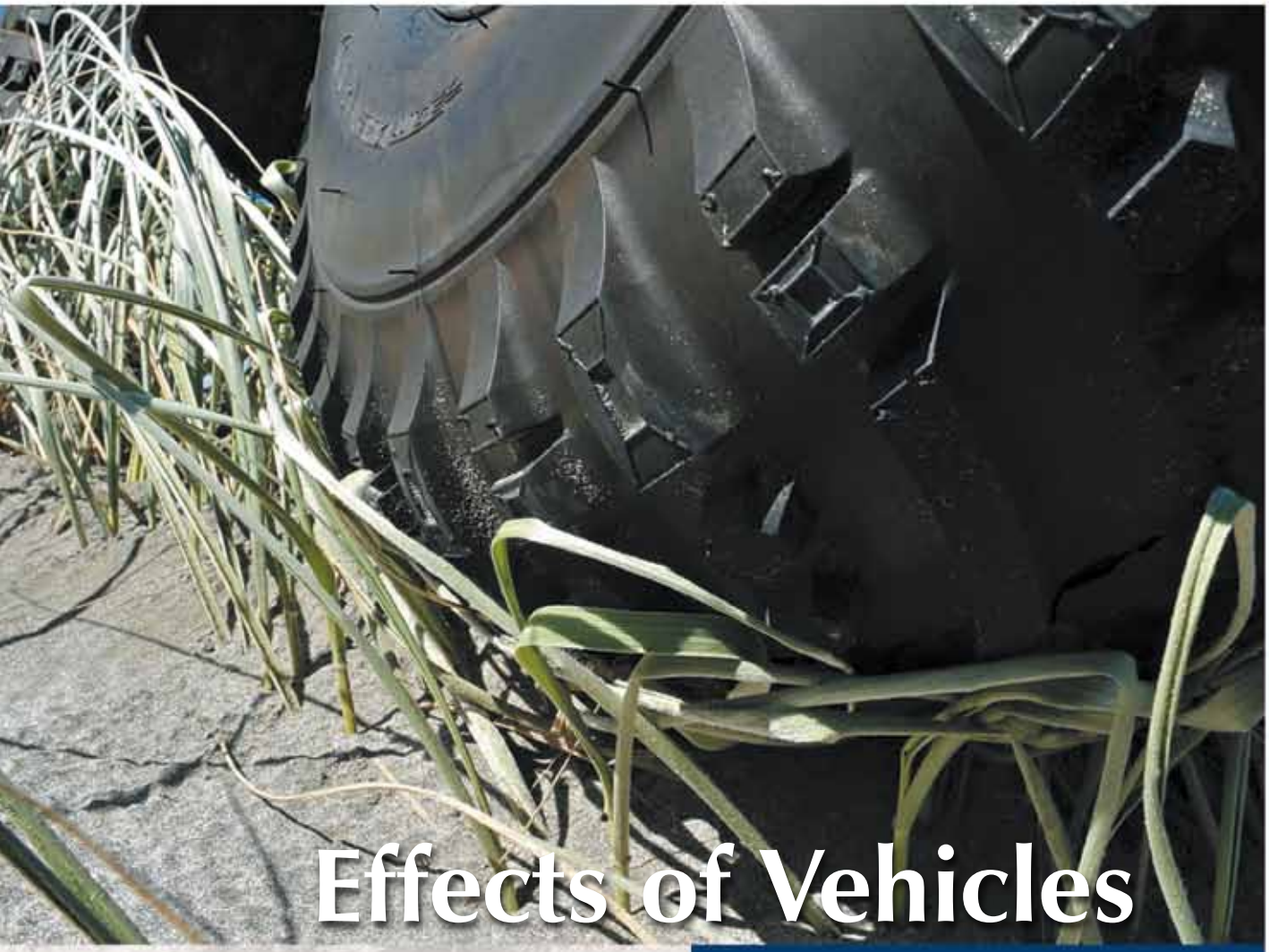
DUNE RESTORATION TRUST OF NEW ZEALAND

Technical Article No. 10.2



Effects of Vehicles

on sand dunes

INTRODUCTION

There is clear and irrefutable evidence from New Zealand and overseas experience that the use of vehicles on beaches can cause adverse environmental and social effects. Agencies in New Zealand and around the world have implemented a variety of management strategies to control these effects on beaches, and draws implications for the use of vehicles on New Zealand's beaches.

