Published in final edited form as:

Urban Ecosyst. 2015 June 1; 18(2): 553–575. doi:10.1007/s11252-014-0412-x.

Ecological concerns following Superstorm Sandy: stressor level and recreational activity levels affect perceptions of ecosystem

Joanna Burger

Division of Biology, Rutgers University, 604 Allison Road, Piscataway, NJ 08854, USA

Joanna Burger: burger@biology.rutgers.edu

Abstract

Coastal habitats are vulnerable to storms, and with increasing urbanization, sea level rise, and storm frequency, some urban populations are at risk. This study examined perceptions of respondents in coastal and central New Jersey to Superstorm *Sandy*, including: 1) concerns about ecological resources and effects (open-ended question), 2) information sources for ecology of the coast (open-ended), and 3) ratings of a list of ecological services as a function of demographics, location (coastal, central Jersey), stressor level (power outages, high winds, flooding) and recreational rates. “Wildlife” and “fish” were the ecological concerns mentioned most often, while beaches and dunes were most often mentioned for environmental concerns. Television, radio, and web/internet were sources trusted for ecological information. The data indicate 1) stressor level was a better predictor of ratings of ecological services than geographical location, but days engaged in recreation contributed the most to variations in ratings, 2) ecological services were rated the highest by respondents with the highest stressor levels, and by those from the coast, compared to others, 3) Caucasians rated ecological services higher than all others, and 4) recreational rates were highest for coastal respondents, and ratings for ecological services increased with recreational rates. Only 20 % of respondents listed specific ecological services as one of their three most important environmental concerns. These data will be useful for increasing preparedness, enhancing educational strategies for shore protection, and providing managers and public policy makers with data essential to developing resiliency strategies.

Keywords

Environmental concerns; Ecological concerns; Ecological services; Superstorm *Sandy*; Climate change; Preparedness; Resiliency; Information sources

Over the past several decades, coastal development has continued at a rapid rate, particularly in urban areas such as New York and New Jersey. Land less than 10 m above sea level covers 2 % of the World’s land, but contains 10 % of the World’s population (McGranahan et al. 2007). Well over half of the US population lives along coasts (NOAA 2012; Crosset et al. 2013), where storms and hurricanes are predicted to increase (Lane et al. 2013; NPCC2 2013). Coastal megacities have had a major role in environmental degradation (Sekovski et al. 2012), even in developing countries (Burak et al. 2004). The corridor from Boston to

Washington DC is now urbanized, with dense high rise housing and residential communities. Build-out has resulted in extensive bulk-heads, piers, boardwalks, marinas, and other types of coastal developments. Small fishing communities have been replaced with urban and residential development. Often, the important role and dynamic nature of coastal beaches, dunes, and salt marshes has not been recognized by the public, managers, and planners, especially in New Jersey (Nordstrom and Lotstein 1989; Nordstrom and Mitteager 2001). Yet, beaches, and associated dunes and marshes, serve as barriers to damages from the forces of wind, waves, currents, and storm surges, providing resiliency to both human and ecological communities (USGS 2010). Further, people in megacities perceive deterioration of water and air quality, which leads to human health problems, economic instability, and social inequities (Sekovski et al. 2012; Newton et al. 2012).

Damages (storm effects) can be high because of an increase in vulnerability and exposure to coastal flooding (Genovese and Przyluski 2013). Severe storms threaten property, health, and the lives of people, tax emergency services and infrastructure, disrupt safety and community operations, and change the physiognomy of coastal ecosystems. Disasters are stressful to individuals and communities (North et al. 2012; Neria and Shultz 2013). Weather-related disasters are characterized by electricity outages lasting days, displacement of people to friend's homes or shelters, breakdowns in infrastructure and information sources, and lack of sufficient resources to survive (clean water, food, heat). Serious health conditions, emotional distress, and grief follow disasters (McLaughlin et al. 2010; Shear et al. 2011). While communication, early warning, and emergency preparedness can help protect communities from the immediate effects of severe coastal storms, long-term resiliency partly depends upon stable dunes and marsh complexes (Plant et al. 2010). The adaptability of large cities is central to resiliency and responses to severe storms and sea level rise (Klinenberg 2013). Understanding the relationship between drivers, pressures, perceptions, impacts and responses is critical to adapting to changing climate and sea level rise (McGanahan et al. 2007; Newton et al. 2012; Klinenberg 2013).

Superstorm *Sandy* made landfall in New Jersey on 29–30 October 2012, and adversely affected New Jersey and New York because the storm stalled over the region. There were 159 deaths and over \$70 billion in damages, with power outages in thousands of homes for weeks or months, and many people were displaced from homes damaged by storm surges, flooding, and loss of power (Freedman 2013). Over 345,000 housing units were destroyed in New Jersey alone, with nearly \$3 billion in damages to NJ transit, roads, and bridges (BBB 2012). Many people sheltered in place, and others evacuated after the storm due to contaminated drinking water, and lack of electricity, heat, and food (Kratovil 2012). Two years later, many people are still displaced. The connection between natural ecosystems (barrier islands, dunes, marshes) and the protection they provide for terrestrial communities is often unclear to people living in urban and residential communities. Personal decisions result from the filtration of values through culture, perception, and a capacity to act (Casagrande 1996). Therefore, understanding perceptions and valuation of ecological services as they affect human health and property damage during disasters is important for future preparedness. Inclusion of stakeholders in decision-making is important to achieve management goals and sustainability (Jentoft 2000; Faust and Smardon 2001; NRC 2008;

Marin et al. 2000). This is especially true given the likelihood of increased storm frequency, precipitation extremes, and sea-level rise (IPCC 2007a, b; Kharin et al. 2007; Russo and Sterl 2012). Further, many of the coastal communities in New Jersey and New York are ethnically and economically vulnerable (Eisenman et al. 2007), making it imperative to determine if there are ethnic differences that can inform and improve future preparedness and resiliency.

This study examined the concerns of people living along the coast and in central New Jersey, and their valuation of ecological structures (beaches, dunes, marshes) and resources (fish, wildlife), including 1) concerns about ecological resources and effects (open-ended question), 2) information sources for ecology and the environment (open-ended), and 3) ratings of a list of ecological services as a function of demographics, location (coastal, central Jersey), and stressor level (power outages, high winds, flooding). The overall objective was to understand the factors that affect perceptions about the importance of ecological services, such as beaches, dunes, marshes, that are essential to resiliency strategies. Environmental and social assessment includes understanding how people perceive the dangers from a storm, possible effects, and the importance of the ecosystem in protecting shorelines.

Interviews conducted within 100 days of superstorm *Sandy* provide data useful for ecologists, ecosystem managers, architects, health professionals, public policy makers, and everyone dealing with preparedness in coastal environments. The study was initiated immediately after *Sandy*, when many of the interviewees were without power, and some were still displaced. The terms environment and ecology are sometimes inter-changeable in the public eye. In this paper we asked people about both their environmental concerns, and their ecological concerns, to determine how the affected public distinguishes these two terms.

Methods

The overall protocol was to interview people in coastal New Jersey from Sandy Hook to Atlantic City ($N=347$), and in central New Jersey centered around New Brunswick ($N=407$) within 100 days of *Sandy* making landfall. The protocol was approved by the human subjects Internal Review Board of Rutgers University (E13-329), and no personal identifiers were recorded. People were asked if they would participate in a survey being conducted by Rutgers University, and were told it was voluntary.

Perceptions can be assessed by surveys conducted by mail, by telephone, by internet, and in person, and each has advantages and disadvantages (Frey and Oishi 1995; Ingle et al. 2004). People may choose to ignore mail surveys, not answer phones, or not be reached if they have only cell phones. Internet surveys obtain information only from those with internet, and then only from people who have found the survey and are interested. In-person interviews are dependent upon finding people willing to be interviewed, and are biased by sampling location. In the present study, people were interviewed in several venues where people gathered to gain storm-related information, and the refusal rate was very low. Further, people wanted to answer the questions, stayed to ask more questions, and surveys required

nearly twice the time such interviews usually take because people wanted to talk about their experiences. The survey results presented in this paper represent those interviewed, although there is no reason to assume a biased sample. Further, both phone and mail disruptions made a phone/email approach impossible within the first 100 days of superstorm *Sandy's* landfall.

