6 Adapting to Climate Change at Gateway

As the previous sections illustrate, climate change could severely impact Gateway's ecological and cultural resources. Moreover, Section 5 highlights Gateway's authority and mandate to incorporate climate adaptation into its management of park resources. The following section will outline a number of strategies that Gateway management could adopt to lessen the severity of climate change impacts.

Climate adaptation, although defined variously by different organizations (see Box 12. Defining Adaptation), generally encompasses three concepts:

- Responsiveness to climate change rather than an attempt to lessen climatic changes.
- Responsiveness to both observed changes and expected changes that are projected yet uncertain.
- Both reactive and preventive measures; actions may try to repair climate change damage or prevent potential future damages.

Any adaptation strategy that Gateway chooses to implement will require normal management procedures undertaken in any park program: from project development to program implementation, and monitoring results. The options we outline here focus primarily on program implementation. Conceptual Model 5 displays the planning and implementation process involved in developing an adaptation project. The operational approaches show categories of adaptation approaches that could be used.

Adaptation Options

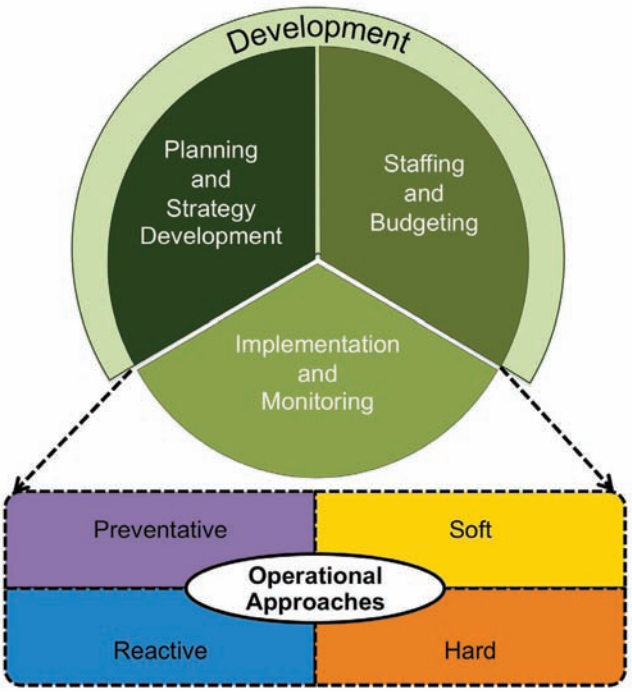
To craft adaptation options for Gateway, we drew upon existing adaptation strategies in the US and abroad (see Appendix C. Global Overview of Adaptation Strategies). We used this information in conjunction with Gateway's existing management strategies and guiding legislation to propose climate change adaptation initiatives.

The adaptation options outlined below constitute an initial framework for forming a complete climate change adaptation strategy at Gateway. These options may form individual elements of such a strategy, or serve to inspire

Box 12. Defining Adaptation

To understand the principles guiding climate change adaptation, it is helpful to examine how relevant institutions define 'adaptation':

- **The United Nations Framework Convention on Climate Change (UNFCCC):** "Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects" (UNFCCC online glossary).
- **The Intergovernmental Panel on Climate Change (IPCC):** "Actual adjustments, or changes in decision environments, which might ultimately enhance resilience or reduce vulnerability to observed or expected changes in climate" (Adger et al., 2007, p. 720).
- **The US Climate Change Science Program and the Subcommittee on Global Change Research:** "Planned adaptation [···] refers to strategies adopted by society to manage systems based on an awareness that conditions are about to change or have changed, such that action is required to meet management goals" (Baron et al., 2008, p. 1).



Conceptual Model 5. Developing an Adaptation Strategy

This report describes the implementation and monitoring elements of climate change planning. These operational approaches are categorized as hard, soft, preventative or reactive.

Hard approaches are engineering-intensive solutions that have a permanent, engineering component. These approaches require more administrative and budgetary resources than soft approaches, which are less technical and often entail strengthening a natural system. Preventative operations are intended to protect against climate change impacts before they are observed, while reactive operations are designed to ameliorate adverse ecosystem responses that are already occurring.

other adaptation projects. Overall, these options address a wide variety of possible adaptation strategies. The strategies identified below address crosscutting climate impacts throughout the park as well as specific impacts on individual ecosystems.

