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Constraints on restoring landforms and habitats on storm-damaged shorefront lots in New Jersey, USA

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ABSTRACT

Removal of shorefront houses following storm damage can provide opportunity to restore landforms and habitats and reduce risk to people and property. This opportunity was evaluated on the ocean coast of New Jersey, USA, following Hurricane Sandy, which occurred 29 October 2012. Houses were removed from 79 of 339 private shorefront lots in the 9 km-long segment having the greatest damage. Sixty lots remained empty four years after the storm. Mean dimensions of these empty lots were 66.3 m across shore and 23.4 m alongshore. Mean area of vegetation cover was 49.8% prior to the storm and 17.7% after the storm. The lots showed little indication of active landscaping after debris clearance, and the lots lacked topographic and vegetation diversity. The real estate value of empty lots appears too great for public purchase, and lots are weak points in shore protection plans when left to evolve naturally. A new bulkhead and extension of a pre-existing seawall built after the storm now isolate the former dune from the active backshore, eliminating natural sediment exchange between beach and dune on 47 of the 60 lots. Loss of the linkage between the backshore and dune caused by shore-parallel walls need not prevent restoration of native vegetation typical of the more stable backdune environments. Restoration actions that do not require buyout of properties for public use can contribute to the diversity, aesthetic appeal and resilience of the dune. The natural image may influence acceptance of natural vegetation and favor acceptance of managed retreat in the future when occupation of the shorefront becomes less tenable.

1. Introduction

1.1. Purpose

Coastal development has eliminated much natural ocean beach and dune habitat worldwide (Defeo et al., 2009). Elimination can occur by constructing buildings and infrastructure directly on coastal landforms or indirectly by progressive erosion of landforms located between the shoreline and fixed human structures. Shore protection structures, such as seawalls, bulkheads and revetments, protect buildings and infrastructure but restrict space for natural landforms and habitats to form or survive (Dugan and Hubbard, 2006; Dugan et al., 2008, 2011; Pilkey and Cooper, 2014). Sandy beach ecosystems can adapt to storms and sea level rise by retreating landward and maintaining structure and function over various spatial and temporal scales (Berry et al., 2013). The advantages of allowing landforms and habitats to evolve by natural processes are acknowledged, but actual responses by removing human structures are limited and often resisted by the public (Ledoux et al., 2005; Abel et al., 2011; Luisetti et al., 2011; Morris, 2012; Niven and Bardsley, 2013; Cooper and Pile, 2014; NRC, 2014; Costas et al., 2015; Harman et al., 2015). Removal of structures occurs mostly on rural lands on low energy coasts to restore marshlands farther landward in managed realignment projects (French, 2006; Rupp-Armstrong and Nicholls, 2007). Managed realignment by removing structures is rarely implemented on exposed sandy coasts because of the great public interest in beach recreation and the human-use value of beaches (Nordstrom et al., 2015) and the great economic value of land already in private ownership. Nevertheless, coastal communities are experiencing rising sea levels and increased frequency and severity of coastal storms (FitzGerald et al., 2008; Boon, 2012; Stocker et al., 2013), requiring reevaluation of practices for managing coastal properties.

Post storm evaluations of damage to developed coastal communities reveal ample evidence of the vulnerability of houses and infrastructure to storm damage (Saffir, 1991; Sparks, 1991; Platt et al., 2002; Kennedy et al., 2011; Hatzikyriakou et al., 2016; Hu et al., 2015; O'Neil and Van Abs, 2016). Destruction of houses during storms provides an opportunity for previously developed land to evolve naturally, if property owners resist developing the land further and avoid selling it for future

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development. Despite this opportunity to restore natural values and calls for implementing strategies for reducing the number of people and buildings at risk (Rabenold, 2013; NRC, 2014), this landscape conversion rarely occurs. Post storm human actions are conducted under extreme pressure of time, media attention and public sympathy for owners of damaged structures, resulting in rapid attempts to reestablish pre-storm uses (Platt et al., 2002), often including structures of greater unit value than the former ones (Nordstrom and Jackson, 1995).

The purpose of this paper is to identify constraints to reestablishing natural landforms and habitats on lots in private ownership fronting ocean beaches and identify opportunities for restoring some of the natural values. Storm damage of shorefront houses provides an incentive for change, but human desire for shorefront property and market value do not favor retreat from the coast. We acknowledge the advantages of reducing the exposure of people and property to hazards, but our emphasis is on restoring natural environments. This potential was evaluated by examining the fate of lots in the first (shorefront) row in northern New Jersey, USA, where houses were destroyed as a result of Hurricane Sandy, occurring 29 October 2012. Damage and removal of houses occurred farther landward than the shorefront, but our attention was on the seaward row of houses, where restoration of critical shore-dependent habitat would have the greatest value. Lots that remained abandoned four years after the storm were examined to see if they showed conspicuous evidence of evolving natural features. Most studies of the effects of damaging storms are conducted within a few months of the storm and published soon thereafter (Nordstrom and Jackson, 1995). We wanted to evaluate conditions several years after a storm when reconstruction of buildings is still occurring and implementation of plans to protect against future storms is in progress.