Information on surveys can be obtained either by open-ended questions (What were your ecological concerns about superstorm *Sandy*?) or with a Likert Scale rating (Please rate the following concerns.). Both approaches were used in this paper, embedded in other questions asked about the storm, property damage, health concerns, and ecological concerns. One additional method was used; people were asked to pick their three top concerns from the list used for the Likert scale evaluations. These three methods provide different kinds of information. On open-ended questions, responses can be so variable as to make it difficult to analyze and reach conclusions, but the information is freely given, and any commonalities are worth considering. Individual ratings on the Likert scale provide easily analyzed information that can be compared; although the scale ranges from 1 to 5, people rarely give a 1. Likert scales have been used to evaluate a variety of environmental concerns, including degradation caused by nature-based tourism (Priskin 2003; Burger 2004), environmental quality and eco-cultural attributes (Burger 2011), land use (Burger et al. 2000, 2001; Burger 2005), and management and restoration options (Myatt-Bell et al. 2002; Burger 2003a, b). Having people select the top three concerns from a larger list forces them to choose their greatest concerns. There is usually high agreement between concerns expressed on open-ended questions, and the ratings from a Likert scale (Burger 2003b). This is more likely to be true where the concerns are obvious and have been previously studied, and where a pilot survey has been completed.

Interviews were conducted where people gathered, such as public meetings, FEMA and town offices, shelters, homes and apartments, recreational centers, universities, convenience stores, fast food places, and emergency food and coffee bars on street corners, as well as at private homes where people were assessing damage and making repairs. Fast food places and convenience stores were often the only sources of food and supplies in the weeks following the storm. Interviews lasted about 25 min; interviewers remained to talk with respondents about their concerns, and some interviews took over 2 h as people wanted to talk about their experiences. Everyone present was approached for an interview, and there was a very low refusal rate (<8 %). Interviews were conducted within 100 days of *Sandy* to ensure that people remembered their concerns and information sources.

The survey instrument included questions on storm effects, concerns, information sources, ratings of concerns, frequency of recreational activities, and demographics. Demographics were asked last so that people were at ease with providing information on ethnicity and income. People self-identified ethnicity and stressor level (power outages, power outages+high winds, and power outages+high winds+flooding). People also were asked the number of days they engaged in recreational activities; the total days recreating was computed for each respondent by adding up the days per year spent walking, fishing, going to the beach, nature watching/photograph, boating, and parasailing or surfing.

An early section of the questionnaire asked respondents to identify their main environmental concerns, and later they were asked to identify their ecological concerns. People could give more than one answer, and we calculated the percent of the respondents that gave each response. We asked about “environmental” and “ecological” concerns separately because some people consider only physical aspects as environmental (e.g. dunes, beach, waves), and only living resources as ecological (e.g. birds, fish, wildlife). Some questions were open-ended (concerns, information sources) and others asked respondents to rate a list of concerns on a scale of 1 (least important) to 5 (most important).

The survey also included a list of 28 concerns, which were later distilled into 5 categories: property damage, health and safety, inconveniences, ecological services, and nuclear (only one concern, but there is a nuclear plant located not far from many respondents’ properties). The initial questionnaire was pilot-tested with people ($N=10$) from the Jersey coast to ensure that the list of concerns given for the Likert rating was appropriate. The ecological services category, the main subject of this paper, included beach erosion, dune protection, dune restoration, replacement of dune vegetation, loss of salt marshes, bird populations, fish populations, and fishing places. An average score for all the concerns in each category was determined. Where informative, data on the other four concern categories are given (i.e. property damage, inconveniences, health, nuclear). Since the nuclear category had only one factor, it is not considered in the rest of the paper, except where essential. After respondents rated each concern, they were handed the list and asked to pick their three top concerns from the list. This allows for a comparison among concern types, forcing people to pick their greatest concerns.

In summary, this paper reports on a survey that examined concerns of New Jersey residents after Superstorm *Sandy*. There were both open-ended and rating questions. On open-ended questions people could say anything they wanted; on rating questions, they were asked to rate a series of 28 possible concerns. The 28 concerns were then divided into 5 categories (health, property damage, inconveniences, ecological services, and nuclear). Ecological services is the main focus of this paper.

Differences among groups were examined using Kruskal-Wallis non-parametric Analysis of Variance. A $P<0.05$ was considered statistically significant (SAS 2005). General Linear Models were developed to examine the factors that accounted for variation in the overall ratings for the four main concern categories (including ecological services); independent variables were total days recreating, location, stress-or level, distance to the ocean, age, sex, ethnicity, education, days without electricity and home repairs needed. This paper addresses concerns about ecological and environmental issues; specific health effects data and information sources can be found elsewhere (Burger et al. 2013; Burger and Gochfeld 2014).

Results

Demographics, storm effects, and recreation rates

There were significant locational differences in age, ethnicity and income of respondents, but not in education or the percent that were female (Table 1). Respondents from the Jersey

coast were older, had higher incomes, and were more likely to be Caucasian than those from central Jersey. Similarly, a higher percentage of coastal respondents lived in houses than did those from central New Jersey, and there was a much higher evacuation rate along the shore (Table 1).

Effects from the storm were more severe for respondents from the shore than for central Jersey respondents (Table 1). A higher percentage of shore respondents lost electrical power, had higher winds, and more flooding, than those from central Jersey. Central Jersey respondents averaged only 6 days without power, while shore respondents averaged 23 days.

As might be expected, a higher percentage of respondents from the shore engaged in more shore-related activities than did those from central New Jersey (Table 1). Exceptions were the percent engaging in nature watching/photograph and freshwater fishing. Shore respondents went to the beach on nearly a third of the days in a year, and those that engaged in photography did so nearly a third of the days of the year. A third of the shore respondents engaged in saltwater fishing for an average of 46 days a year, while a higher percentage of central Jersey respondents engaged in freshwater fishing for more days of the year (Table 1).

Ecological concerns and information sources

Early in the interview, respondents were asked what their major ecological and environmental concerns were, and what information sources they used to obtain information on these issues. Wildlife and fish were the ecological concern mentioned most often, while beaches and dunes were mentioned the most under environmental concerns (Table 2). The information sources given most often for both ecological and environmental information were television, radio, and the web/internet. Friends/family, social media and local government were also important (Table 2).

Overall concern rating

The 28 concerns rated by respondents were grouped into 5 categories. The average rating for ecological services was lower than for property damage, inconveniences, and health, but slightly higher than nuclear (Fig. 1). Further, there was more variation in responses for ecological services than for all other concern categories, except nuclear. The means and medians were rather similar for each concern category, indicating normal distribution of the data.

The best model accounting for variation in rating of ecological services explained 34 % of the variation by total days people recreated ($F=26.1$, $P<0.0001$), stressor level ($F=11.2$, $P<0.0009$), and ethnicity ($F=6.3$, $P<0.0001$, Table 3). Distance from the ocean was an important variable for ecological services, and the largest differences occurred for people living a km to 8 km from the ocean (Fig. 2). Because of the importance of stressor level to ecological services concern rating, models were constructed for each stressor level (Table 3). Again, total days recreating explained more of the variation in ecological services rating than any other factor, followed by ethnicity and days without electricity.

Recreational rates by stressor level (% participation, and use rates), are given in Table 1 (by location). Mean ratings differed significantly as a function of stressor category and

recreation level (i.e. days per year, Table 5). People with the highest stressor level rated general ecological services as more important than others, and in general, people with the highest recreational levels rated general ecological services as more important than others (even within each stressor level, Table 5).

The ethnic differences were largely present in central New Jersey, and there were no ethnic differences in how people from coastal New Jersey rated ecological services (Table 4). Ethnicity differences were also examined by stressor level (Tables 3–5). The following conclusions can be drawn: 1) all respondents from the coast rated ecological services higher than those from central Jersey, 2) respondents with the greatest stressor level (power outages, high winds, and flooding) rated ecological services higher than those with lower stressor levels, 3) Caucasians rated ecological services higher than others, and 4) Asians with power outages and high winds rated ecological services the lowest. Thus, regardless of whether one examines the data by location or stressor level, Caucasians rated ecological services higher than did other ethnic groups (Table 3).