Vehicles that typically frequent beaches and dunes include four-wheel-drives (4WDs), trail bikes and quad bikes. Collectively they are termed off-road-vehicles (ORVs) in this article.

POLICY GOALS

National and regional policy documents emphasise the importance of protecting the natural character of the New Zealand coast and avoiding or mitigating any adverse effects on the coastal environment. Public access to the coast is a matter of national importance that must be maintained. However, there are clear policy directives enabling access to be controlled if an activity's environmental effects are deemed to be adverse or if there are particular ecological, cultural, or health and safety reasons for doing so.

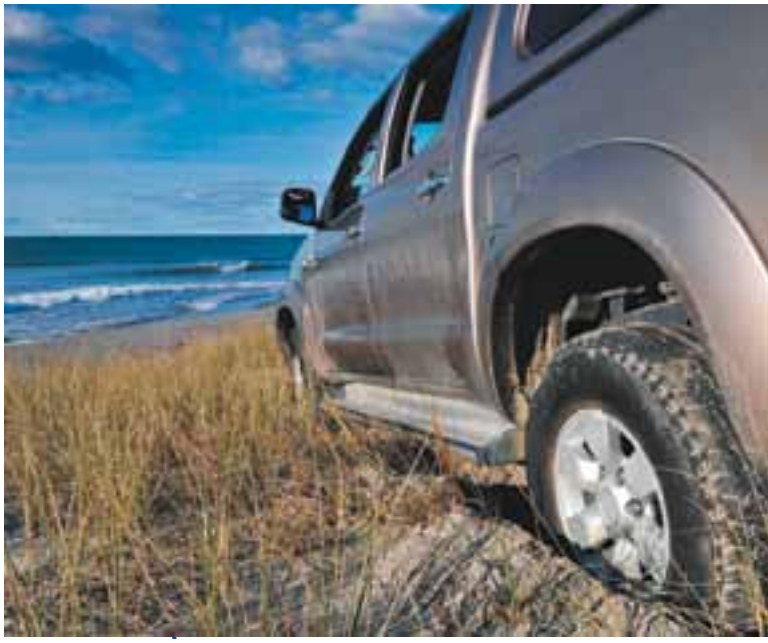
Often these policy goals form key components of council plans. Left unmanaged, the use of vehicles on beaches, frequently leads to community and council's aspirations for maintaining the beaches' natural character being unfulfilled.

Different types of vehicle use are likely to havedifferent impacts on individual beaches. For example, the impacts from slow speed access along the foreshore for fishing purposes will differ from vehicles travelling at high speed in dune areas. In addition, different beaches will have different capacities to withstand the impacts of vehicles. Use that may be seen as acceptable at one place may not be appropriate at another.

VEHICLE USE

Vehicles are used on beaches for a wide variety of reasons. These include:

- boat launching;
- access for fishing and surfing areas;
- sightseeing;
- four wheel drive club activities;
- emergency services (including surf life saving);
- racing (formal and informal);
- events (e.g. thundercat racing, beach volley ball,etc);
- technical (e.g. beach profiling, bird monitoring, etc);
- management (e.g. beach nourishment); and
- commercial (e.g. filming advertisements or movies).



Many of these activities, although perhaps benign in isolation, contribute to a cumulative negative impact upon the coastal environment. These impacts can be directly on the beach systems (i.e. physical or biological) or between beach users (i.e. social conflict). An outline of the type of potential impacts of vehicles on beaches is provided.