Each of the following options attempts to address the climate change impacts that make park resources vulnerable (see Sections 3 & 4. Climate Change Impacts). In order to logically connect this section to the previous, each strategy is categorized by major combined effect. The options address each combined effect, aiming to reduce impacts (see Conceptual Model 6. Adaptation Options). Addressing each one of these stressors will prove crucial to adapting park resources to furthest extent possible. The strategies are:

Park-wide Capacity Building for Climate Adaptation:

- Long-range Ecosystem Planning
- Task Force to Monitor Sea Level Rise

Reducing Changes in Species Composition:

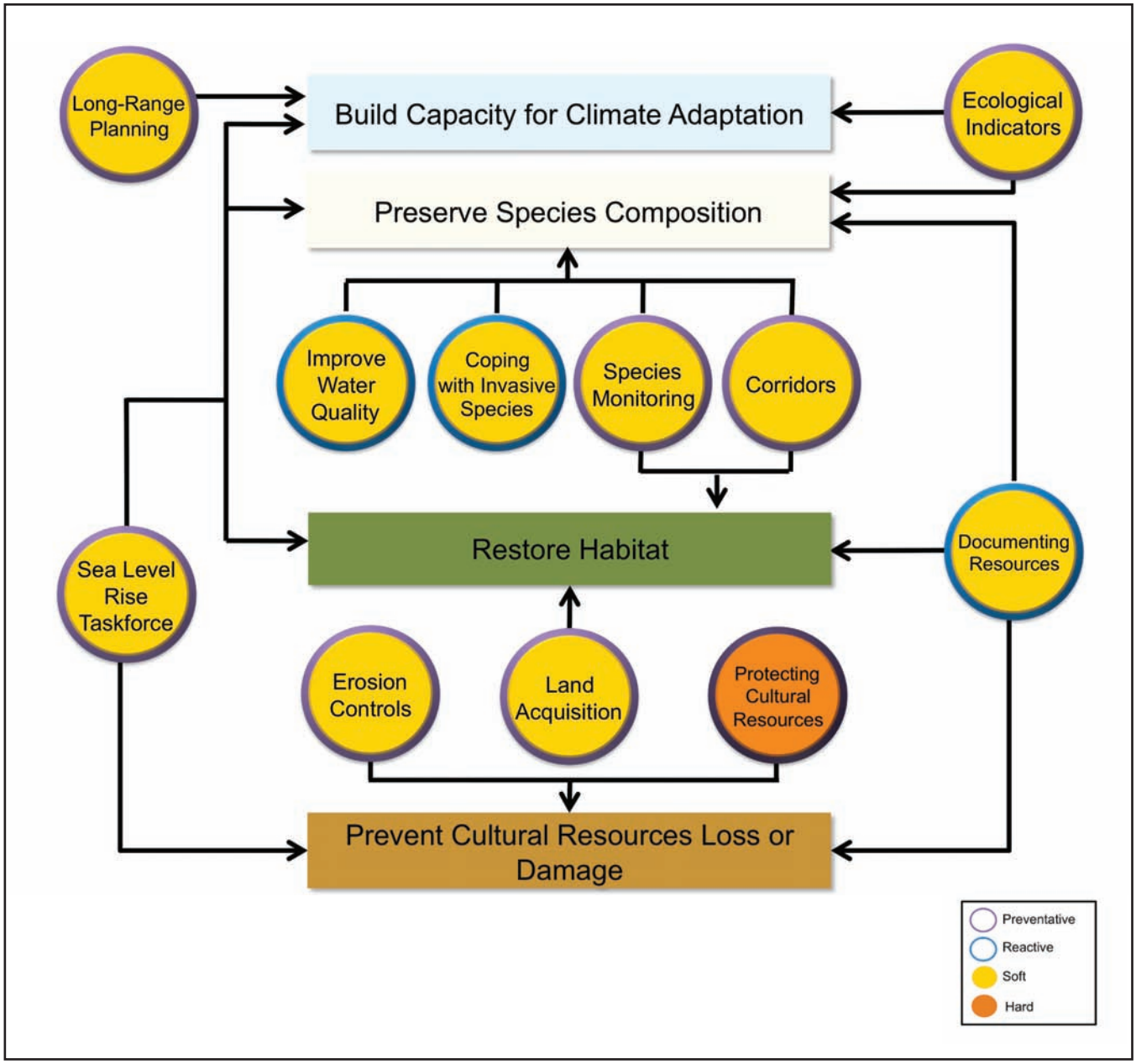
- Ecological Indicators to Monitor Climate Change Impacts
- Keystone Species Monitoring and Management; Horseshoe Crab
- Coping with Invasive Species and Range Shifts

