Yu-Fai Leung
Nigel Shaw
Keith Johnson
Roland Duhaime

More than a Database:

Integrating GIS Data with the Boston Harbor Islands Visitor Carrying Capacity Study

Introduction

Visitor carrying capacity has long been a management challenge in U.S. national parks (Manning 1998). This challenge is being intensified, as most national parks have witnessed a continual increase in visitation during the past two decades, prompting serious questions such as "Where is the limit?" and "How much is too much?" The development of the Visitor Experience and Resource Protection (VERP) framework in the early 1990s, and its recent incorporation into the National Park Service (NPS) general management plan process, are significant steps toward addressing visitor carrying capacity issues from a systematic and scientific approach (NPS 1997; NPS 2000b). The VERP framework emphasizes the importance of setting management objectives and zones, selecting indicators and standards, implementing a monitoring program, and developing management guidelines. First experimented with at Arches National Park in Utah, the VERP framework is being implemented in a number of national park units across the United States (Hof et al. 1994; Manning 2001). Substantial amounts of data are typically required in order to develop indicators and standards in any VERP implementation process. This is particularly true as the latest visitor carrying capacity research projects, including that presented in this paper, attempt to integrate social and resource concerns throughout the process.

The objectives of this paper are to outline the Boston Harbor Islands National Recreation Area geographic information systems (GIS) database and to illustrate its integration with an ongoing visitor carrying capacity or VERP research project. The paper first describes the Boston Harbor Islands and the GIS database development effort for this new NPS area, followed by an overview of the VERP project. We illustrate how the GIS database is being integrated with the VERP project by using resource-based indicators for social (or unofficial) trails.

The Boston Harbor Islands NRA and its GIS Database

Established in 1996, Boston Harbor Islands National Recreation Area is also known as the Boston Harbor Islands National Park Area. This new NPS unit consists of 34 islands and peninsulas (referred to collectively as "islands" herein) within the Greater Boston shoreline, encompassing 1,600 acres of land and spread over 50 square miles in a busy working harbor. The islands are managed by a partnership of 13 organizations and agencies, including NPS, island owners, state and local government agencies, and other interests on the islands. In addition to this unique arrangement, the islands' range of character and diversity of resources are striking. This park unit contains the only drumlin field in the United States that intersects a coast (NPS 2000a). There are a number of concerns about the sensitivity of the island resources. The resiliency of the natural environment—which is characterized by thin soils, abundant wildlife habitat, fragile incipient salt marshes, and coastal barrier beaches—to increased visitation is limited, but the limits are unknown. Currently there is no systematic method for assessing and managing visitor impacts on the park's natural and cultural resources.

The park is currently undertaking the preparation of its first general management plan (NPS 2000a). A number of assessment and research projects are also taking place on the islands to establish the "baseline" of natural and cultural resources on the islands. The general management plan and individual projects are supported by the NPS Boston Support Office and NPS Field Technical Support Center (FTSC) housed at the University of Rhode Island through the development of a comprehensive GIS database.

The park's GIS database was directed by the fourth author, an FTSC member who is responsible for designing the structure, researching, developing and converting spatial data, and coordinating support activities such as the "GPS [Global Positioning System] SWAT Team" and other student participation and training. Not surprisingly, there is a lot of existing digital spatial data for the Greater Boston area. In addition to standard U.S. Geological Survey (USGS) and state GIS programs, spatial data were also drawn from numerous other sources. Each data theme from each source was evaluated for relevance to the park's mission, quality, documentation thoroughness (e.g., metadata complying with Federal Geographic Data Committee standards), and convertibility. Data for the selected themes were acquired, converted, and fully documented. Data themes from these sources are listed in Table 1.

In addition to the above themes, two GPS SWAT teams were assembled by the second and fourth two

Table 1. Data themes included in the Boston Harbor Islands GIS database.

