# Monitoring Visitor Impacts in Coastal National Parks: A Review of Techniques

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## Introduction

Coastal areas, particularly sandy coasts and barrier islands, are prime destinations for outdoor recreation activities, yet the same zones possess diverse, dynamic, and, often, sensitive ecosystems (Beatley et al. 2002). There are 295 barrier islands, totaling 2,700 miles of barrier length in the 18 eastern U.S. states alone (Leatherman 1988). Visitor use and impacts are an important and growing concern in national parks located in these sensitive zones. Activities such as the use of off-road vehicles (ORVs), walking on the beach or dunes, and feeding wildlife can trample vegetation, accelerate soil erosion, reduce sand dune height, and change wildlife behavior.

The utility of visitor impact monitoring as an effective tool for managing visitation in coastal parks has been recognized (Marion et al. 2001). As part of the National Park Service (NPS) Vital Signs Program, we initiated a research project to develop visitor impact indicators and monitoring protocols for seven park units within the NPS Northeast and Barrier Network. One of the project objectives was to conduct a thorough review of the scientific literature, with the scope set to sandy coasts and barrier islands. This paper highlights results of this literature review. We identified relevant publications in our personal databases and also conducted thorough searches in reference databases through the university libraries. A substantial number of references were identified, but only a small portion is applicable to sandy coasts and barrier islands. Several studies were conducted in the park units included in this project (such as Patterson et al. 1991; Steiner and Leatherman 1981).

## Research on Coastal Visitor Impacts

Earlier studies of visitor impacts to coastal areas have been reviewed by Leatherman (1988) and Vaske et al. (1992). Leatherman and Steiner (1987) compiled an annotated bibliography with 110 entries on the impacts of ORVs and walking traffic on coastal ecosystems. This bibliography included both social and environmental impacts, and most of the entries are rather dated (1970s or earlier).

ORV use was an early but consistent visitor impact concern in coastal parks, particularly on barrier islands and near sand dunes (Rickard et al. 1994). At Cape Cod National Seashore, Godfrey and Godfrey (1980) conducted a comprehensive study on the effects of ORV use on different ecological components such as birds, sand dunes, and salt marshes. Management implications of their findings were provided (Godfrey et al. 1980). In the same region, Carlson and Godfrey (1989) applied vegetation survey and mapping techniques to evaluate the effectiveness of a visitor management plan developed for R.T. Crane, Jr., Memorial Reservation in Massachusetts. McAtee and Drawe (1981) studied recreational impacts on the beach and foredune microclimate in Texas. The primary effect was reduced vegetation cover and lower species diversity. They also found that as recreational activities increased, the dune height decreased. In North Carolina, Hosier and Eaton (1980) studied ORV impacts to

dunes and found that vegetation cover and the number of species were lower in areas with ORV use. The potential impacts of ORVs on macroinvertebrates have also been investigated (Wolcott and Wolcott 1984).

Much of the literature focused on the effects of visitor impacts on the ecological communities. Steiner and Leatherman (1981) studied the distribution of ghost crabs at Assateague Island National Seashore in relation to ORV and pedestrian usage. Pedestrians were found to have no harmful effects on ghost crabs. In fact, the density was higher in these areas, possibly due to the abundance of food scraps. The ORV sites contained significantly fewer ghost crabs than the pedestrian sites. The difference between areas of high and low ORV use was not significant. Barros (2001) found the number of ghost crab burrows in non-urban beaches to be higher than in urban beaches.

Thomas et al. (2003) studied the effects of visitor activities on the foraging behavior of sanderlings. They found through field observation that the number and proximity of people, their activity, and the presence of free-running dogs significantly reduced the amount of time sanderlings spent foraging. Through a controlled experiment, they found group size to be significant in reducing foraging time. In both measurements, they found that sanderlings respond (by either running or flying) when humans approach within 30 m. Burger (1986) found that only 30% of birds were unaffected by human activity, and that most birds flew away in response. Burger was unable to determine if these activities were harmful to the overall health of the birds, but indicated that disturbance during prime foraging times would have an adverse affect on health. Patterson and others (1991) found no evidence to suggest that recreational activities had a detrimental effect on the productivity of piping plovers. Low productivity was attributed to predation.