Reducing Habitat Loss:

- Sediment Trapping to Control Coastal Erosion
- Strategic Land Acquisition & Partnerships
- Increasing Habitat Connectivity with Corridors
- Reducing Nitrogen Loading
- Adaptive Restoration

Reducing Cultural Resource Damage and Loss:

- Protecting Cultural Resources
- Documenting Resources & Climate Change Education



Conceptual Model 6. Proposed Adaptation Strategies

The adaptation strategies we have developed for Gateway are designed to direct park-wide management towards climate change adaptation, preserve species composition, restore habitat loss, and prevent cultural resources from loss or damage. The adaptation strategies are described as hard, soft, preventative and reactive. While the options are organized by the topic they most closely address, the model shows how most options can influence multiple aspects of climate change adaptation.

1a Long-range Ecosystem Planning

Strategy

In order to effectively prepare for climate change, Gateway should consider incorporating climate change mitigation and adaptation into all long-range planning decisions.

Description

Climate change impacts will increase in severity over time. Therefore, climate change planning should occur on a long-term timescale. The 2009 General Management Plan is an opportunity for Gateway to ensure that climate change is a core component of all long-term planning decisions across the park. Management decisions could take into account IPCC predictions and new climate science when making priorities and developing projects across all park units.

Gateway could require all new park projects to consider incorporating both climate change mitigation and adaptation strategies in the planning phase, including projects not responding directly to climate change. Within all initiatives, Gateway can look for opportunities to lessen GHG emissions, to educate visitors about climate change, or implement adaptation, buffering resources against future climate change impacts.

Along with long-term adaptation planning, Gateway can be a leader in climate change mitigation efforts. To set an example for other NPS units and visitors, Gateway can strive to adopt climate-friendly practices in park operations. Gateway can target:

- ***Building practices:*** Gateway can continue to incorporate Leadership in Energy and Environmental Design (LEED) certification into its construction and renovation plans, as exemplified by the Jamaica Bay Visitor Contact Station.
- ***Vehicle improvements:*** Gateway can pledge to replace old vehicles with hybrid or alternative fuel vehicles.
- ***Carbon sequestration:*** Gateway can preserve vegetation, possibly creating a net carbon sink; however this depends on many factors, including decomposition.
- ***Eco-friendly products:*** Gateway can supply its offices, visitor centers, cafeterias and other facilities with products containing recycled and biodegradable content.

Incorporating climate change into all park actions will ensure that Gateway is able to make informed investments and management decisions, fulfilling its long-term goals, continuing to protect park resources and serving visitors even as it responds to climatic changes. Considering climate change in all planning is in line with the 16 January 2009 Secretarial Order on Climate Change (see Box 11. Secretarial Order no. 3326A1).

Benefits

- Coordinating with the DOI offices established by the Secretarial Order.
- Building capacity to respond to future impacts proactively.

Challenges

- Incorporating climate change into all park operations will require additional coordination, staffing and research.
- Allocating funds based on uncertain future conditions may be controversial.

1b Task Force to Monitor Sea Level Rise

Strategy

Gateway could create and implement a Sea Level Rise Adaptation Strategy presided over by a Sea Level Rise Adaptation Task Force. Focusing on sea-level rise could help Gateway adopt adaptive management practices to continuously monitor, plan, and manage climate change adaptation.

Description

While gradual sea level rise contributes to habitat loss, the greatest damage from extremely high sea levels will be to cultural resources and infrastructure (Bindoff et al., 2007, 414). Gateway or the broader Northeast Coastal and Barrier Network, a monitoring and inventorying program within the NPS, could identify a team of employees who would remain up-to-date on potential sea level rise conditions and their likely effects on the region. This team would meet regularly to review climate change monitoring information, discuss impacts and oversee adaptation planning. In addition, this team would develop a Sea Level Rise Adaptation Strategy, identifying specific sea level rise threats and adaptation measures, including specific timelines to deal with these threats.