Theme	*Description*
d_abandoned_bogs	Based on the MassGIS (state of Massachusetts GIS) ab_cran coverage, no abandoned bogs are present within the study area.
d_acecs	Areas of critical environmental concern, from MassGIS.
d_boha_GPS_Themes _draft_1	Coverages created from field GPS data. These include: Built_Water_Features Flora-Fauna-Farm Memorials Other See d_paths Piers Recreation_Areas Roads Selected_Built_Features See d_social_trails Unauthorized_Recreation_Use Waste_Management
d_channels	Boston Harbor shipping channels digitized from National Oceanic and Atmospheric Administration (NOAA) nautical charts.
d_clipcovs	The clip coverages used to extract regionally specific data from MassGIS coverages.
d_coastline	Boston Harbor region coastline and islands.
d_color	Color orthophotographic mosaic of Boston Harbor.
d_discharge_points	Groundwater discharge points.
d_eelgrass	Eelgrass habitats.
d_elevation	Interpolated elevation grid for the region surrounding Boston Harbor.
d_esi anadfish- birds- esi fish- habitats- hydro- index- invert- mgt- m_mammal- nests- reptiles- salinity- socecon-	Coverages taken from NOAA Environmental Sensitivity Index records, listed below: anadromous fish bird habitats environmental sensitivity marine fish habitat types hydrology boundaries marine invertebrates managed lands marine mammal habitats bird nesting areas marine reptiles(sea turtles) salinity socioeconomic/human-use features
d_ferryroutes	Ferry routes accessing the Boston Harbor Islands.

d_geology	Surficial geology.
d_landuse	Land use/land cover data for the region.
d_moorings	Anchorage boundaries from NOAA lines from NOAA nautical charts
d_nigelcad	Computer-assisted drawing (CAD) files containing information on various aspects of the Boston Harbor Islands.
d_noaa	Digitized NOAA nautical chart of Boston Harbor.
d_panchromatic	Black-and-white orthophotographic mosaic
d_roads	Line coverage of roads in the region surrounding Boston Harbor, broken down as roads, street, route, CSN, admin.
d_shellfish_areas	Shellfish growing areas.
d_shellfish_stations	Sampling locations for shellfish toxins and/or general water quality.
d_soils	Soil types of the Boston Harbor region. See metadata for extent info.
d_streams	Rivers and streams in the study area (not merged due to errors with wetlands).
d_structures	Miscellaneous coverages of structures on the Boston Harbor Islands. The only coverage here presently is DOCKS, which shows docks and piers digitized from orthophotos.
d_usgs_bathy	Interpolated bathymetry of Boston Harbor, USGS
d_vernal_pools	Potential vernal pools and certified vernal pools from MassGIS.

GPS SWAT teams were assembled by the second and fourth authors to work on several other themes between November 2000 and July 2001. These themes were identified by principal investigators of individual research projects as the most critical additions to the available themes (Table 1). These additional themes include recreation facilities, official and social (unofficial) trails, roads, and seawalls. A total of 11 islands were mapped using GPS by the SWAT teams. Work on the remaining islands will continue as funding allows.

The Visitor Carrying Capacity Project

Visitor carrying capacity addresses the amount and types of visitor use that can be accommodated without causing unacceptable resource and social impacts (Shelby and Heberlein 1986). Examples of resource impacts include vegetation loss, tree damage, soil compaction, soil erosion, and wildlife disturbance, while perceptions of crowding, conflict, and excessive resource impacts are common forms of social impacts that may detract from visitors' experiences (Manning 1998; Leung and Marion 2000). Manning (2001) provides an overview of the visitor carrying capacity issue and the previous VERP implementations, and a recent issue of *The George Wright Forum* (Vol. 18, No. 3, 2001) was devoted to this topic. The

Boston Harbor Islands visitor carrying capacity project is a collaborative effort between North Carolina State University (for the resource component) and the University of Vermont (for the social component). The following discussion, however, focuses only on the resource component of the project.

Resource research within the VERP and other related management planning frameworks has focused on resource assessment, indicator identification and measurement, and standards formulation. Field surveys have been carried out to assess and monitor resource conditions on trails, campsites, and other recreation sites (Leung and Marion 2000; Marion and Leung 2001). Similarly, the resource component of this project was designed to help the park formulate resource-based indicators and standards of quality that are pertinent to management goals and objectives. The examples discussed in this paper are part of the first phrase of the research, which is the development of resource-based indicators.

A substantial number of potential resource indicators have been identified through review of scientific literature, a survey of local experts, and a visitor survey conducted by the University of Vermont. These potential indicators were evaluated and selected based on established criteria used in previous VERP implementation projects (Belnap 1998; Greater Yellowstone Winter Visitor Use Management Working Group 1999).

One interesting group of indicators is related to the extent and distribution of social or unofficial trails on these islands. Social trails can be defined as discernible and continuous trail segments that were created by visitors (not constructed) and which do not follow a park's formal trail system (Leung 2001). These trails are of increasing management concern since they are usually poorly located and aligned, are not maintained, and are often in a degraded condition. These trails can be a significant threat to the natural resources when they are in close proximity to sensitive habitats or resources (Belnap 1998). Measurements of social trails are relatively straightforward, low-cost, and low-impact—three important criteria for indicator selection.

