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Human Threats to Ecological Attributes of Sandy Beaches

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Abstract. Australia's ocean beaches are one of its most recognised icons and a fundamental lifestyle asset to our communities. Sandy beaches are the geographically dominant type of shore along much of South-east Queensland. They underpin much of the area's economy and are of immense socio-cultural significance to residents and visitors. In addition sandy beaches provide habitat for numerous plants and animals and harbour unique and diverse suites of species not found in any other marine habitat. Currently, human impacts are causing considerable pressure on this ecosystem. Some threats to this habitat are; erosion and changes to beach shape, mechanical beach cleaning practices, human trampling, pollution and 4WD vehicles.
While beaches are consistently valued in our society for the aesthetic, recreational, and storm buffer services that they provide, their ecological contributions have often been ignored. Research and conservation of beach habitat could directly benefit a whole range of organisms from plants and invertebrates to high priority shorebirds and mammals. We believe that appropriate management actions can only be taken if the complex ecology of these ecosystems is understood and this information is explicitly incorporated into management practices. Therefore, new initiatives in both research and management are needed to address the conservation crisis facing beaches.

INTRODUCTION

The South–east Queensland region incorporates 18 local government areas and extends approximately 240 km from Noosa to the Gold Coast. The region's shoreline is dominated by sandy beaches which are a significant natural asset. It is the sandy beaches which are one of South-east Queensland's most recognised icons: they present a fundamental lifestyle asset for the region's rapidly growing population and are prime recreational areas. Beaches underpin much of the area's coastal economy, supporting tourism and coastal development. Beaches also play a crucial role in controlling coastal erosion dynamics, a function which will become increasingly important in face of rising sea levels caused by climate change.

Less acknowledged is the wide range of ecosystem services provided by beaches and their ecological importance. Beaches may appear barren, largely devoid of life. In reality, however, beaches support a great diversity of fauna. These biological assets remain out of sight to the casual observer because most organisms are small (a centimetre long or less) and live buried in the sand (McLachlan and Brown, 2006). Animals that live on sandy beaches include representatives from most of the major invertebrate groups such as crustaceans, polychaetes and molluscs. Some are relatively well known by the public like ghost crabs, pippis and beach worms (Jones et al., 2003). Beach animals are highly adapted for life on sandy beaches: almost all animals show great mobility, can burrow quickly into the sand when dislodged, are apt in orientating with the aid of the sun and moon, and display amazingly accurate rhythms of activity in relation to tides and waves (McLachlan and Brown, 2006).

WHY ARE SANDY BEACHES IMPORTANT?

Sandy beaches provide habitat and support a great diversity of animals. Beaches dynamically link the sand dunes with the surf zone through a constant interchange of sand, organic matter and nutrients. The surf zones of beaches are important nursery and recruitment areas for fish that rely on the smaller invertebrates as a supply of food. Beaches also provide habitat for many migratory and resident birds, reptiles and other animals which nest, breed, feed and rest on the dunes or open beach (Clark, 1998). Sandy beach invertebrates feed on what the ocean brings to shores such as phytoplankton (tiny floating plants) and algae (McLachlan and Brown, 2006). The sea also brings ashore larger dead organisms such as fish, jellyfish and other invertebrates which are eaten by the scavengers like ghost crabs and birds. Some beaches naturally accumulate considerable amounts of seaweed and seagrass on the upper shore near the dunes. This material commonly called "wrack" is very important because it provides food and shelter to many sandy beach animals and plays an important role in the nutrient dynamics of beaches.

HUMAN IMPACTS ON BEACHES

South-east Queensland comprises 65% of Queensland's population and is Australia's fastest growing region (EPA, 2007). This exponential population growth has lead to extensive development with resultant losses of large areas of natural vegetation and a wide range of habitats. Crucially, much of this development is concentrated in a narrow coastal strip with widespread loss of habitats such as sand dunes. Sandy beaches are the most popular area of the seashore: more people use sandy beaches than any other type of coastal habitat (Schlacher, et al., 2006). The human use of beaches is increasing sharply, mainly as a consequence of burgeoning coastal population growth and an increasing number of visitors. Today, man-made disturbances on beaches act at unprecedented frequencies, intensities and scales. In the coming decades, global climate change will raise sea levels and increase storminess and beaches will face stronger erosion and will migrated inland (Schlacher et al., 2007b).