This strategy would help Gateway adapt to climate change impacts through:

- Periodic revisions of predictions on expected sea level rise.
- Monitoring storm and tidal surge impacts from nor'easters and hurricanes as their impacts will likely result in more significant damage.
- Engage in analysis of threats to both ecosystems and cultural resources.

A team responsible for the continuous study of sea level rise could serve to revise the adaptation strategy when necessary. This decision informs all other planning decisions and could operate through a combination of National and State parks and other bodies with vested interest. Melbourne, Australia is one example of a city that includes the task force model in its adaptation planning (Maunsell Sustralia Pty, Ltd, 2008, 78-83). Key components of their plan suggest that an effective strategy should:

- Begin active planning immediately with ongoing planning in the future.
- Develop suitable planning guidelines for different sea levels based on model results.
- Model the altered flood risk and impacts to coastal infrastructure.
- Establish a strategy to communicate adaptation decisions to stakeholders.
- Identify appropriate adaptation measures for distinct geographic areas or features.

A Sea Level Rise Adaptation Task Force could aid other plans for adaptation measures throughout the park and with other invested bodies. Establishing a dedicated team in the near future to address this encroaching issue will help Gateway lessen or even avoid significant long-term risks and costs.

Benefits

- Providing a framework for adaptive management and decision-making in response to new information on sea level rise (Maunsell Sustralia Pty, Ltd, 2008, 78).
- Establishing a forum for discussing current knowledge about climate change and impacts.
- Integrating climate change adaptation across multiple parks' departments.
- Requiring minimal additional funding.

Challenges

- Adding to existing staff's workload beyond capacity.
- Requiring additional technical knowledge which current staff members may not possess.
- Focusing too heavily on sea level rise, possibly to the exclusion of other climate change impacts.

2a Ecological Indicators to Monitor Climate Change Impacts

Strategy

Gateway could devise and implement a monitoring system that accurately identifies climate change impacts within the park, a prerequisite for an effective response to these changes. Utilizing existing or new datasets could establish this new monitoring system.

Establishing baseline climate information and tracking future measurements would allow Gateway management to identify deviations from normal readings, as well as their statistical relevance. Creating a monitoring network across the park would also provide better information to decision-makers, allowing for adaptive management.

Description

First, critical indictors could be identified. The Northeast Coastal and Barrier Network, an NPS monitoring program, currently monitors "vital signs" to track ecosystem health. The concept of ecological indicators is similar, but would specifically measure climate change impacts; indicators from this program could be adapted or filtered through a climatic change lens.

For example, Pukaskwa National Park in Canada, along Lake Superior, uses specific ecological indicators to monitor climate change. Pukaskwa's park biologists selected ten ecological indicators, including songbirds, several rare plants, caribou and, more broadly, forest health to monitor the park's health (Taylor et al., 2006, 69). While climate change adaptation plans typically include water and air temperature as indicators, using key species or ecosystems as biological climate change indicators offers an innovative and useful approach for parks.

The second step in setting up this program is identifying the necessary information Gateway is already collecting through other monitoring programs and understanding what data is missing. Gateway can begin to populate the climate change indicator datasets with existing data while beginning to collect new data as necessary.

The final step in creating an ecosystem indicator program is database analysis. Once the relevant data is collected in an indicator database, managers can use this information to track climate change impacts at Gateway. Creating a scoring tool to understand and track climate change impacts may prove useful in understanding different ecosystem impacts. Descriptions would accompany the score to add context for the rating. For instance, average monthly sea level could be used as an example indicator:

- Current levels could be given a 'green' level.
- An increase of 15 cm might trigger an "alert, area subject to flooding during storms or high seas."
- A further increase to 40 cm might trigger an alert level of "danger, coastal erosion ongoing, infrastructure threatened during storms."

Benefits

- Building upon preexisting information.
- Improving decision-making.
- Offering a starting point for interactive dialogue with other parks in the Northeast.
- Offering a platform for regional collaboration on climate change monitoring with neighboring organizations and stakeholders.
- Aiding parks in the Northeast region in planning for climate change impacts.