Managing human effects on the complex and dynamic geomorphological and ecological processes that combine within the beach system is a challenge world-wide. Human impacts on beaches are related to the ways in which we access beaches, as well as the types of activities we undertake, and the duration and frequency of those activities. Whilst all activities undertaken on beaches could potentially have an impact on the natural beach systems, vehicles have a greater potential impact on beaches when compared to pedestrians due to:

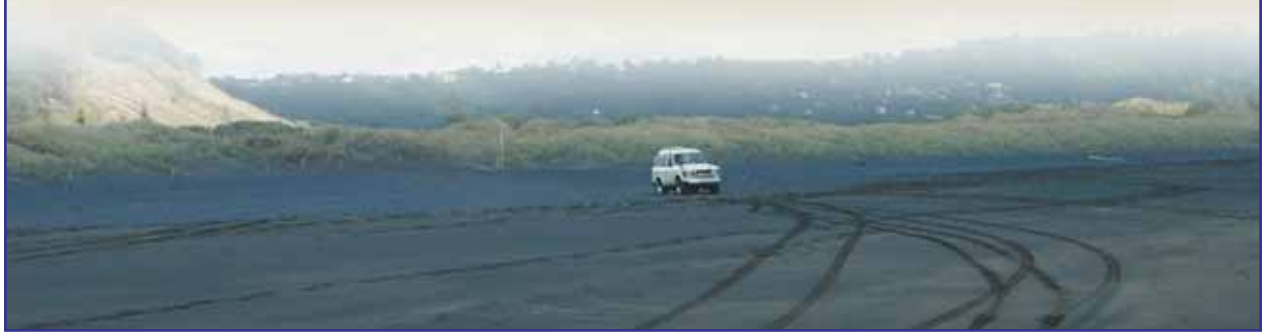
- the weight of the vehicle;
- the engine power transferred to the wheels;
- speed;
- potential range of vehicles;
- noise generated; and
- potential safety impact on other beach users
- (Lindberg and Crook, 1979).

Adverse effects of vehicles

NO DISPUTE!

A significant body of literature on the subject of vehicles on beaches has been generated from the United States over the last 30 years as well as impacts being recorded from many other places aroundthe world. The literature consistently reveals negative effects of vehicles on the beach geomorphologicaland ecological systems (e.g. Sheridan, 1979).

The debate within the international literature focuses largely on how to manage vehicle use on beaches and/or the carrying capacity of particular sites. There appears to be no dissenting authors that suggest vehicles have no impact on natural beach systems. Popular literature and writings from vehicle use advocacy groups (e.g. four wheel drive clubs, tourism organisations, etc) also appear to discuss how to minimise the adverse effects rather than dispute that there are effects of vehicle use on beach systems (e.g. Queensland Parks and Wildlife Service, 2005).



IMPACTS OF VEHICLES ON BEACHES

There are three key impacts of vehicles on beaches:

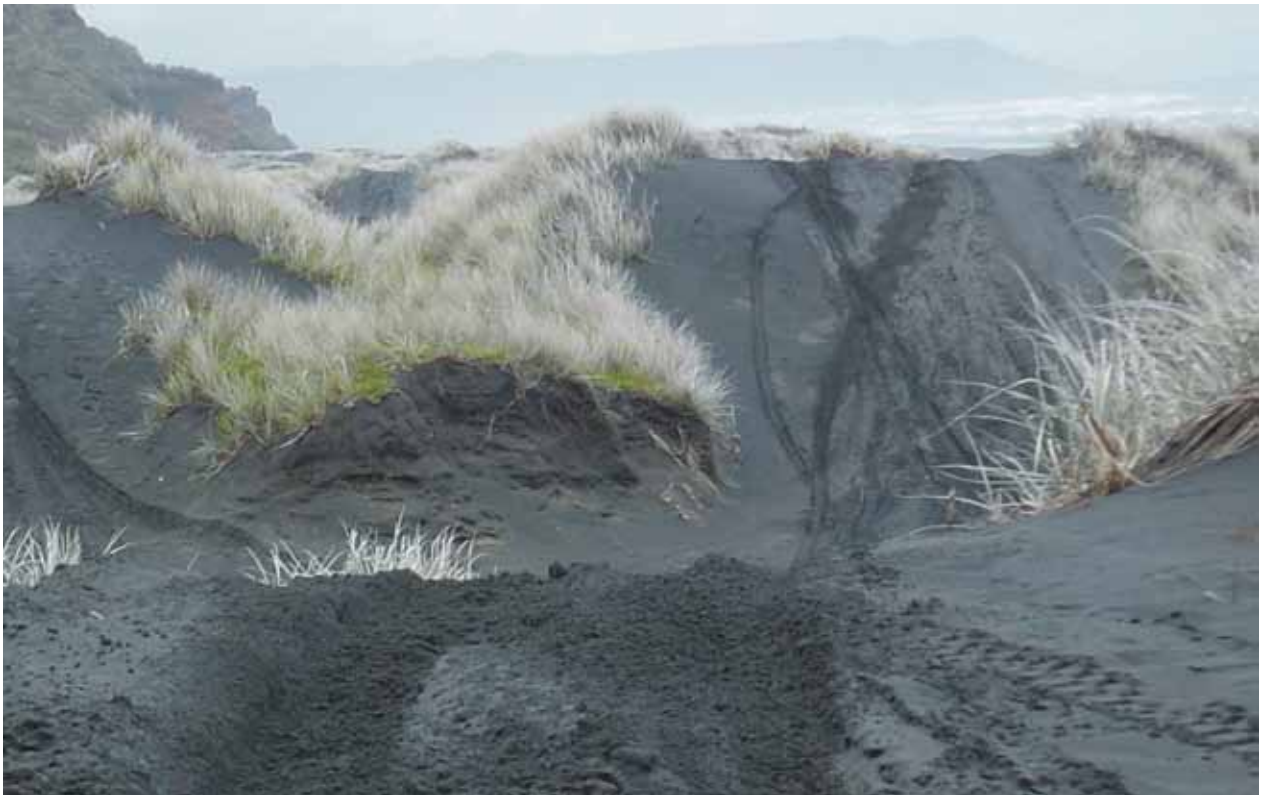
- ***Physical impacts*** **-** direct effect of pressure from wheels driving on vegetation and dunes;
- ***Impacts on biodiversity*** **-** indirect effects related to loss of vegetation, changes in microclimate
- (localised atmospheric conditions such as wind speed and temperature) loss of and changes to biodiversity; and
- ***Social and other impacts*** **-** vehicle use that conflicts with non-motorised beach users.

1. Physical impacts

The direct impact of vehicles on beaches largely relates to compaction and displacement of sand and beach soils; localised stripping of vegetation; damage to fauna; and creation of access tracks over dunes, across the foreshore and through vegetation. This in turn can lead to ‘blow-outs’ or dune erosion.

Vegetation and soil

The stresses of turning wheels can crush plants, break underground rhizomes (roots), reduce root production and decrease the percentage cover of vegetation and its diversity (Stephenson, 1999).



Wilshire et al. (1978) assessed the impacts of off-road vehicles on vegetation and soil at seven representative sites in the San Francisco Bay area. They recorded the complete stripping of plant cover by the activities of both two and four-wheel vehicles.