Integrating with the Park's GIS Database

Most social trail indicators developed in previous studies are essentially spatial indicators, involving some measure of spatial quality, such as extent, density, and distribution(Belnap 1998; Leung and Marion 1998). Hence, the Boston Harbor Islands GIS database was identified early on as an important data source for developing social trail indicators for this project.

The first integration between the carrying capacity project and the GIS database development effort took

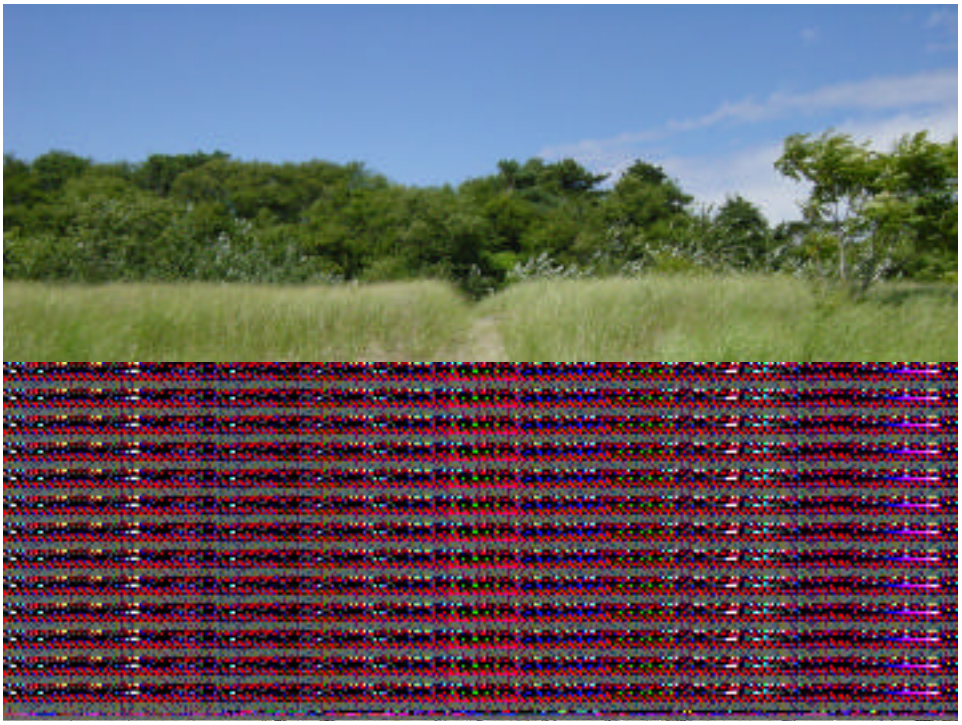

Figure 1. A social trail cutting through a sand dune on Lovells Island.

place before the GPS SWAT teams started field data collection. A condition-class rating system for social trails, which was adapted from an earlier study (Cole et al. 1997), was incorporated into the GPS data dictionary and applied directly in field mapping. All discernible social trail segments were mapped using a GPS unit. Each social trail segment was assigned to one of the following four condition classes:

- ***Class 1***. Trails are disturbed but not well established. They retain at least 20% of vegetation cover on the treads. The boundaries between trail treads and off-trail areas are often unclear.
- ***Class 2***. Trails are disturbed and well established. They retain less than 20% of vegetation cover on the treads. These trails are less than 1 ft wide. The boundaries between trail treads and off-trail areas are often discernible.
- ***Class 3***. Trails are disturbed and well established. They retain less than 20% of vegetation cover on the treads and are between 1 and 2 ft wide. The boundaries between trail treads and off-trail areas are usually discernible.
- ***Class 4***. Trails are disturbed and well established. They retain less

Figure 2. The third author mapped a social trail segment on Raccoon Island.

than 20% of vegetation cover on the treads and are more than 2 ft wide. The boundaries between trail treads and off-trail areas are usually discernible.