Challenges

- Picking the right biological indicators could be difficult.
- Gathering the data could be time consuming and expensive.
- Managing extensive data could require specialized personnel.
- Discerning which changes are meaningful could be ambiguous.

Proposed Monitoring Network

We recommend Gateway consider selecting indicator species for a proposed climate change monitoring network. Initial ideas for possible indicators are listed below.

Possible Abiotic Indicators

1) Water levels: A successful monitoring network at Gateway could include tracking data from the following NOAA tidal stations:

- The Battery, Station ID 8518750
- Sandy Hook, Station ID 8531680
- Bergen Point West Reach, Station ID 8519483

This data can be used to track water levels over time. Due to the high potential for storm damage, Gateway should also consider monitoring average high water levels (see Appendix A. Water Levels at Sandy Hook).

2) Water temperature: Some aquatic species are particularly sensitive to changes in water temperature. Tracking temperature, particularly in Jamaica Bay, would alert park staff to anomalies. Currently installed monitoring systems do not sufficiently track temperatures in Jamaica Bay and around Sandy Hook.

3) Air temperature: Temperature data stations at sites adjacent to known temperature-sensitive species would enable park staff to compare changes in species behavior with recorded air temperatures. Current systems focus on either weather information or a specific species and lack an integrated systems approach.

Possible biotic indicators:

1) **American eel:** This is the only fish found in Jamaica Bay that lives in freshwater but moves to saltwater in order to breed. Despite declining numbers in North American waters, their ease of identification by amateurs make them convenient indicators (Waldman, 2008). Eels are sensitive to climatic changes, specifically the strength and position of the Gulf Stream which transports young eels (Wirth, 2003). Eels may also be subject to environmental sex determination (see Box 13. Environmental Sex Determination & Climate Change; Waldman, 2008). Monitoring and analysis of eel gender and eel biology in the Jamaica Bay watershed could provide critical information on the significance of changes in water temperature in the bay and in the Atlantic Ocean.

2) **American horseshoe crab:** These crabs play a critical role in the food chain, as their eggs are important dietary components for migratory birds (Waldman, 2008). Understanding if their reproduction period is shifting due to climatic changes is critical information for Gateway management. Horseshoe crabs could prove an important climate change indicator if, for example, warmer water temperatures lead crabs to lay eggs earlier during full and new moon tides.

3) **Monarch butterfly:** Monarch butterflies exhibit particular sensitivity to temperature. In a dramatic and well-known event, monarch butterflies migrate through Jamaica Bay in autumn (Waldman, 2008). Geographic or temporal shifts in migration patterns could indicate changes in climate.

4) **Migratory birds:** Gateway could track the arrival and departure dates of key bird species to better identify changes in climate. Ideal bird species include those common to Jamaica Bay, well-documented in historical records and easily recognizable. Linking this data to horseshoe crab information could help uncover whether mistimings (phenological asynchrony) are occurring. Two suggested species are:

- Common tern: A migratory shorebird which occupies seven colonies totaling more than 1000 individuals in Jamaica Bay (Waldman, 2008).
- Barn swallow: The most numerous neotropical migrant (Waldman, 2008).

5) **Mosquitoes:** Indicators could include species not currently existing within Gateway. New species typically found south of Gateway could indicate a warming climate, possibly forecasting species range shifts. Howard Ginsberg, an entomologist, surveyed Gateway in 2001 and did not find a specific mosquito species in the park (*Anopheles atropos;* Lussier et al. 2006). This species thrives in coastal salt marsh and rock pools in the south; Maryland is the current northern extent. Dr. Ginsberg notes that, if this species was recorded in Gateway, climate change could be a contributing factor (H. Ginsberg, personal communication, 27 March 2009).

Box 13. Environmental Sex Determination & Climate Change

Some species do not undergo sex determination until after conception; these species are at greater risk of extinction, because environmental factors such as temperature and humidity influence the sex of the offspring (Hulin et al., 2009). Climate change increases vulnerability in these populations, disrupting sex ratios in offspring.