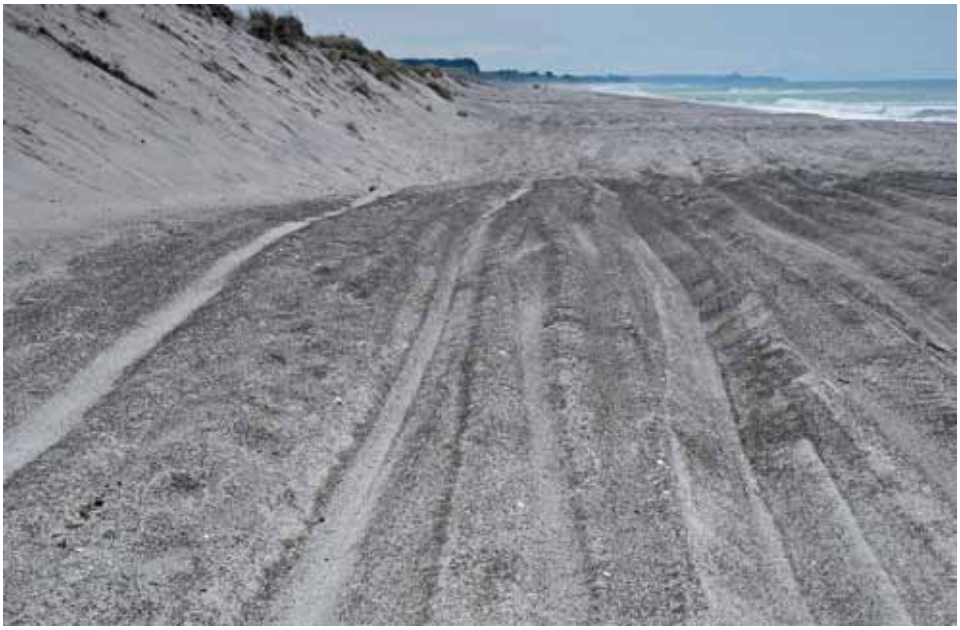
Direct impacts on soil structure include:

- increased soil densities;
- reduction of soil moisture;
- greatly reduced infiltration;
- extension of the diurnal temperature range by as much as 12°C; and
- reduction of organic carbon by an average 33% in exposed soils.

These types of changes are significant for beaches and dunes because they change the conditions that allow vegetation to grow and regenerate.

Griggs and Walsh (1981) attribute loss of vegetation, severe erosion and increased sediment discharge to off-road-vehicle (ORV) activity. They also highlight the “well-documented” physical environmental impacts of increased usage of ORVs on public lands throughout the USA. These physical and chemical impacts indirectly reduce the land’s capability of restoring its’ vegetative cover. Both the loss of plant cover and the physical changes caused by vehicles promote erosion.

The physical impacts of vehicles on beaches are also recognised at the microclimate scale (localised atmospheric conditions). For example, McAtee and Drawe (1981) who investigated impacts along the Texas coast found that the microclimate was greatly modified by vehicular and pedestrian traffic. The primary effect of human activity on the microclimate was a reduction in vegetation cover and species diversity.



Vehicle use on beaches can lead to significant damage to foredune vegetation including crushing and breakage of spinifex runners.

McAtee and Drawe (1981) also describe specific changes that occur as the intensity of human activity

- increases on dunes including:
- increased average wind velocities near the
- ground surface;
- increased evaporation rates;
- increased atmospheric salinity near the ground surface;
- increases in wind-carried sand particles near the ground surface;
- increased soil salinity;
- increased soil pH;
- increases in average soil temperature and range;
- increase in soil density;
- decreased beach elevation;
- reduced vegetation cover; and
- changes to the soil structure.

Many of these changes lead to increased vulnerablility of sand dunes to wind erosion. Changes in microclimate are therefore important particularly on dunes because once the vegetation is disrupted, the associated increases in wind velocity then enable a greater volume of sand to be transported from the dune. This creates dune 'blow-outs'. Once mobilized, dune blow-outs can potentially inundate any habitat, property or infrastructure behind the dune and these are difficult to repair (Gadgil, 2006).