The second and ongoing integration involves the derivation of various resource impact indicators using data themes available from the park's GIS database. Table 2 provides an example of selected social trail indicators for Georges, Grape, and Peddocks islands. In addition to the social trail data set, two data themes from the GIS database were utilized to delineate zones that are sensitive to visitor impacts. The first data theme used was a land use–land cover (LULC) data set created using photo interpretation and automation by the Resource Mapping Project at the University of Massachusetts–Amherst. Interpretation was made from 1:40,000 color infrared aerial photos taken in summer 1985. The second data theme was the National Wetlands Inventory (wetlands) data set that was interpreted (again, by the university) using stereo photogrammetric techniques on 1:12,000 color infrared photographs. The delineation was based on a combination of the Anderson and

Cowardin classification schemes. Zones that are considered to be sensitive to visitor impacts include features such as barrier beach, coastal bank bluff or sea cliff, coastal dune, salt marsh, and shallow marsh meadow. While the criteria for defining sensitive zones may change in the future, the same approach and procedures can be applied to derive different resource-based indicators. Table 2 shows that most social trails are located outside the defined sensitive zones except on Peddocks Island, where more than 400 m, or about 44%, of social trails lie within sensitive areas. In addition, some of the social trails within sensitive zones are in Class 3 or Class 4 condition, indicative of widening treads and more human presence.

Another way of using the GIS database was the creation of new resource-impact indicators by on-screen or heads-up digitizing using 1:30,000 digital orthophotos of the islands. Figure 3 shows an example in which intersection points between official trails and social trails were digitized for Peddocks Island. The number of intersection points is being considered as an alternative social trail indicator, because it does not require time-consuming assessment of the entire social trail network.

Table 2. Conditions of selected social trail indicators on three islands. These indicators were derived using three data themes from the Boston Harbor Islands GIS database.
* Zones that are considered sensitive to visitor impacts.
** Trail segment with a condition class of 3 or 4. Details of the condition class rating scale are described in the text.

Island	***Location with respect to sensitive zones****	***Indicator***		
		Number of Segments	*Cumulative Length (m)*	*Length in poor condition (m) ***
Georges	Inside	6	56	0
	Outside	134	1,448	160
Grape	Inside	0	0	0
	Outside	33	475	68
Peddocks	Inside	28	466	89
	Outside	26	1,063	257

Concluding Remarks

This paper has provided an overview of the GIS database development for Boston Harbor Islands National Recreation Area and the resource component of the on-going visitor carrying capacity project. Examples of integration between the research project and the GIS database were also highlighted. Other natural resources assessment projects in this new park unit will similarly benefit from the wealth and quality of spatial data available in this database.

The addition of new data themes created by various on-going research projects will continue to expand the Boston Harbor Islands GIS database. It will provide an excellent opportunity for performing integrated evaluations of natural and cultural resources. For instance, intertidal and inland habitat data sets that are being developed by other research teams could be integrated with the trail and campsite assessment data sets to identify problem locations with respect to the protection of natural habitats. Within the carrying capacity research project, integration between the resource and social components is underway through the use of GIS (Newman et al. 2001). Such integration facilitates the formulation of indicators and standards of quality—a critical step in the VERP implementation process.

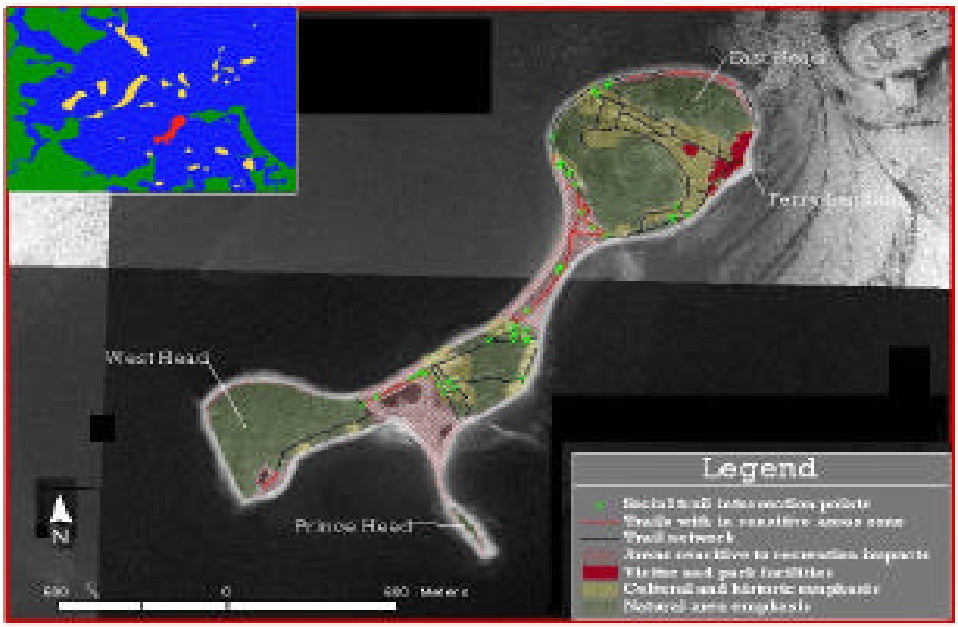

Figure 3. Developing new resource impact indicators, such as trail intersection points for Peddocks Island, using the Boston Harbor Islands GIS database.