Fish and reptiles are temperature-dependent sex determination (TSD) species, since external temperatures determine the sex of the embryo. For turtles, low temperatures produce males and high temperatures produce females (Hulin et al., 2009). Gateway supports a wide array of fish species and the endangered diamondback terrapin; warmer temperatures can potentially alter sex ratios and reduce population growth in these species.

2b Keystone Species Monitoring and Management; Horseshoe Crab

Strategy

Gateway is home to a rich number of ecosystems, with complex food webs. Keystone species, which maintain other species, may be especially important to monitor for responses to changing climate conditions, to prevent loss or extinction in other populations. Gateway may consider continuing to monitor the horseshoe crab, due to its central importance in the park's food web.

Description

Gateway collects data on many species within its boundaries. Gateway could use new and existing monitoring programs to track keystone species' responses to climate change, protecting them from adverse affects. For instance, a Horseshoe Crab Monitoring and Management program could build upon the NPS' current program by continuing to utilize GIS to periodically track and map horsehoe crab population densities. Migratory bird species dependent on horseshoe crab eggs could be identified and monitored in order to analyze the relationships between the horseshoe crab and these charismatic populations. Specifically, migratory birds' weight gain could be monitored to establish whether the birds are gaining sufficient fat reserves to complete migration (Mizrahi, 2006). If horseshoe crab populations do not rebound to appropriate levels, the program could also investigate captive breeding programs and expanding sandy beach habitats.

The program could include provisions to prevent crab harvesting and maintain suitable horseshoe crab populations. Until the spring of 2008, the horseshoe crab harvest quota for New York was approximately 350,000 individuals per year; this quota was voluntary. Starting in February 2009, however, the quota became fully enforced within Gateway.

Goals

Researchers have observed declines in horseshoe crab abundance at Gateway (Sclafani, 2006). Climate change will likely cause horseshoe crab populations to decline more rapidly in the future, through damaged salt marsh and tidal flat habitats. Monitoring and managing these populations would help maintain horseshoe crab populations, as well as the species that depend on them, preserving this species as a key component of Gateway's Jamaica Bay ecosystem.

Benefits

- Protecting an endangered species that depend on critical food sources.
- Interacting with existing data collection activities.
- Using student volunteers can decrease costs.

Challenges

- Challenging enforcement due do staffing and budgetary limitations.

2c Coping with Invasive Species and Species Range Shifts

Strategy

Establish a research, monitoring and control program, in coordination with partners, to cope with species range shifts and invasive species under climate change.

Description

Gateway will need to plan and respond to species range shifts due to changing climatic conditions. A rise in mean minimum temperatures will assist the northward expansion of many species (Parmesan et al. 1999), and species currently limited by cold weather will be more difficult to control (Hellmann et al., 2008). As some native species migrate out of the park, new, non-native species may arrive in their place.

In some cases, non-native species may be benign or could prove beneficial, helping to stabilize ecosystem functions. Other non-native species may expand rapidly, encroaching on other species' habitats and threatening the ecosystem's biodiversity. Species that are disturbance-adapted may thrive as a result of disruptions associated with climate change, including vegetation loss and changes in species diversity (Zabaleta & Royal, 2001). Gateway management will face the challenge of distinguishing between non-native and invasive species, which is often a difficult task. Understanding what new species may arrive in Gateway due to climate change impacts, and how these new species will interact with Gateway's ecosystems, can help managers prepare for these changes.

As well as determining what species are likely to arrive in Gateway, the park could organize a conference to discuss what might constitute a harmful invasive species as opposed to a non-native species pressured to migrate by climate change. This may involve ethical dimensions, including species valuation and discussions on appropriate control mechanisms. Once a list of likely invasive species is established, Gateway can develop research, monitoring and control programs.

Potential participants in a discussion of what species should be considered invasive include the NPS Washington Office, NPS Northeast Region units, Greenbelt Native Plant Center, New York City Parks and Recreation and New York City Botanical Gardens.

Benefits

- Sharing information among parks may lead to more effective regional collaboration.
- Anticipating species changes proactively may reduce costs.
- Providing a framework for devising strategies to address unexpected species that appear in the park.

Challenges

- Navigating uncertainty on what species may arrive at Gateway and how they may interact with existing species.
- Navigating internal debates over valuation and ethical control approaches.