Increased erosion

The effect of increased wind speed and corresponding dune erosion by vehicles was recorded by Brodhead and Godfrey (1977) in an investigation of the rates of vegetation breakdown and natural recovery at Cape Cod National Seashore, Massachusetts. In the study, the effects of controlled impacts of vehicles on a variety of coastal habitats were measured in terms of above and below ground biomass. Dune sites, ranging from unstabilised to moderately stabilised, were driven on at varying levels of intensity and along different exposures relative to slope and prevailing wind direction. They concluded that a single summer season of driving, comprising 300–700 passes of vehicles on a confined track through dense stands of dune vegetation, completely destroyed the above-ground portions but left enough underground roots for a small amount of vegetative re-growth after vehicle use was ceased. The removal of the vegetation resulted in increased wind speeds at ground level with a corresponding increase in dune deflation rates (the rate in which sand is transported away).

Anders and Leatherman (1987a) examined the effects of ORVs on the dune system of Fire Island National Seashore, New York during a detailed, two year field study. Monitoring of foredune vegetation showed a significant loss of vegetation resulting from ORV impacts. Loss of vegetation resulted in an alteration of the natural foredune profile, which could increase dune erosion during storm wave attack. The same authors also suggested that ORV use could contribute to the overall erosion rate by delivering large quantities of sand to the swash zone where it can be reached by the sea (Anders and Leatherman,1987b).

Creation of tracks

Vehicle tracks are evident on many dune systems throughout New Zealand. As erosion takes place creating open areas, studies show that vehicle users see these areas as legitimate tracks because they are largely un-vegetated and therefore utilise them, causing further damage. Lindberg and Crook (1979) report that once the initial damage to dune vegetation has been done. Other ORV users feel that a “legitimate trail” is available for use. In a review by Priskin (2004) of a 33-year study on the use and impacts of ORVs for recreation and commercial eco-tourism in the Central Coast Region of Western Australia, increased significantly. For example, the number of vehicle access points increased from 412 to 908 over a 271 km stretch of coastline as well as an increase in the total length of vehicle tracks. He concluded that vehicles caused extensive and significant impacts on the soil and vegetation of dunes and foreshores.

2. Impacts on biodiversity

National and international examples

Luckenbach and Bury (1983) studied vehicle impacts in the Algodones Dunes, the largest dune complex in California and also the area that received the greatest use by ORVs. Studies of paired plots where ORVs were used or not, clearly demonstrated that ORV activities in the dunes significantly reduced the biota, both plant and animal. There were marked declines in herbaceous and perennial plants, arthropods, lizards and mammals in ORV-used areas compared with nearby controls. All sand-adapted species, including several plants considered rare or threatened species, were greatly reduced in habitats where ORVs operated. Importantly they described the biota as negatively affected even by relatively low levels of ORV activities with areas heavily used by ORVs having virtually no native plants or wildlife remaining.

Stephenson (1999) provides a comprehensive review of vehicle impacts on New Zealand beaches. He concluded that:

> ***“Vehicle impacts on the biota of backshore sandy beaches and on the biota of coastal dunes have been demonstrated to be severe and these areas are considered to have a nil ‘carrying capacity’ with respect to vehicle use”.***

Adverse effects recorded within this review include loss and change of composition of vegetation, disturbance to wildlife, introduction of exotic animal and plant species, erosion, litter and increased exploitation of marine animals.

Invertebrates

There is a lack of research available into some classes of New Zealand invertebrates to make an informed assessment of the impact vehicles have on these organisms. These include worms species (ribbon worms/nemertean, round worms nematodes, polychaete) and some crustaceans (copepods, cumaceans, amphipods and isopods).

International research results show that the use of vehicles on beaches can reduce the abundance and number of species on and below the soil/sand surface. The impacts noted are:

- crushing of organisms (often many at once);
- destroying leaf litter and drift wood where
- organisms feed and live;
- changes to the soil properties and microclimate such as compaction; and
- the related reduction of plant cover.

Stephenson (1999) extrapolates that many crustaceans, insect and spider species (such as the katipo) would be crushed if run over by a vehicle. Insect species are also vulnerable if their food and shelter (for example drift wood, seaweed in the tide line) is pulverised or moved. However, research indicates that there are some species which may be more resilient to vehicle damage, depending upon their position in the beach system and their habits.