Specific ecological service concern rating

The general category, ecological services, was composed of a number of different coastal structures (beach, dunes, salt marsh) and resources (fish populations, bird populations, fish habitat). For the whole sample, there were significant differences in ratings among the different types of ecological services, with beach erosion being rated the highest, followed by dune protection, dune restoration, and then loss of salt marshes. Protection of bird and fish populations, and fishing places were rated the lowest (Fig. 3).

Among the concerns that relate directly to providing resiliency for coastal ecosystems and communities, there were significant differences as a function of type of ecological service, and stressor level (Fig. 4). Respondents with power outages, high winds and flooding rated all the services the highest, while those with only power outages rated them the lowest. Beach erosion was rated the highest within each stressor category, but the relative ratings for the others varied. Loss of salt marshes was rated either the lowest or second lowest by people in all stressor levels. The rating for different ecological services varied significantly by level of recreation (Tables 4–6). Ratings for every ecological service increased with recreational rates (Table 6). Beach erosion, higher dunes, dune protection and replacing dune vegetation were rated the highest.

Ethnicity was an important variable for ratings of the different types of ecological services (Table 6). There were significant differences within each ethnic group, and among ethnic groups, except for rating of dune protection and fishing places. The relative ratings were generally similar among ethnicities. That is, all ethnicities rated beach erosion the highest, and fishing places the lowest, except for Middle Easterners who rated replacing dune vegetation the lowest (Table 7). In general, Caucasians rated each of the ecological services higher than did others. Middle Easterners rated most of them the lowest, except for beach erosion (rated the lowest by African Americans).

Three most important concerns

At the end of the rating exercise, respondents were given the list on a card and asked to select their three most important concerns (only 8 of 28 were ecological services, 29 %) from the list. Overall, only 14 % of respondents listed one of the ecological services (dunes, beach, salt marshes) in their top three concerns. As expected from the rating of ecological services: 1) Caucasians listed significantly more ecological services than others, 2) after Caucasians, Hispanics listed them the most often, 3) only 2 % of Asians listed them, 4) none were listed by Middle Easterners, and 5) the differences were significant for the whole data set, but not for the shore or central Jersey when considered separately (Table 8).

Discussion

Studies examining ratings for environmental and ecological concerns usually include demographics, location, and proximity to some stressor, such as a nuclear or chemical plant (Kunreuther et al. 1990; Bullard 1994; Greenberg et al. 2007), wind facility (Bartlett 2011), or airport (Kirschenbaum et al. 2012). For New Jersey, ratings of ecological concerns have been examined (Burger 2004; Burger and Greenberg 2006), but not for natural disasters. Support for environmental protection in New Jersey, especially from pollution, waxes and wanes (Greenberg 2004, 2005). The predicted increase in severity and frequency of hurricanes and other storms (IPCC 2007a, b; Kharin et al. 2007; Russo and Sterl 2012) will likely result in a greater awareness of the importance of ecological structures (i.e. high dunes, complex salt marshes), but there is a clear need to hasten this process.

Expressed ecological and environmental concerns and trusted information sources

On open-ended questions in the present study, respondents most often mentioned wildlife and fish as their greatest ecological concern, while beaches and dunes were most often mentioned as their greatest environmental concern. These data indicate that respondents distinguished resources (i.e. wildlife) from ecological structures (i.e. dunes), calling the latter environmental concerns. Clearly, the words are perceived differently, since both structure and resources are part of ecosystems. Toxics, a response often given to questions about environmental concerns, were mentioned far less often by respondents than beaches, dunes, and marshes.

While the responses indicate a general knowledge about the resources and ecological structures at risk from severe storms such as *Sandy*, they also indicate a lack of specific information about the important characteristics of ecological barrier (e.g. dunes, marshes) for resiliency. People generally mentioned beaches or dunes, without distinguishing protection, restoration, rebuilding, resiliency, or the role of each in overall protection of shore communities. Marshes were mentioned less often than beaches and dunes, perhaps because all shore residents are protected by beaches along the Atlantic coast, and only some of the communities are located on the mainland that have salt marsh complexes between the barrier islands and the mainland. A few people mentioned that marshes are flat, and so did not stop the storm surge, while high dunes did.

Wildlife and fish were the resources most often mentioned as important ecological concern. That wildlife was mentioned more often than fish may indicate concern for the food chain, rather than just a consumptive resource, such as fish. The listing of wildlife may well reflect overall recreational rates; a much higher percentage of respondents went to the beach or engaged in nature watching/photography than engaged in fishing, and they did so more often.

Stressor levels and ratings of ecological services

Stressor level (power outages, high winds, flooding) was a better predictor of ratings of ecological services than location (coastal vs central Jersey). This was surprising since nearness to the coast (the site of intense storm surges, high evacuation rates, and the longest power outages) should predict a close association with concern for ecological services. People with the greatest stressor level (and the most damage) rated ecological concerns higher than people with lower stressor levels and less damage. This indicates a degree of self-interest and the recognition that ecological services provided protection.

That people with less damage rated ecological services lower suggests the need for an integrated communication strategy to inform people of the interconnectedness of coastal and inland habitats and communities. The effect of distance from a disaster on perceptions has been noted previously (Trumbo et al. 2011). Over the long term, dunes, beaches and marshes (green infrastructures) protect communities; otherwise the coastline will simply migrate inland with the increasing frequency and intensity of storms. Coastal and nearby inland communities are linked by roads, power grids, commercial activity, and recreational opportunities (McGranahan et al. 2007; Klinenberg 2013). This is especially true in New Jersey where tourism is a main economic driver. Tourism involves day-trips, as well as seasonal rentals. Further, the Jersey shore has a number of permanent residents, and second-home residences (that may be rented out). Thus, although it was homes and businesses along the shore that suffered the most damage (Pffaf 2012), the effects cascaded throughout New Jersey and the region.

Recreational activities ratings

In the present study, recreational rate was the strongest predictor of ecological ratings following superstorm *Sandy*, for all stressor levels. In a previous study, Burger (2001) showed a positive relationship between recreational rates and valuation of ecological resources, but there was a correspondence between the rating and resource; people who engaged in a high frequency of fishing rated restoring fish populations higher than others ecological concerns. People who had the highest frequency of engagement in recreational activities also rated ecological services (dune protection, beach protection, salt marsh protection) higher than others. However, there was no direct connection between specific activities (e.g. fishing, boating) and ecosystem protection and integrity (dune restoration, loss of salt marshes). Clearly, however, coastal-oriented recreational activities depend upon a functioning ecosystem even though the connections were not as clear.

The lack of a direct connection, as occurs when people who fish frequently rate protection of fish populations high, suggests that connections should be made to the public in an

integrated educational strategy. For example, there is an economic connection between dune, beach, and salt marsh protection because coastal ecosystem integrity is essential to foster increased tourism, increased use of shore restaurants and businesses, and increased economic viability. Drawing the connections between coastal ecosystem health, recreation, tourism, and economic growth can lead to increased expenditures for protection of these ecosystems. This is a win-win situation, but requires collaboration among ecologists, economists, social scientists, physical scientists, architects, and the public to enhance the total ecological, economic, and cultural character of shore ecosystems.

Ethnic differences in ratings

There were significant ethnic differences in the overall ratings of ecological services, as well as for specific ecological services, for only central Jersey respondents. It is not clear whether this difference was due to age, income, education, or some other factors. Ethnic differences in environmental concerns have been reported in many studies, and minorities are often portrayed as less concerned about environmental issues (Arp and Kenny 1996; Bronfman and Cifuentes 2003), although it is not always the case (Burger 1998; Burger et al. 2004; Greenberg 2005). The question of culturally-dependent perceptions is important if we are to manage coastal communities for diverse populations (Burger and Greenberg 2006), especially given the changes in demographics expected over the next few decades (Huerta and Macario 1999). The New York/New Jersey area also experiences high rates of immigration into the region, and new immigrants may be less aware of the potential for coastal flooding because of time in the region, education, or lack of exposure to coastal dynamics. In a survey from Newark Bay and adjacent coastal New Jersey, Hispanics gave higher ratings to adding educational signs, creating more information brochures, and removing invasive plants, Asians gave higher ratings for improving habitat for birds, African Americans gave higher ratings to building promenades, and Caucasians and Asians gave higher ratings to improving habitat for butterflies than did others (Burger 2003b). In the present study, Caucasians also rated habitat (beaches dunes, marshes) higher than other ethnic groups.

