

Research paper

Urbanisation alters processing of marine carrion on sandy beaches

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HIGHLIGHTS

- Coastal urbanisation significantly alters the composition of scavenger assemblages.
- Invasive mammals replace iconic raptors as scavengers on urban sandy beaches.
- Raptors rapidly remove marine carrion from rural beaches.
- Profound effects of land-use changes on key ecological processes.

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ABSTRACT

Sandy shores are highly attractive for urban development. Urbanisation of beaches is, however, not without environmental consequences, but metrics of ecological change along metropolitan coasts are poorly developed. This lack of metrics impedes environmentally effective coastal zone management. Here we test the effects of urbanisation on a pivotal ecological process on sandy shorelines: carrion removal by vertebrate scavengers. Scavenging is a key process linking ocean and land ecosystems via animal carcasses deposited on beaches and subsequently consumed by mostly terrestrial animals. In this study, experimentally placed fish carcasses were monitored with motion-triggered cameras on urban and rural beaches on the east coast of Australia. Urbanisation substantially influenced the structure of the scavenger guild and the frequency of carrion removal within 24 h. Large raptors were abundant on rural beaches where they rapidly detected and consumed carrion (98% of carcasses removed within 24 h). We detected no scavenging activity of raptors on urban beaches, where scavenging birds of prey were functionally replaced by nocturnally foraging, non-native mammals (red fox, *Vulpes vulpes*) or feral species (cats, dogs) known to threaten beach-dwelling wildlife. Our findings emphasise the value of non-urbanised coastal dunes and sandy beaches as important feeding sites and habitats for iconic and threatened raptors. We also show that human changes in coastal land-use profoundly alter ecological structures and processes on sandy shorelines, aspects that warrant explicit inclusion in landscape management and planning of the coastal strip.

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1. Introduction

Coastal cities are hotspots of environmental change, driven by the continual expansion of the urban footprint in a narrow strip of land bordering the oceans (Martínez et al., 2007). This growth of coastal urbanisation has serious environmental consequences,

such as the loss and fragmentation of habitats, overexploitation of fish stocks, pollution, and depletion of populations of coastal species (Lotze et al., 2006; Schlacher & Thompson, 2012). Environmental management of the growing urban footprint in coastal areas is a formidable challenge, chiefly because the main objectives of protecting infrastructure and maximising amenity values often dominate the agenda at the cost of environmental conservation (Duxbury & Dickinson, 2007; Schlacher et al., 2006, 2007).

Sandy beaches geographically dominate coastlines around the world, and much of the coastal urban development occurs behind sandy beaches (Gurran, 2008; Noriega, Schlacher, & Smeuninx, 2012). Beaches are the longest ecological interface between the oceans and the land, forming hotspots of bio-geochemical processing of material (Schlacher et al., 2008). Almost all of the

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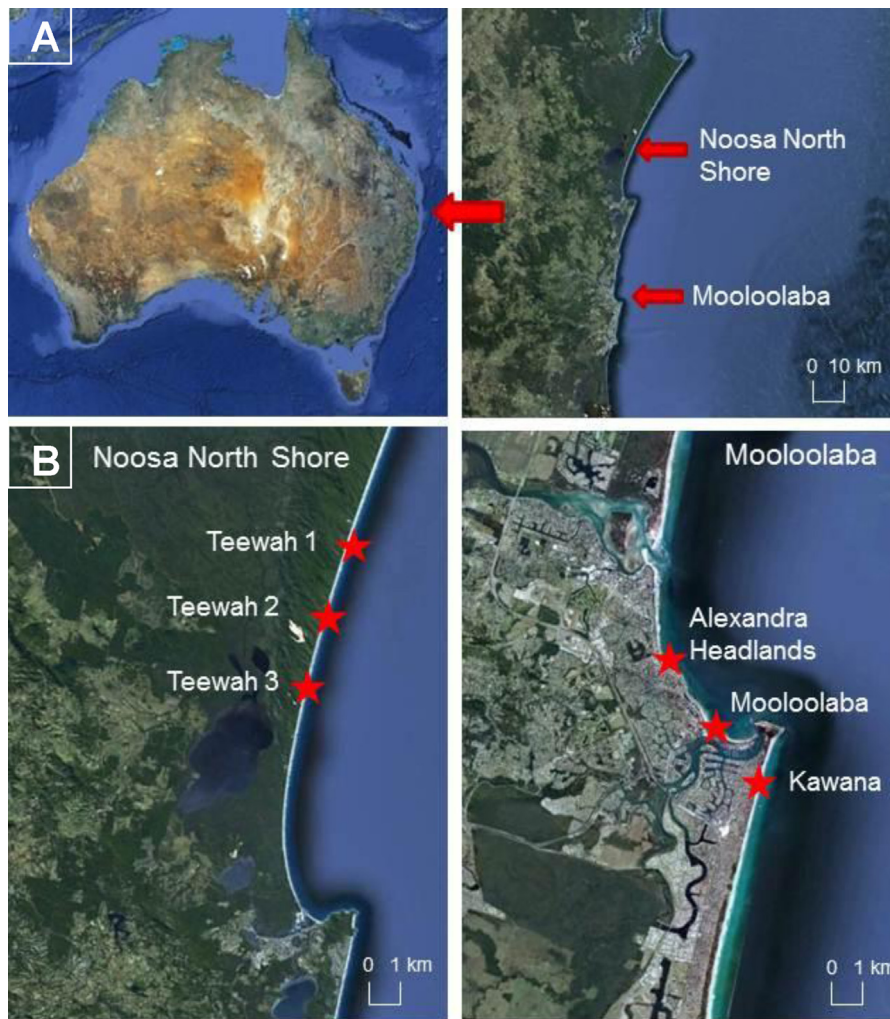