References

Belnap, J. 1998. Choosing indicators of natural resource condition: A case study in Arches National Park, Utah, USA. *Environmental Management* 22, 635-642.

Cole, D.N., A.E. Watson, T.E. Hall, and D.R. Spildie. 1997. *High-Use Destinations in Wilderness: Social and Biophysical Impacts, Visitor Responses, and Management Options.* Research Paper INT-RP-496. Ogden, Ut.: U.S. Department of Agriculture–Forest Service, Intermountain Research Station.

Duhaime, R., C. LaBash, and B. Mackey. 2000. *Boston Harbor Islands Spatial Data Review*. Unpublished report to NPS Boston Support Office.

Greater Yellowstone Winter Visitor Use Management Working Group 1999. *Winter Visitor Use Management: A Multi-Agency Assessment.* Final Report of Information for Coordinating Winter Recreation in the Greater Yellowstone Area. Jackson, Wyo.: National Park Service.

Hof, M., J. Hammett, M. Rees, J. Belnap, N. Poe, D.W. Lime, and R.E. Manning. 1994. Getting a handle on visitor carrying capacity: a pilot project at Arches National Park. *Park Science* 14:1, 11-13.

Leung, Y.-F. 2001. Social trail proliferation in national parks: assessment and management issues. P. 67 in *Crossing Boundaries in Park Management—The 11th Conference on Research and Resource Management in Parks and on Public Lands: Abstracts*. Hancock, Mich.: The George Wright Society.

Leung, Y.-F., and J.L. Marion. 1998. Evaluating spatial qualities of visitor impacts to recreation resources: An index approach. *Journal of Applied Recreation Research* 23:4, 367-389.

Leung, Y.-F., and J.L. Marion. 2000. Recreation impacts and management in wilderness: a state-of-knowledge review. Pp. 23-48 in *Wilderness Science in a Time of Change Conference—Volume 5: Wilderness Ecosystems, Threats, and Management*. D.N. Cole, S.F. McCool, W.T. Borrie, and J. O'Loughlin, comps. RMRS-P-15-VOL-5. Ogden, Ut.: U.S. Department of Agriculture–Forest Service, Intermountain Research Station.

Manning, R.E. 1998. "To provide for the enjoyment": recreation management in the national parks. *The George Wright Forum* 15:1, 6-20.

———. 2001. Visitor Experience and Resource Protection: a framework for managing the carrying capacity of national parks. *Journal of Park and Recreation Administration* 19:1, 93-108.

Marion, J.L., and Y.-F. Leung. 2001. Trail resource impacts and an examination of alternative assessment techniques. *Journal of Park and Recreation Administration* 19:3, 17-37.

Newman, P., J.L. Marion, and K. Cahill. 2001. Integrating resource, social, and managerial indicators of quality into carrying capacity decision-making. *The George Wright Forum* 18:3, 28-40.

NPS [National Park Service]. 1997. *The Visitor Experience and Resource Protection (VERP) Framework: A Handbook for Planners and Managers.* Publication No. D-1215. Denver: NPS Denver Service Center.

———. 2000a. *Boston Harbor Islands National Recreation Area Draft General Management Plan.* Boston: National Park Service, Boston Harbor Islands National Recreation Area.

———. 2000b. *Management Policies 2001*. Publication D-1416. Washington, D.C.: National Park Service.

Shelby, B., and T.A. Heberlein. 1986. *Carrying Capacity in Recreation Settings.* Corvallis: Oregon State University Press.

Yu-Fai Leung, Department of Parks, Recreation and Tourism Management, North Carolina State University, Box 8004, 4012F Biltmore Hall, Raleigh, North Carolina 27695-8004; Leung@ncsu.edu

Nigel Shaw, National Park Service, Boston Support Office, 15 State Street, Boston, Massachusetts 02109; Nigel_Shaw@nps.gov

Keith Johnson, Department of Parks, Recreation and Tourism Management, North Carolina State University, Box 8004, 4008 Biltmore Hall, Raleigh, North Carolina 27695-8004; kjohns5@unity.ncsu.edu

Roland Duhaime, Natural Resources Science, Coastal Institute in Kingston, University of Rhode Island, Kingston, Rhode Island 02881; roland@edc.uri.edu