Dune protection and perceptions

Understanding both physical and biological components of storm impacts, as well as human perception for the marsh/dune/barrier island complex along the coast, is critical to future preparedness. While considerable attention has been devoted to understanding and modeling storm impacts on beaches, dunes, and barrier islands (e.g. Roessler and Wells 2001; Stockdon et al. 2007), far less attention has been devoted to understanding perceptions of the importance of dunes, beaches, and marshes to protect human communities (Klinenberg 2013). The bottom-up approach of using beach-user's perceptions to guide management and public policy is not generally applied, but Roca et al. (2009) found that loyal, local users were more concerned with natural beach conditions than visitors. This agrees with the findings in the present study.

Coastal dunes are valued for aesthetics, as well as their ability to protect ecological and human communities (Nordstrom and Mitteager 2001; Pries et al. 2008). The quantity of storm-generated dune erosion is a function of storm characteristics, length of the storm, dune

structure, and storm surge (Sallenger 2000). In turn, dune structure and height influence surge effects on communities behind the dunes, whether ecological or human (Miller et al. 2001). The effect of storm-induced surges on communities depends upon surge elevation relative to dune height (Houser et al. 2008). The magnitude of damage to barrier islands and coastal communities is also partly dependent upon dune structure and height (Houser et al. 2008). Salt marsh vegetation provides a partial barrier to storm surges, although coastal vegetation is best suited to control sedimentary dynamics in response to gradual changes (e.g. sea level rise)(Nyman et al. 1995; Feagin et al. 2009). Although the public may appreciate beaches and dunes, they seldom appreciate salt marshes or understand the relationship among these coastal habitats (Koutrakis et al. 2011).

It was expected that people living along the coast would recognize the importance of beaches, dunes and marshes in preventing or dampening storm surges and flooding. Hurricanes with severe winds have hit New Jersey only three times in the last 700 years – in 1821 and in 1962, with another sometime between 1278 and 1438 (Donnelly 2001). Superstorm *Sandy* was not quite so severe, but overwash sediment was deposited along the coast (Pffaf 2012; USGS 2013).

There was considerable media attention following the storm (for those who had access to power) about the greater damage suffered by communities with no dunes or low dunes, compared to those with high and stable dunes. For many residents living close to the ocean, visibility of the ocean is an important attribute, and many fight vigorously against high dune restoration. This is likely to change because of the severity and increasing frequency of storms, sea level rise, and pressure from neighbors a few blocks away (who bear the risk from surge flooding, but do not reap the benefits of an ocean view). This dichotomy represents a “commons” issue; high dunes protect coastal communities from storm surges, thereby contributing to future resiliency, high dunes diminish beach-front residents view the ocean.

In the present study only 14 % of respondents listed ecological services that protect the shore and communities as one of their top three concerns from the list given ($N=28$ concerns). Further, only Caucasians listed loss of salt marshes as one of their top concerns. This may not be surprising, given that property damage, health issues, and inconveniences affected individuals directly, immediately, and personally, while dune protection may be perceived as a “community” or “commons” issue. That is, the “community” rather than the individual should pay for these services. Dune protection and dune restoration, however, were rated the highest for ecological services in general. A failure to list dune protection or restoration as one of their most important concerns may indicate a general failure to recognize the importance of dunes in protection of coastal communities, including protecting them directly from property damage due to storm surges.

Several surveys examined perceptions about environmental protection (Gallup Organization 2003, 2013; Greenberg 2004, 2005; Burger 2011). Overall, concern for loss of natural habitat for wildlife has declined from 58 % in 1989 to 44 % in 2008 (Gallup Organization 2013). Far fewer studies examine ecological structure, such as populations (e.g. birds, butterflies), or habitats (dunes, marshes), unless they relate to sensitive, charismatic, or

endangered species (Brackney and McAndrew 2001; Burger 2011; Choi and Fielding 2012, Rodrigues et al. 2012). Further, few studies examine perceptions of ecological functioning such as the role of beaches, dunes or marshes in upland protection (but see Priskin 2003; Harmon et al. 2004; Marin et al. 2000; Roca et al. 2009; Koutrakis et al. 2011).

Public policy implications

It is critical for the public to understand the importance of ecological barriers (beach/dune, salt marsh ecosystem) that protect upland ecosystems and associated human communities, and for regions to develop paradigms for sustainable development of coastal zones (Koutrakis et al. 2011; Klinenberg 2013). Addressing coastal conflicts between individual and community interests, and protecting natural and cultural resources, pose long-term challenges. There is a need to balance coastal development with restoring or maintaining an ecologically functioning coastal environment (Thom et al. 2005). New Jersey dealt with the storm by waiving permit requirements to fasttrack rebuilding infrastructure, such as roads, bridges, bulkhead and culverts (Pffaf 2012), perhaps wasting an opportunity for smart rebuilding that is ecologically sound.

Coastal communities without ecological barriers to the action of surges, waves, and wind are vulnerable to severe storms (Day et al. 2007). Beach replenishment (or nourishment) along the 208 km of NJ Atlantic coast, whereby sand is replaced in depleted beaches by pumping in submerged sand, has cost taxpayers \$475 million since 1990 (Pffaf 2012). This sand replaced beaches, but it did not create dunes that could protect communities. While creating and restoring stable, high dunes is more costly and more difficult than merely pumping sand onto depleted beaches, it is more effective over the long-term. Without an understanding of the ecological dynamics, or at the least an understanding of the role of dunes, marshes, and barrier islands in the protection of human communities, coastal inhabitants will be doomed to continued vulnerability and storm-related damage.

Resiliency may well depend upon rebuilding based on pre-existing conditions, thus returning the coastal environment to its natural state, with wide beaches, high dunes, back flood-pans, salt marshes, and robust barrier islands. While development is inevitable along the New Jersey shore, and elsewhere in the northeastern United States, rebuilding coastal communities soundly, taking into account the natural functioning of beaches, dunes and salt marshes, will increase resiliency. Managing these environments by building higher dunes, stabilizing dunes, maintaining long stretches of dunes of similar height and complexity, and creating flooding catchments will further improve resiliency. In some places, the reestablishment of more natural coastal ecosystems, often called managed realignment, is viewed as “giving in” to the sea (Myatt-Bell et al. 2002), and is opposed by the public. Since many different perceptions affect public responses to managing coastal environments, it is important to understand these perceptions, and their relationship to demographics, past damage from storms, location of residency, and recreational rates.

The importance of stressor level, and damages suffered, to ratings of ecological services is not surprising. People who suffered flood damage are likely to look to coastal structures that did or did not protect their homes and personal safety. This suggests that the relationship between ecological barriers and damage/health and safety effects needs to be part of coastal

education and training programs so that both coastal and inland communities recognize the importance of dunes, beaches, and salt marshes. Site-specific, local needs should be addressed with particular assessments, educational strategies, and demand-driven studies.

People who use the shore clearly have a better understanding of the role of beach, dunes and salt marshes in protection of their communities. This finding provides an entrée to development of an educational strategy that aims to highlight the importance of dunes, beaches and marshes to community protection, and suggests that encouragement of more widespread use of coastal resources could lead to improved investment in these ecosystems. This would increase tourism in the coastal zone, directly through expenditures of tourists, but indirectly through investment in tourist-related industries and transportation infrastructure.