Humans impact the ecological health of beaches directly. Such human impacts are already manifest today and are predicted to increase substantially in the future. Direct human impacts on South east Queensland's beaches are caused by many pressures, such as recreational activities (e.g. trampling and 4WD) (Schlacher et al., 2007a; Schlacher and Thompson, in press), coastal development, mechanical beach cleaning and engineering solutions to combat erosion such as the construction of groynes and seawall and beach nourishment.

Table 1. Summary of human threats for sandy beaches (modified from Schlacher et al., 2007).

Key pressure	References
Climate change and sea level rise	Feagin et al., (2005); Cowell et al., (2006); Harley et al., (2006); Brown and Mclachlan (2002)
Coastal infrastructure and development	Nordstrom (2000);
Shoreline armouring and erosion	Beentjes et al., (2006); Dugan and Hubbard (2006)
Beach nourishment	Peterson et al., (2000, 2006); Peterson and Bishop (2005); Speybroeck et al., (2006)
Fisheries	Defeo and de Alava (1995); McLachlan et al., (1996); Schoeman et al., (2000)
Grooming and cleaning	Llewellyn and Shackley (1996); Dugan et al., (2003)

Human trampling	Fanini et al., (2005); Gheskiere et al., (2005)
Off-road vehicles (ORVs)	Godfrey and Godfrey (1980); Schlacher and Thompson (in press) and Schlacher et al., (2007a).
Wildlife disturbance	Burger (1991); Thomas et al., (2003)

Beach nourishment and shoreline stabilization

Coastal engineers typically rely on three types of strategies to protect structures from shoreline erosion: hard stabilization; non-structural alternatives, such as relocation or retreat; and soft stabilization (Pilkey and Dixon, 1996). The ecologically ideal solution is to allow for the natural landward migration of shorelines. Such non-structural alternatives mandate the removal of structures or relocating them further landward. This solution may not necessarily be acceptable because of valuable infrastructure being located too close the beach, but the very real prospect of “coastal retreat” is starting to gain currency in Australia, especially in face of predicted shoreline migrations caused by global climate change. Soft structural stabilization techniques include activities such as beach nourishment and beach bulldozing (i.e. beach scraping).

There is mounting evidence that hard engineering solutions (e.g. seawalls, groynes) are generally the ecological most harmful interventions in shore management. Consequently, “soft solutions”” in the form of beach nourishment are seen as more environmentally friendly. However, these interventions can also have a range of negative ecological consequences which affect all levels of ecological organisation on beaches (Greene, 2002). Beach nourishment can bury shallow reefs, degrade other beach habitats including those of endangered vertebrates, and reduce invertebrate prey for shorebirds and surf fishes (Peterson and Bishop, 2005; Speybroeck et al., 2006). Ecological impacts of nourishment operations are generally most severe if the replenished sand does not match the natural characteristics of the beach deposits. Natural storm events such as Tropical Cyclones or East Coast Lows may have similar impacts. However, these are relatively rare events to which the sandy beach is adapted through evolution, whereas frequent nourishment is a more continuous form of disturbance and acts *in addition* to natural disturbance events.

Mechanical beach cleaning

Mechanical cleaning of beaches provides a beach free of rubbish and natural debris to improve the safety and aesthetic appeal for people. The machines suck up and filter the sand, capturing not only debris, but also small organisms (Brown and McLachlan, 2002). As a result, mechanical beach cleaning severely disrupts the natural ecological processes and modifies the function and structure of the beach ecosystem. Cleaning machines can kill organisms near the sand surface and can crush deeper-living invertebrates inside their burrows (Brown and McLachlan, 2002).

