on the park. This may encourage visitors to make changes in their lifestyle, helping to reduce emissions.

An example site for this type of educational tourism is Battery Weed, where the original sea-wall and lower portions of the waterfront exterior are already threatened by rising sea levels, erosion and other factors. Adaptation options to preserve the Battery may be too costly, leaving it vulnerable to the rising sea.

In the development of this option, historical sites may play an important role as they are a significant cultural resource for Gateway. However, this idea is also applicable to natural resources. Gateway could document and share species and ecosystems that may no longer exist at Gateway in the future.

In order to educate visitors, Gateway could create an exhibit at the park devoted to climate change. This could help raise awareness on local climate change, and could be a destination for school field trips. The exhibit could include:

- Explanations of why climate change is occurring, how species react and Gateway's adaptation and mitigation efforts.
- Maps and photographs documenting changes around the park including "before and after photographs" of original sites.
- A display of past and present species occupying Gateway's ecosystems.
- Ideas to help households and individuals help fight climate change.

Benefits

- Extending Gateway's climate change adaptation initiatives beyond the park through educational programs.
- Using funds more effectively through targeted adaptation.
- Ensuring preservation through documentation and display.

Challenges

- Making the difficult decision that a resource or species can not be saved.
- The NPS may not consider this adequately fulfilling the obligations under the Organic Act.