The data presented herein have implications for public policy, particularly with respect to building regulations (where and how high to build structures), beach nourishment, dune stabilization, salt marsh protection, and other management options (Rogers 1990). Sound public policy must incorporate the development of an integrated coastal protection policy that benefits the larger society, rather than the few that live adjacent to the beach with the means to rebuild after every disaster. The data in this study indicate that ecological services, and the protection of coastal ecological barriers, were not rated as high as gas shortages, downed trees, and other inconveniences. A targeted information strategy should be part of the public policy debate about resiliency. Disruption of coastal communities no longer affects only those living within a few km of the coast, but the entire region. While the health risk to coastal communities may be severe, inland communities can suffer (severe hurricanes come inland), and even without direct damage, inland communities suffer because of the disruption to the larger regional infrastructure, tourism, and redirection of construction and repair industries. Disaster relief becomes a national issue because the entire country pays for these programs (e.g. FEMA, HUD). Understanding and influencing perceptions of the importance of maintaining healthy coastal ecosystems, with wide beaches, stable dunes, and a complex of salt marshes, is essential to building resiliency in coastal communities.

Acknowledgments

We particularly thank the respondents who gave willingly of their time to be interviewed, and the many town officials, agency personnel, commercial owners and others who gave permission to interview people in their facilities, as well as C. Jeitner, T. Pittfield and M. Donio for help with the interviews and graphics. This research was funded by a pilot grant from NIEHS (P30ES005022). This paper represents the views of the author, and not the funding agency.

References

- Arp W III, Kenny C. Black environmentalism in the local community context. *Environ Behav.* 1996; 28:267–282.
- Barneget Bay Beat (BBB). Special Report: Sandy-a record setting storm. Barneget Bay Partnership Quart. Publ. 2012:7.
- Bartlett, G. Joint fact finding and stakeholder consensus building at the Altamont Wind Resource Area in California. In: Burger, J., editor. *Stakeholders and scientists: achieving implementable solutions to energy and environmental issues.* Springer; New York: 2011. p. 255-282.

- Brackney M, McAndrew FT. Ecological World views and receptivity to different types of arguments for preserving endangered species. *J Environ Educ.* 2001; 33:17–20.
- Bronfman N, Cifuentes L. Risk perception in a developing country: the case of Chile. *Risk Anal.* 2003; 23:1271–1285. [PubMed: 14641900]
- Bullard, RD. *Unequal protection: environmental justice and communities.* Sierra Club Books; California: 1994.
- Burak S, Dogan E, Gazioglu C. Impact of urbanization and tourism on coastal environment. *Ocean Coast Manag.* 2004; 47:515–527.
- Burger J. Environmental attitudes and perceptions of future land use at the Savannah River Site: are there racial differences? *J Toxicol Environ Health.* 1998; 53:255–262.
- Burger J. Stewardship and future land use at a Department of Energy site: does self-interest determine ratings? *J Toxicol Environ Health.* 2001; 63:383–395.
- Burger J. Assessing perceptions about ecosystem health and restoration option in three East Coast estuaries. *Environ Monit Assess.* 2003a; 83:145–162. [PubMed: 12691528]
- Burger J. Consistency among methods of assessing concerns about the Los Alamos National Laboratory. *J Toxicol Environ Health.* 2003b; 66:199–210.
- Burger J. Fish consumption advisories and why people fish in an urban estuary. *J Risk Res.* 2004; 7:461–479.
- Burger J. Assessing environmental attitudes and concerns about a contaminated site in a densely populated suburban environment. *Environ Monit Assess.* 2005; 101:147–165. [PubMed: 15739267]
- Burger J. Valuation of environmental quality and eco-cultural attributes in Northwestern Idaho: native Americans are more concerned than Caucasians. *Environ Res.* 2011; 111:136–142. [PubMed: 21035796]
- Burger J, Gochfeld M. Health concerns and perceptions of central and coastal New Jersey residents within 100 days of Superstorm *Sandy*. *Sci Tot Environ.* 2014; 481:611–618.
- Burger J, Greenberg M. Ethnic differences in ecological concerns: spanish-speaking Hispanics are more concerned than others. *Environ Res.* 2006; 102:36–45. [PubMed: 16457804]
- Burger J, Roush DE, Ramon R, Gochfeld M. Risk concerns, land use, stewardship, and the Idaho National Engineering and Environmental laboratory: attitudes of the Shoshone-Bannock and other American Indians. *Environ Res.* 2000; 83:298–310. [PubMed: 10944074]
- Burger J, Sanchez J, Roush D, Gochfeld M. Risk perception, future land use and stewardship: comparison of attitudes about Hanford Site and Idaho National Engineering and Environmental Laboratory. *J Environ Manag.* 2001; 61:265–280.
- Burger J, Myers O, Boring CS, Dixon C, Lord C, Ramos R, Shukla S, Gochfeld M. Perceptions of general environmental problems, willingness to expend federal funds on these problems, and concerns regarding the Los Alamos National Laboratory: Hispanics are more concerned than others. *Environ Res.* 2004; 102:36–45. [PubMed: 16457804]
- Burger J, Gochfeld M, Jeitner C, Pittfield T, Donio M. Trusted information sources used during and after Superstorm *Sandy*: TV and radio were used more often than social media. *J Toxicol Environ Health.* 2013; 76:1138–1150.
- Casagrande DG. A value based policy approach: the case of an urban salt marsh. *Coastal Manag.* 1996; 24:327–337.
- Choi AS, Fielding JS. Environmental attitudes as WTP predictors: a case study involving endangered species. *Ecol Econ.* 2012; 89:24–32.
- Crosset, K.; Cultiton, T.; Wiley, P.; Goodspeed, T. Population trends along the coastal United States 1980–2008. 2013. <http://oceanservice.noaa.gov/programs/mb/pdfs/coastal.pop.trends.complete.pdf> Accessed 14 May 2013
- Day JW Jr, Boesch DF, Clairain EJ, Kemp GP, Laksh SB, Mitsch WJ, Orth K, Mashrqui H, Reed DJ, Shabman L, Simenstad CA, Steever BJ, Twilley RR, Watson CC, Wells JT, Whigham DF. Restoration of the Mississippi Delta: lessons from hurricanes Katrina and Rita. *Sci.* 2007; 315:1679–1684.
- Donnelly JP, Roll S, Wengren M, Butler J, Lederer R, Webb T III. Sedimentary evidence of intense hurricane strikes from New Jersey. *Geol.* 2001; 29:615–618.