## Visitor Impact Monitoring: Methodologies and Techniques

A thorough review of relevant scientific literature suggests that there are two dominant methodological approaches to visitor impact monitoring in coastal areas (Figure 1). The

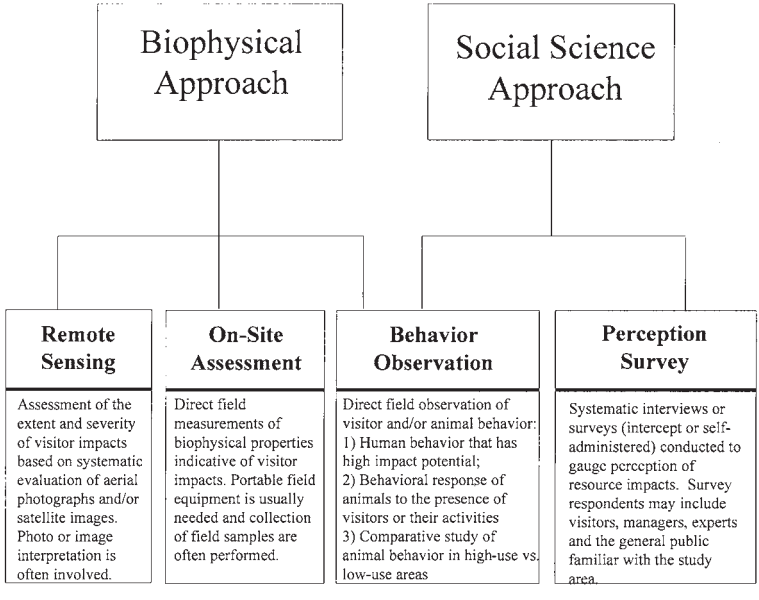


Figure 1. A classification of visitor impact monitoring techniques developed for coastal parks and protected areas.

*biophysical* approach includes studies that evaluate the extent and intensity of visitor impacts based on remotely sensed data or direct measurements of recreation sites, coastal habitats, and wildlife behavior. Within this first approach, remote sensing, on-site assessments, and observation of animal behavior are the three major groups of techniques. On the other hand, studies that employ the *social science* approach evaluate the extent and intensity of visitor impacts based on (1) perception of park visitors, managers, local experts, and/or general public; or (2) direct observation of visitor behavior that has high impact potential. The following is a concise description of each group of techniques with examples from past studies.

**Remote sensing.** Remote sensing refers to the detection and recording of values of emitted or reflected electromagnetic radiation with sensors onboard aircraft or satellites. This group of techniques is particularly useful for monitoring easily detectable visitor impacts that occur in a large expanse of coastal areas. Butler and Wright (1983) discuss the potential of remote sensing in recreation research, including the measurement of user density and intensity and comparison of changes over time. Welch et al. (1999) created databases of digital maps detailing vegetation and ORV trails in the Everglades for use in management and modeling. Hockings and Twyford (1997) used aerial photography to identify beach camping impacts. They used the extent of clearing and vehicle tracks as indicators. They compared their findings with ground surveys and found aerial photography to be a valid and reliable measure. Aerial photography was also used in the study to examine spatial and temporal changes within the campsites.

**On-site assessment.** On-site biophysical assessment refers to direct measurements or assessments on the ground, usually with portable field equipment. This research approach may also involve collection of field samples for laboratory analysis. Several campsite impact studies recently have been conducted in North America (Monz 1998; Gajda et al. 2000). These studies extended field procedures from earlier studies conducted in inland forests and parks (Leung and Marion 2000). In North Carolina, Buerger et al. (2000) assessed impacts of recreation on a barrier island. Researchers identified impact areas as sites (resulting from camping, picnicking, and boat landings) and trails. Physical impacts such as compacted sand, loss of vegetation, and trash were recorded. These impacts were compared over time to determine if mitigation of recreation impacts occurred naturally. They found the degree of mitigation depended largely on the location of the impact on the island. Sites closer to the water had a higher level of mitigation. Chandrasekara and Frid (1996) used on-site measurements to determine the effects of trampling on tidal flat infauna. Faunal and sediment samples were taken from the site and brought to the lab for further analysis. Sediment pH was measured on site. The authors found trampling caused a change in the composition of benthic fauna.