Fig. 1. (A) Location of the study area in Eastern Australia, with (B) exact locations of three sections of beach along the rural Noosa North Shore (left panel), and three urban beaches in the vicinity of the town of Mooloolaba (right panel).

material processed in beach ecosystems is imported from the sea, making beaches prime examples of ‘subsidised’ food webs (Polis & Hurd, 1996). Carrion (animal carcasses, usually washed ashore) is a distinct source of marine subsidy to beaches, and a diverse suite of scavengers utilise this resource (McLachlan & Brown, 2006). Scavengers on beaches tend to be facultative rather than obligate scavengers, and are little studied (Beasley, Olson, & DeVault, 2012).

Scavenging, on beaches and elsewhere, is a key ecological process (Barton, Cunningham, Lindenmayer, & Manning, 2013). Numerous factors (e.g., carrion availability, predictability, quality) influence the diversity and type of scavengers, and the rate at which carrion is processed (DeVault, Rhodes, & Shivik, 2003). Notwithstanding this variability, scavenging is seen as a pivotal pathway of energy transfer in most food webs (Wilson & Wolkovich, 2011). Previously, most research has focused on scavenging communities in undisturbed habitats (e.g., Ogada, Torchin, Kinnaird, & Ezenwa, 2012; Parmenter & MacMahon, 2009; Selva, Jędrzejewska, Jędrzejewski, & Wajrak, 2005), with only a few studies addressing this important ecological process in ecosystems affected by human impacts (DeVault, Olson, Beasley, & Rhodes, 2011). Because sandy beaches are systems that are underpinned energetically by imports of organic matter (overwhelmingly from the sea), scavenging is predicted to be a key functional element of beach systems (Rose & Polis, 1998; Schlacher, Strydom, & Connolly, 2013), yet how this process is influenced by urbanisation of sandy beaches is unknown.

We used a field experiment to assess the effects of coastal urbanisation on scavengers and necromass consumption on sandy beaches. Urbanisation globally causes biotic homogenisation, often at the cost of native species (McKinney, 2006), and thus is predicted to alter the species richness and composition of scavenger guilds on urban beaches. We specifically tested if: (a) the species composition of the scavenger guild at beaches and dunes differs between urban and rural areas, and (b) whether such structural changes have consequences for the short-term scavenging efficiency (i.e., carcass removal within 24 h) of carrion from the shoreline.

2. Methods

2.1. Study area

This study was conducted on the Sunshine Coast in southeast Queensland, Australia (Fig. 1A). This area is one of the fastest-growing coastal regions in Australia, and is intensively used for beach recreation. Areas of intense coastal urbanisation, such as the town of Mooloolaba, are interspersed with rural coastal areas, such as those found to the north of the Noosa River Estuary (Fig. 1B). We use the term ‘rural’ as defined by the Australian Bureau of Statistics as being non-urban, having extremely low levels of human habitation and generally natural vegetation.

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