- Eisenman DP, Cordasco KM, Asch R, Golden JF, Glik D. Disaster planning and risk communication with vulnerable communities: lessons from Hurricane Katrina. *Am J Publ Health Suppl.* 2007; 1(97):S109–115.
- Faust BB, Smardon RC. Introduction and overview: environmental knowledge, rights, and ethics: co-managing with communities. *Environ Sci Policy.* 2001; 4:147–151.
- Feagin RA, Lozada BML, Ravens TM, Moller I, Yeager KM, Baird AH. Does vegetation prevent wave erosion of salt marsh edges. *PNAS.* 2009; 106:10109–10113. [PubMed: 19509340]
- Freedman, A. Heeding Sandy's lessons, before the next big storm. *Climate Central.* 2013. www.climatecentral.org/news/four-lay-lessons-learned-from-hurricane-sandu-15928. Accessed 17 June 2013
- Frey, JH.; Oishi, SM. *The Survey Kit.* Vol. 4. Sage; California: 1995. How to conduct interviews by telephone and in person.
- Gallup Organization. Environment. 2003. <http://gallup.com/poll/topics/environment.asp>. Accessed 4 May 2009
- Gallup Organization. Environment. 2013. <http://gallup.com/poll/1615/environment.aspx?>. Accessed August 2013
- Genovese E, Przulski V. Storm surge disaster risk management: the Xynthia case study in France. *J Risk Res.* 2013; 16:825–841.
- Greenberg M. Is public support for environmental protection decreasing? *Environ Health Perspect.* 2004; 112:121–125. [PubMed: 14754564]
- Greenberg M. Concern about the environment: how much difference do race and ethnicity make? *Environ Health Perspect.* 2005; 113:369–374.
- Greenberg M, Lowrie K, Burger J, Powers CW, Gochfeld M, Mayer H. Nuclear waste and public worries: public perceptions of the United States major nuclear weapons sites. *Human Ecol Rev.* 2007; 14:1–12.
- Harmon, D.; Kilgore, BM.; Vietzke, GE. *Protecting our diverse heritage: the role of parks, protected areas and cultural sites.* George Wright Soc; Michigan: 2004.
- Houser C, Hapke C, Hamilton S. Controls on coastal dune morphology, shoreline erosion and barrier island response to extreme storms. *Geomorphol.* 2008; 100:223–240.
- Huerta EE, Macario E. Communicating health risk to ethnic groups: reaching Hispanics as a case study. *J Natl Cancer Inst Monogr.* 1999; 35:23–26. [PubMed: 10854453]
- Ingle, C.; Leung, Y.; Monz, C.; Bauman, H. Monitoring visitor impacts in coastal national parks: a review of techniques. In: Harmon, D.; Kilgore, BM.; Vietzke, GE., editors. *Protecting our diverse heritage: the role of parks, protected areas and cultural sites.* George Wright Soc; Michigan: 2004. p. 228–233.
- IPCC. *Climate change 2007: synthesis report. Contribution of working groups I, II and III to the fourth assessment report of the intergovernmental panel on climate change.* Geneva, Switzerland: IPPC; 2007. p. 104
- IPCC. *Climate change 2007: the physical science basis.* Geneva, Switzerland: IPPC: 2007. p. 28
- Jentoft S. Commentary - co.-managing the coastal zone: is the task too complex? *Ocean Coast Manag.* 2000; 43:527–535.
- Kharin VV, Zwiers FW, Zhang X, Hegerl GC. Changes in temperature and precipitation extremes in the IPCC ensemble of global coupled simulations. *J Clim.* 2007; 20:1419–1444.
- Kirschenbaum AA, Mariani M, Van Gulijk C, Rapaport C, Lubasz S. Airports at risk: the impact of information sources on security decisions. *J Transp Secur.* 2012; 5:187–197.
- Klinenberg E. *Adaptation.* New Yorker. 2013:32. Jan 7, 2013.
- Koutrakis E, Sapounidis A, Marzetti S, Marin V, Roussel S, Martino S, Fabiano M, Paoli C, Rey-Valette H, Povh D, Malvarez CG. ICZM and coastal defense perception by beach users: lessons from the Mediterranean coastal area. *Ocean Coast Manag.* 2011; 54:821–830.
- Kratovil, C. Drinking water problems cause evacuation of every dorm in New Brunswick. *New Brunswick Today.* 2012. Available: <http://newbrunswicktoday.com/article/drinking-water-concerns-cause-rutgers-pull-students-out-new-brunswick> Accessed 17 June 2013

- Kunreuther H, Easterling D, Desvousges W, Slovic P. Public attitudes toward siting a high-level nuclear waste repository in Nevada. *Risk Anal.* 1990; 10:469–484.
- Lane LK, Charles-Guzman K, Wheeler Z, Abid N, Graber N, Matte T. Health effects of coastal storms and flooding in urban areas: a review and vulnerability assessment. *J Environ Publ Health.* 2013; 2013:1–13.
- Marin V, Palmisani IR, Dursi R, Fabiano M. Users' perception analysis for sustainable beach management in Italy. *Ocean Coast Manag.* 2000; 52:268–277.
- McGranaham G, Balk D, Anderson B. The rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones. *Environ Urbaniz.* 2007; 19:17–37.
- McLaughlin KA, Fairbank JA, Gruber MJ, Jones RT, Osofsky JD, Pfefferbaum B, Sampson NE, Kessler RC. Trends in serious emotional disturbance among youths exposed to Hurricane Katrina. *J Am Acad Child Adolesc Psy.* 2010; 49:990–1000.
- Miller DL, Thetford M, Yager L. Evaluation of sand fence and vegetation for dune building following overwash by hurricane Opal on Santa Rosa Island, Florida. *J Coastal Res.* 2001; 17:936–948.
- Myatt-Bell LB, Scrimshaw MD, Lester JN, Potts JS. Public perception of managed realignment: Brancaster West Marsh, UK. 2002
- National Research Council (NRC). Panel on public participation in environmental assessment and decision-making. National Academy of Sciences; Washington DC: 2008.
- Neria Y, Shultz JM. Mental health effects of Hurricane Sandy: characteristics, potential aftermath, and response. *JAMA.* 2013; 308:2571–2572. [PubMed: 23160987]
- New York City Panel on Climate Change (NPCC2). Climate risk information 2013. NYC Mayor's office; New York: 2013.
- Newton A, Carruthers TJB, Icely J. The coastal syndromes and hotspots on the coast. *Estuar Coast Shelf Sci.* 2012; 96:39–47.
- NOAA (National Oceanographic and Atmospheric Administration). Communities: the U.S. population living in coastal watershed counties. 2012. <http://stateofthecoast.noaa.gov/population/welcome.html>. Accessed 3 April 2012
- Nordstrom KF, Lotstein EL. Perspectives on resource use of dynamic coastal dunes. *Geograph Rev.* 1989; 79:1–12.
- Nordstrom KF, Mitteger WA. Perceptions of the value of natural and restored beach and dune characteristics by high school students in New Jersey, USA. *Ocean Coastal Manag.* 2001; 44:545–559.
- North CS, Oliver J, Pandya A. Examining a comprehensive model of disaster-related posttraumatic stress disorder in systematically studied survivors of 10 disasters. *Am J Publ Health.* 2012; 102:40–48.
- Nyman JA, Crosier CR, DeLaune RD. Roles and patterns of hurricane sedimentation in an estuarine marsh landscape. *Estuar Coastal Shelf Sci.* 1995; 40:665–679.
- Pffaf LG. Sea change: the post-Sandy rebuilding is about to begin. *New Jersey Monthly.* 2012; 2012:45–51.
- Plant NG, Stockdon HF, Sallenger AH Jr, Turco MJ, East JW, Taylor AA, Shaffer WA. Forecasting hurricane impact on coastal topography. *Eos.* 2010; 91:65–72.
- Pries AJ, Miller DL, Branch LC. Identification of structural features that influence storm-related dune erosion along a barrier island ecosystem in the Gulf of Mexico. *J Coastal Res.* 2008; 24:168–176.
- Priskin J. Tourist perceptions of degradation caused by coastal nature-based recreation. *Environ Manag.* 2003; 32:189–204.
- Roca E, Villares M, Orgego MI. Assessing public perceptions on beach quality according to beach users' profile: a case study in the Costa Brava (Spain). *Tourism Manag.* 2009; 30:598–607.
- Roessler TX, Wells JT. Beach changes along eastern Bogue Banks, North Carolina, resulting from the 1996 hurricane season. *J Coast Res.* 2001; 17:964–975.
- Rogers, SM, Jr. Designing for storm surge and wave damage in coastal buildings. *Coast Envineer Conf*; Netherlands: 1990.
- Russo S, Sterl A. Global changes in seasonal means and extremes of precipitation from daily climate model data. *J Geophysic Res.* 2012; 117 DOI 108.

- Sallenger AH Jr. Storm impact scale for barrier islands. *J Coastal Res.* 2000; 16:890–895.
- Sedovski I, Newton A, Dennison WC. Megacities in the coastal zone: using a driver-pressure-state-impact-response framework to address complex environmental problems. *Estuar Coast Shelf Sci.* 2012; 96:48–59.
- Shear MK, McLaughlin KA, Ghesquiere A, Gruber MJ, Sampson NA, Kessler RC. Complicated grief associated with hurricane Katrina. *Depres Anxiety.* 2011; 28:648–57.
- Statistical Analysis Systems (SAS). *Statistical Analysis.* Cary NC: SAS; 2005.
- Stockdon HF, Sallenger AH Jr, Holman RA, Howd PA. A simple model for the spatially-variable coastal response to hurricanes. *Mar Geol.* 2007; 238:1–20.
- Thom RM, Williams GW, Diefenderfer HL. Balancing the need to develop coastal areas with the desire for an ecologically functioning coastal environment: Is net ecosystem improvement possible? *Restor Ecol.* 2005; 13:193–203.
- Trumbo C, Lueck M, Marlatt H, Peek L. The effect of proximity to Hurricanes Katrina and Rita on subsequent hurricane outlook and optimistic bias. *Risk Anal.* 2011; 31:1907–1918. [PubMed: 21605150]
- US. Geological Survey (USGS). Fact Sheet 2010–3012. US Dept of the Interior; Washington, DC: 2010. Impacts and predictions of coastal change during hurricanes.
- US. Geological Survey (USGS). Hurricane Sandy: updated assessment of potential coastal-change impacts. 2013. <http://coastal.er.usgs.gov/hurricanes/sandy/coastal-change/initialassessment.php> Accessed 22 July 2013