1.2. The issue

The condition of shorefront lots must be placed in the context of the natural gradient of processes and landforms and the restrictions caused by human actions. The first row of buildings in the study area and in many other developed shores throughout the world is located where the dune would be under natural conditions, greatly restricting the size, shape and mobility of dunes that are allowed to form. Dunes on naturally-functioning sandy ocean beaches undergo cycles of sediment exchange with the beach and backshore. Dune erosion by storm waves moves sediment offshore, but sediment is moved back to the beach after storms, providing a source for wind-blown sand for dune building.

Dunes provide many non-consumptive ecosystem functions and services. These include protection for human structures landward of them, aesthetic and therapeutic opportunities, cultural/environmental heritage, educational resources, filter for pollutants, retention area for groundwater, ecological niche for plants adapted to dynamic conditions, habitable substrate for invertebrates, refuge areas for wildlife, nest or incubation sites, food for primary consumers and higher trophic levels, synergistic benefits of multiple habitat types (e.g. corridors), and intrinsic value (Lubke and Avis, 1998; Arens et al., 2001; Peterson and Lipcius, 2003; Everard et al., 2010; NRC, 2014). The full expression of many of these functions and services is restricted in developed areas because of spatial constraints or emphasis on active recreational uses and the perceived need for buildings and infrastructure to facilitate these uses (Nordstrom et al., 2011). The value of dunes for shore protection (providing sediment and a physical barrier or resistant vegetation to address wave runup and erosion) is well known and often provides the basis for land use regulations. The natural values of dunes, in contrast, are generally under-appreciated in developed areas (Martinez et al., 2013).

The composition and number of species of vegetation on natural beaches and dunes are related to gradients of salt spray, wind stress, aeolian transport and wave inundation that differ with distance from the water and topographic sheltering (Doing, 1985; Moreno-Casasola, 1986; Barbour, 1990; Ehrenfeld, 1990; Wilson and Sykes, 1999; Lortie and Cushman, 2007). Only a few species that tolerate the stresses of sand mobility and salt spray near the beach occupy the upper backshore above normal wave attack. In New Jersey, these include sea rocket (*Cakile edentula*), Russian thistle (*Salsola kali*), seaside spurge (*Chamaesyce polygonifolia*), and the endangered seabeach amaranth (*Amaranthus pumilus*) and seaside knotweed (*Polygonum glaucum*)(Kelly, 2016; Wootton et al., 2016). Vegetation on the backshore contributes to formation of embryo dunes, while grasses form foredune ridges in locations farther landward (Hesp, 1989; Seabloom and Wiedemann, 1994). American beachgrass (*Ammophila breviligulata*) is the dominant dune builder in New Jersey. Seaside goldenrod (*Solidago sempervirens*) occupies a more landward portion of the foredune zone. Farther landward within the dune (here called the backdune), increased protection from physical stresses favors woody shrubs, with trees and upland species in the most landward portions. The transition from pioneer beach plants to fully mature forests on natural dunes can extend over gradients of hundreds to thousands of meters (McLachlan, 1990). The few extensive backdune environments in New Jersey are in natural parks and refuges. These locations can have multiple ridges with dry swales or wetland swales close to the ground water and blowouts created following dieback or grazing of vegetation. Bayberry (*Myrica pensylvanica*), beach heather (*Hudsonia tomentosa*), beach plum (*Prunus maritima*), poison ivy (*Toxicodendron radicans*) and Virginia creeper (*Parthenocissus quinquefolia*) are common species. Differences in height and morphology and local zones of accretion and scour in natural dunes contribute to variety of microhabitats, leading to considerable variety of insects, birds, mammals and reptiles. The gradient of processes and habitats found across the beach, foredune and backdune in nature is often managed in developed areas as three distinct shore-parallel zones.

The encroachment of human facilities can severely restrict the space available for natural landforms and vegetation, and environmental gradients can be truncated, fragmented or compressed (Nordstrom, 2008). Regulations in New Jersey and many other jurisdictions now limit construction of permanent facilities on the backshore and confine human uses to day-use recreation, although pedestrian trampling, vehicle driving and mechanical raking can reduce or eliminate beach vegetation cover and wrack (Kelly, 2016; Wootton et al., 2016). Human uses in foredunes are more severely regulated because of the acknowledged value of foredunes for shore protection. Sand fences and vegetation plantings are authorized and are used to stabilize the foredunes, but their width is often greatly restricted by buildings and infrastructure landward and their height is restricted as a result of resident demands to keep top elevations low to allow for views of the sea from their properties. The foredunes are often kept in the same location and maintained in a consistent shape by installing sand fences, planting stabilizing vegetation and shaping with bulldozers (Jackson and Nordstrom, 2011).

Backdune environments on developed shores, can fare worse than backshores and foredunes because they are often completely eliminated to facilitate construction of houses and infrastructure, and the land not devoted to structures is maintained according to suburban conceptions of landscape taste, using lawn grass and ornamental exotics or crushed gravel that is kept unvegetated (Mitteager et al., 2006). The free interplay of natural processes that has value for maintaining natural diversity is restricted by stabilizing the foredunes, and the natural vegetation that could take advantage of the reduced mobility is replaced by exotics. Removal of houses provides space for natural cycles of beach and dune change to occur, space to accommodate landward migration of the active beach and foredune and space for characteristic backdune habitats to form. The amount of space required to maintain coastal habitats in the future will have to be wider across the shore-land transition than single lots (Burger et al., 2017), but we feel that acceptance of change to a more natural system will not be immediate and will depend in large part on precedents established for the first row of developed lots.