**Behavior observation.** Behavior observation is a group of techniques that may fall within either the biophysical or social science methodological approach, depending on the actual subject of observation. In visitor observation, human behaviors that cause impacts are systematically observed. In wildlife observation, immediate behavioral response of wildlife to the presence of visitors or visitor activities is observed. These techniques can be used together (Burger 1986; Thomas et al. 2003) or separately (Patterson et al. 1991; Loegering and Fraser 1995). Burger (1986) found walking (40%) and fishing (10–20%) to be responsible for the majority of disturbances to shore birds. Dogs accounted for less than 10% of the disturbances. Shorebird responses were recorded as one of three behaviors: remained at the site, flew away but returned, and flew away and did not return. While there were some differences between sites, the percentage of birds that flew away and did not return was inversely related to the number of disturbances. Burger also found evidence to suggest that birds in small flocks were more likely to fly away and not return than birds in large flocks. Thomas et al. (2003) found that group size, activity type, and free-running

dogs tend to have a significant effect on the foraging time of sanderlings. Observation of behavior has also been used to determine if human disturbance had an effect on animal survival (Patterson et al. 1991; Loegering and Fraser 1995).

**Perception survey.** The extent and severity of visitor impacts may be evaluated based on human perceptions of such problems. This social science approach can be implemented in forms of systematic interviews and/or surveys (intercept or self-administered). Survey respondents typically include visitors and managers of the study area. However, the general public and professionals who are familiar with the study area may also be surveyed. Vaske et al. (1992) used written self-administered surveys to understand visitor perceptions of conflict and of the natural environment. Responses were separated by user group (pedestrian, boater, ORV user) and by use area. They found that boaters were less educated about the ecology of the area, regulations, and human impacts. Survey responses also revealed that visitors felt the beach area was becoming crowded. The responses from the surveys were combined with ecological data to create new management techniques. Becker et al. (1986) assessed the threats of human impacts to coastal areas based on a survey of visitors and public, though managers and experts were also involved. Similar to surveys of visitors and the public, surveys or interviews of managers may also be used to gauge the extent and intensity of visitor impacts, based on managers' or experts' perceptions. In the Becker et al. (1986) study, coastal park managers and experts were also involved in the survey. No other park manager/expert surveys focusing on perceived visitor impacts on coastal areas have been identified.

## Discussion and Conclusions

The scientific assessment and monitoring of visitor impacts on sandy coasts and barrier islands emerged about 30 to 40 years ago, though our knowledge of direct impacts of visitors on coastal resources is still limited. A variety of monitoring techniques have been developed or adapted for a wide array of impact indicators, although on-site assessment and behavior observation appear to be the most popular methodological approaches. On-site biophysical assessment has been applied to various countries, while remote sensing and behavior observation techniques were largely developed in North America.

Several current trends in methodologies for coastal visitor impact monitoring were identified:

1. Expanding geographic scale of monitoring studies from primarily North America to different world regions in recent years, partly as a result of rapid growth in coastal ecotourism;
2. Increased number of integrated studies that include both biophysical and social research components; and
3. Increased application of technologies in visitor impact monitoring studies. These technologies, such as global positioning systems (GPS), geographic information systems (GIS), and remote sensing, enhance the overall quality and especially the spatial accuracy of monitoring data.

The process of literature review benefits the next steps of this project. For example, some of the indicators reviewed, such as the use of remotely sensed data, site assessments, shorebird responses, the presence of ghost crabs, and visitor behavior observation, are being adapted to the project. Informed by the state-of-knowledge in visitor impact monitoring, our next critical step is to adapt or develop network-wide and park-specific impact indicators and monitoring protocols for the seven park units and integrate these procedures into the broader Vital Signs Program, which strives to protect the park resources for future generations.

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