Fig. 1. Relative ratings on different categories of concerns, including property damage, inconveniences, health, ecological and nuclear, given by coastal and central New Jersey respondents following Superstorm *Sandy*

Fig. 2.
Mean ($\pm$ standard deviation) rating of general ecological services as a function of distance respondents lived from the ocean

Fig. 3. Mean ($\pm$ standard deviation) rating of specific ecological services for respondents from central and coastal New Jersey following Superstorm *Sandy*

Fig. 4. Rating of specific ecological services for respondents from central and coastal New Jersey as a function of stressor level. Note that the scale differs from Fig. 3

Table 1

Demographics and effects following Superstorm Sandy for people living in Central and Coastal New Jersey.
Given are means±standard error

	Overall (N=756)	Jersey Shore (N=347)	Central New Jersey (N=409)	
Demographics	Mean Std Error	Mean Std Error	Mean Std Error	Kruskal Wallis Chi-square (p)
Age	41.5±0.64	51.79±0.76	32.64±0.76	218 (<0.0001)
Years of education	14.24±0.16	14.98±0.12	13.57±0.27	NS
Income	65,286±3,298	68,683±3,247	59,054±7,196	15.8 (<0.0001)
% Female	49.3 %	46.5 %	51.6 %	NS
Ethnicity				
Caucasian	65.5 %	86.8 %	46.6 %	161 (<0.0001)
Hispanic/Latino	6.5 %	5.6 %	7.3 %	
African American	5.6 %	4.7 %	6.5 %	
Indian	6.6 %	1.8 %	10.9 %	
Asian	12.9 %	1.2 %	23.3 %	
Middle Eastern	2.9 %		5.4 %	
Mean Distance to Ocean	12.7±0.7	2.14±0.22	21.25±1.08	384 (<0.0001)
Percent Live in House	77.9 %	84.3 %	71.4 %	56.9 (<0.0001)
Outcome and Effects				
% evacuated	28.6 %	46.8 %	13.1 %	103 (<0.0001)
% mandatory evacuation (of those evacuated)	64.1 %	69.9 %	51.0 %	5.5 (0.02)
mean days evacuated	29.3±2.3	35.1±2.77	11.24±2.92	25.0 (<0.0001)
mean height of water in House (inches)	30.8±1.6	36.47±2.93	15.5±2.81	26.3 (<0.0001)
% lost electricity	95.4 %	99.4 %	91.9 %	24.0 (<0.0001)
% lost electricity and wind damage	59.9 %	83.1 %	39.6 %	152 (<0.0001)
% lost electricity, wind damage, and flooding	31.9 %	52.5 %	13.7 %	135 (<0.0001)
mean days without electricity?	13.3±0.7	22.79±1.36	6.01±0.32	242 (<0.0001)
% had generator	28.2 %	36.0 %	21.5 %	18.6 (<0.0001)
Recreational Rates				
Go to beach % participate	83.3 %	87.0 %	80.2 %	6.3 (0.01)
(days/year) for those who participate	59.2±3.6	105.8±6.3	16.3±1.5	226 (<0.0001)
Boating % participate	24.2 %	27.4 %	21.5 %	3.5 (0.06)
(days/year) for those who participate	19.8±2.5	29.5±4.1	9.3±2.1	27.8 (<0.0001)
Parasailing/Surfing % participate	7.4 %	5.8 %	8.8 %	NS
(days/year) for those who participate	17.1±4.3	27.9±10.2	11.2±3.2	5.0 (0.03)
Nature watching/photography % participate	26.9 %	18.2 %	34.2 %	24.7 (<0.0001)
(days/year) for those who participate	52.2±6.9	109±16.6	26.6±5.6	42.2 (<0.0001)
Fishing (total) % participate	26.7 %	37.5 %	17.6 %	37.8 (<0.0001)
(days/year) for those who participate	46.3±5.8	46.4±6.1	46.01±12	7.7 (0.006)
Fishing (saltwater) % participate	20.5 %	36.0 %	12.5 %	35.3 (<0.0001)
(days/year) for those who participate	34.3±4.9	45.7±7	11.3±1.87	14.9 (0.0001)

	Overall (N=756)	Jersey Shore (N=347)	Central New Jersey (N=409)	
Demographics	Mean Std Error	Mean Std Error	Mean Std Error	Kruskal Wallis Chi-square (p)
Fishing (freshwater) % participate	8.6 %	36.0 %	12.5 %	13.0 (0.0003)
(days/year) for those who participate	47.2±13.4	17.3±4.1	56.9±17.6	NS

Table 2

Ecological concerns and trusted information sources following Superstorm Sandy. Percent of subjects ($N=747$) from the Jersey Shore and Central New Jersey that had the following Ecological and Environmental concerns with Superstorm Sandy. People often gave more than one response

<u>Ecological and Environmental Concerns</u>				<u>Ecological and Environmental Information Sources</u>			
<u>Ecological</u>		<u>Ecological</u>		<u>Ecological</u>		<u>Environmental</u>	
	Freq	Percent			Percent		Percent
Wildlife	84	55	65.5 %	TV	58.7 %	TV	61.4 %
Fish	84	33	39.3 %	Web/Internet	Web/Internet	Web/Internet	17.9 %
Ocean or Bay	84	7	8.3 %	Radio	9.1 %	Radio	10.7 %
They Return	84	4	4.8 %	Friends/Family	7.1 %	Town	7.9 %
All/Everything	84	4	4.8 %	Social Media	5.4 %	Government	4.6 %
Other	84	4	4.8 %	Town & Reverse 911	5.4 %	Friends/Family	5.0 %
Soil	84	3	3.6 %	Government	4.2 %	Social Media	4.3 %
Sludge	84	2	2.4 %	University/Scientist	2.2 %	All	2.1 %
Trees	84	1	1.2 %	Email	1.7 %	State	2.1 %
Environmental				Newspapers	1.5 %	Newspaper	1.4 %
				State	1.5 %	University/Scientist	1.4 %
Beaches	107	76	71.0 %	Other	1.0 %	Email	1.1 %
Dunes	107	55	51.4 %	Community	0.7 %	Newspaper	1.1 %
Marshes	107	24	22.4 %	FWS	0.5 %	EPA	0.7 %
Other	107	8	7.5 %	Media	0.5 %	Self	0.7 %
Toxics	107	4	3.7 %	NJ DEP	0.2 %	Board of Health	0.4 %
Debris	107	2	1.9 %	FEMA	0.2 %	Boat captain	0.4 %
Everything	107	2	1.9 %	Police	0.2 %	NJ DEP	0.4 %
Mold	107	2	1.9 %	Self	0.2 %	Police	0.4 %
Oil/Gas	107	2	1.9 %	Signs	0.2 %	Waterways Dept	0.4 %

Table 3

Models explaining variation in overall ecological ratings for people interviewed following Superstorm Sandy in New Jersey as a function of stressor level.

	Ecological			
	Overall	Power Outages	Power Outages & Wind Damage	Power Outages Wind Damage & Flooding
Model				
F	21.7	3.3	9.2	3.8
df	14	13	13	13
P	<0.0001	0.0002	<0.0001	<0.0001
r ²	0.34	0.18	0.43	0.20
Factors entering				
F (p)				
Total Days Recreating	26.1 (<0.0001)	7.8 (0.006)	8.2 (0.005)	13.0 (0.0004)
Location	NS	NS	NS	NS
Stressor Level	11.2 (0.0009)	–	–	–
Distance to Ocean	3.0 (0.09)	NS	NS	NS
Location X Age	NS	NS	NS	NS
Location X Education	NS	NS	NS	NS
Ethnicity	6.3 (<0.0001)	2.1(0.08)	4.3 (0.002)	NS
Days without Electricity	NS	6.1 (0.01)	2.9 (0.09)	NS
Home Repairs Needed	NS	NS	NS	NS

NS = not significant

Table 4

Ethnic differences in general ecological concerns rating (mean±standard error) for people interviewed in New Jersey following Superstorm Sandy. *N* = no one of that ethnicity.