Wrack (the build-up of debris consisting of seagrass/weed, marine organisms and other material deposited on the beach with the tides and waves), which is removed by beach cleaning, is a vital element in maintaining the ecology of sandy beaches (Jones et al., 2003). Wrack provides essential habitat for intertidal organisms and is an important food source for many animals. Wrack lines may also help to stabilise wind blown sand and start the growth of dunes. In essence, beach cleaning reduces the number and type of organisms living on the beach. These environmental impacts should be considered along with public expectations of a safe and clean beach environment.

Trampling and 4WD vehicles

Trampling on the unvegetated beach (i.e. intertidal slope) typically may have less of an impact than in the dunes. However the evidence about impacts of human trampling on beaches is scant, but it is measurable and may injure and kill invertebrates such as delicate crustaceans and juvenile bivalves (Moffet et al., 1998).
Except for the irreversible and dramatic impacts of habitat destruction by development, driving of 4WD vehicles is the most harmful human activity on sandy beaches (Godfrey and Godfrey, 1980). Cars dramatically change the physical properties of beaches leading to deep rutting. Fragile dune vegetation is easily destroyed by vehicles. Animals inhabiting beaches are highly susceptible to vehicle impacts: 4WDs can destroy nests and kill chicks of shorebirds, turtle hatchlings show lower survival rates on beaches open to 4WD vehicles, and ghost crabs can be crushed in large numbers by night traffic. Many other smaller, buried invertebrates of the beach may also be greatly impacted by beach traffic leading to reduced standing stocks and lower diversity of fauna on beaches open to 4WD vehicles (McLean 2006; Schlacher et al 2007).

RESEARCH NEEDS & MANAGEMENT IMPLICATIONS

Present beach management is almost exclusively focused on physical processes, access for recreational amenity and shoreline protection. By contrast, the ecological and broader environmental values of beaches are largely ignored (James, 2000). Yet, sandy coastlines are fragile environments and require conservation and special management techniques if they are to continue to function ecologically and provide for quality recreation (Mclachlan and Brown, 2006). Therefore, beaches require credible, scientifically–based management strategies that address ecological objectives as well as socio-economic ends (Jones et al 2004).

We believe that appropriate management actions can only be taken if the complex ecology of these ecosystems is understood and this information is explicitly incorporated into management practices. Robust scientific information on the ecological characteristics of South-east Queensland's beaches and their vulnerability to human impacts is, however, presently limited. Arguably, this lack of fundamental knowledge impedes the development of management guidelines that encompass the conservation of crucial ecosystem components and functions (Schlacher et al., 2007).

Knowledge gaps in sandy beach conservation and management have recently been identified by Schlacher et al. (2006,2007b). In summary, the following research needs are considered critical to address current limitations to effective ecological management of these ecosystems:

1. The identification, quantification, and economic valuation of vital ecosystem services provided by beaches;
2. The responses of beach ecosystems to the intensification of erosion and disturbance regimes and to human interventions that seek to counteract shoreline change and beach erosion;
3. The ecological consequences, including impacts on ecosystem services, of human activities, such as recreation, extractive use, and pollution, that directly impact beaches;
4. The functional relationships between drivers of the physical environment (e.g. wave regimes, sediment properties), organism transport, and the structure and function of beach ecosystems;
5. The implications of habitat loss and fragmentation as well as weakened linkages across critical ecotones and habitats for the conservation of sandy beach biodiversity, including endangered vertebrates such as turtles.

TAKE HOME MESSAGES

Beaches are the prime recreational asset of the Southern Queensland coast and support a sizeable economy based on this crucial natural asset. Beaches are, however, also complex ecosystems that provide a range of ecosystems services (e.g. filtration of large volumes of seawater, nutrient recycling), are habitat to a diversity of fauna (including turtles and birds) and support important fisheries. Yet, burgeoning population growth in the coastal zone and the lack of explicit conservation measures for beaches are increasingly threatening the ecological integrity of these systems. There is already evidence of direct negative human effects caused by a range of activities from sand nourishment to 4WD driving, but specifics about the exact response of regional beaches to the plethora of human interventions are not quantified in many situations. Such knowledge gaps are identified as impediments to expand beach management from the current physical dimensions to equally focus on the maintenance of ecological structure and function. Therefore, new initiatives in both research and management are needed to address the conservation crisis facing beaches.

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