Overall <i>n</i> =728		Coastal New Jersey <i>n</i> =342	Central New Jersey	χ^2 Kruskal-Wallis
Ethnicity	N			
Overall		2.62±0.04	2.08±0.05	190 (<0.0001)
Caucasian	477	2.92±0.05	2.31±0.08	83.9 (<0.0001)
Hispanic	47	2.40±0.17	1.84±0.18	16.5 (<0.0001)
African American	41	2.32±0.17	1.84±0.18	12.4 (0.0004)
Asian	142	1.99±0.09	1.95±0.09	4.3 (0.04)
Middle Eastern	21	1.63±0.18	1.63±0.18	
χ^2		93.5 (<0.0001)	NS	20.5 (0.0004)

NS = not significant

Table 5

Rating of ecological concerns (mean $\pm$ standard error) following Superstorm Sandy as a function of ethnicity and recreational rates.

		Power Outages $n=263$	Power Outages & Wind Damage $n=208$	Power Outages Wind Damage & Flooding $n=236$	χ^2 Kruskal-Wallis
Total Days Recreating/Year	N				
Overall		2.27 $\pm$ 0.07	2.60 $\pm$ 0.08		
0 to 3	157	1.81 $\pm$ 0.12	2.01 $\pm$ 0.14	3.15 $\pm$ 0.07	72.0 (<0.0001)
4 to 12	145	2.11 $\pm$ 0.16	1.95 $\pm$ 0.16	2.70 $\pm$ 0.20	16.9 (0.0002)
13 to 40	172	2.27 $\pm$ 0.12	2.45 $\pm$ 0.15	2.48 $\pm$ 0.21	NS
41 to 125	143	2.67 $\pm$ 0.15	3.02 $\pm$ 0.15	2.86 $\pm$ 0.16	8.9 (0.01)
Over 125	148	3.22 $\pm$ 0.23	3.55 $\pm$ 0.17	3.33 $\pm$ 0.13	10.7 (0.005)
χ^2		40.3 (<0.0001)	54.9 (<0.0001)	3.58 $\pm$ 0.11	NS
	n=263		n=207	31.7 (0.02)	
Ethnicity				n=229	
Overall		2.27 $\pm$ 0.07	2.60 $\pm$ 0.08	3.15 $\pm$ 0.07	72.0 (<0.0001)
Caucasian		2.53 $\pm$ 0.1	2.93 $\pm$ 0.09	3.27 $\pm$ 0.08	31.3 (<0.0001)
Hispanic		2.14 $\pm$ 0.24	2.35 $\pm$ 0.36	3.21 $\pm$ 0.26	6.5 (0.04)
African American		1.84 $\pm$ 0.23	2.04 $\pm$ 0.29	2.98 $\pm$ 0.31	7.7 (0.02)
Asian		2.03 $\pm$ 0.13	1.77 $\pm$ 0.13	2.46 $\pm$ 0.25	NS
Middle Eastern		1.84 $\pm$ 0.29	2.25 $\pm$ 0.15	N	NS
χ^2		16.5 (0.002)	42.0 (<0.0001)	9.7 (0.02)	

N=no one of that ethnicity. NS=not significant

Table 6

Differences in the rating (mean $\pm$ standard error) of specific ecological services following superstorm Sandy as a function of recreational rates.

	Total number of days recreating outdoors per year						Kruskal-Wallis χ^2
	Overall $n=765$	0 to 3 $n=157$	4 to 12 $n=145$	13 to 40 $n=172$	41 to 125 $n=143$	Over 125 $n=148$	
Overall Ecological Services	2.62±0.04	2.05±0.08	2.09±0.09	2.47±0.08	3.00±0.08	3.48±0.09	162 (<0.0001)
Beach erosion	3.14±0.05	2.35±0.11	2.52±0.12	3.18±0.10	3.66±0.10	3.97±0.09	144 (<0.0001)
Dune protection	2.83±0.05	2.20±0.11	2.26±0.12	2.74±0.11	3.25±0.11	3.66±0.11	104 (<0.0001)
Dune restoration	2.83±0.06	2.25±0.12	2.13±0.11	2.66±0.11	3.34±0.12	3.76±0.11	124 (<0.0001)
Loss of salt marshes	2.61±0.05	2.07±0.10	2.04±0.11	2.50±0.10	3.04±0.10	3.40±0.11	109 (<0.0001)
Replace dune vegetation	2.66±0.05	2.14±0.11	2.03±0.11	2.42±0.10	3.10±0.12	3.58±0.11	121 (<0.0001)
Bird populations	2.25±0.05	1.80±0.08	1.90±0.10	2.15±0.09	2.42±0.10	2.97±0.11	80.3 (<0.0001)
Fish populations	2.34±0.05	1.82±0.09	1.80±0.10	2.16±0.10	2.61±0.11	3.30±0.12	111 (<0.0001)
Fishing places	2.20±0.05	1.69±0.08	1.70±0.10	1.91±0.09	2.52±0.11	3.18±0.13	117 (<0.0001)
χ^2		32.4 (<0.0001)	40.3 (<0.0001)	103 (<0.0001)	104 (<0.0001)	58.3 (<0.0001)	

NS=not significant

Table 7

Ethnic differences in the rating (mean±standard error) of specific ecological services following superstorm Sandy.

	Overall <i>n</i> =408	African American <i>n</i> =25	Asian <i>n</i> =132	Caucasian <i>n</i> =180	Hispanic <i>n</i> =28	Middle Eastern <i>n</i> =21	Kruskal-Wallis χ^2
Overall Ecological Services	2.08±0.05	1.84±0.18	1.95±0.09	2.31±0.08	1.84±0.18	1.63±0.18	20.5 (0.0004)
Beach erosion	2.61±0.07	2.08±0.21	2.27±0.12	3.06±0.10	2.29±0.25	2.43±0.32	31.4 (<0.0001)
Dune protection	2.25±0.07	1.84±0.24	2.21±0.12	2.44±0.11	2.22±0.28	1.71±0.25	8.8 (0.07)
Dune restoration	2.14±0.07	1.60±0.17	1.92±0.10	2.47±0.11	2.04±0.26	1.33±0.16	26.5 (<0.0001)
Loss of salt marshes	2.11±0.06	2.04±0.25	1.91±0.11	2.37±0.10	1.82±0.21	1.71±0.23	15.4 (0.004)
Replace dune vegetation	1.99±0.06	1.60±0.17	1.92±0.10	2.16±0.09	1.86±0.22	1.24±0.15	17.3 (0.002)
Bird populations	1.92±0.06	1.64±0.21	1.92±0.10	2.06±0.09	1.54±0.14	1.57±0.25	10.5 (0.03)
Fish populations	1.90±0.06	2.12±0.28	1.73±0.10	2.14±0.10	1.54±0.20	1.57±0.21	15.2 (0.004)
Fishing places	1.70±0.05	1.80±0.27	1.68±0.09	1.78±0.08	1.43±0.18	1.43±0.18	NS
χ^2	265 (<0.0001)	NS	26.0 (0.0005)	95.1 (<0.0001)	15.2 (0.03)	14.5 (0.04)	

NS=not significant

Table 8

People who listed these as one of their three top priorities of a list of concerns given. The overall χ^2 was 63.6 ($p < 0.0001$)

None of these concerns		Beach Erosion		Dune Protection, Restoration or re-vegetation		Loss of Salt Marsh		
	N		N		N		N	
Overall	608	86.2 %	64	9.1 %	81	11.5 %	5	0.7 %
Caucasian	368	81.8 %	54	12.0 %	70	15.6 %	5	1.1 %
Hispanic	37	86.0 %	3	7.0 %	5	11.6 %	0	0.0 %
African American	32	88.9 %	2	5.6 %	5	13.9 %	0	0.0 %
Asian	128	98.5 %	2	1.5 %	0	0.0 %	0	0.0 %
Middle Eastern	21	100.0 %	0	0.0 %	0	0.0 %	0	0.0 %
Chi-square (p)				14.7 (0.005)		22.2 (0.0002)		NS