Gastropods (molluscs)

A study of vehicles on beaches in South Africa show that some species of Gastropod living on the foreshore were able to survive being driven on by vehicles if they are buried (the normal situation when the tide is out) and the sand is relatively compacted (Stephenson, 1999). One study shows that individual *Bullia rhodostoma* were robust enough to withstand being run over by vehicles even when placed on the surface. However individuals of the other three species being studied (*Donax serra, D. sordidus* and *Gastrosaccus psammodytes*) were easily crushed in this situation. Little research has been undertaken in New Zealand with regard to the impact vehicles have on Gastropod species. However, Stephenson (1999) suggests that species of similar size and robustness to *Bullia*, living in similar locations and that are buried when the tide is out, may not be at risk from vehicle use in areas of the beach they inhabit (for example *Amalda australis, Cominella adspersa* and *C. glandiformis*).

Bivalves

Important New Zealand bivalves are tuatua (*Paphies subtriangulata* and *P. donacina*), toheroa (*P. ventricosa*) and pipi (*P. australis*). These species are important for biodiversity and because they are mahinga kai (local food) species. Tuatua and toheroa are found on exposed beaches and pipi in more sheltered sites. There is some evidence based on studies of *Donax sp*. in South Africa, (Stephenson 1999) that suggest larger tuatua and toheroa buried in compacted sands can withstand vehicle impact. However, juveniles, that are smaller with softer shells and are distributed across the beach in high densities where vehicles are most likely to drive, may be vulnerable. In conditions where the surface of the beach is semi liquefied after vehicle use, toheroa float to the surface. This can potentially make them vulnerable to predators,such as gulls (Stephenson, 1999).

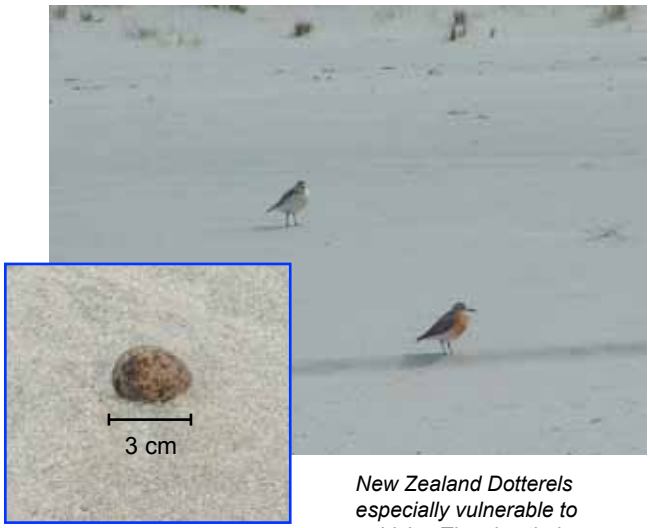
Birds

Bird families feeding on sandy beaches include gulls and terns (*Laridae* species), godwits and sandpipers (*Scolopacidae* species), oystercatchers (*Haematopodidae* species) and dotterels, and plovers (*Charadriidae* species). These birds are susceptible to damage from vehicles driving in feeding areas on the foreshore and in nesting areas. Vehicle use has been linked with decreases in bird productivity related to crushing of nests and eggs, collision and disturbance.

Jeffery (1987 in Stephenson, 1999) directly correlated a sudden decrease in fledged oystercatchers with increasingly frequent vehicle traffic. The number of nests also decreased. Western (2003) describes two main impacts of vehicles on the Australian Hooded Plover a rare ground-nesting shorebird that has a similar habitiat to the New Zealand dotterel. Nests and young birds were crushed and vehicles collided with flying birds. Buick and Paton (1989) estimated 81% of Hooded Plover nests were crushed by vehicles within the normal incubation period.

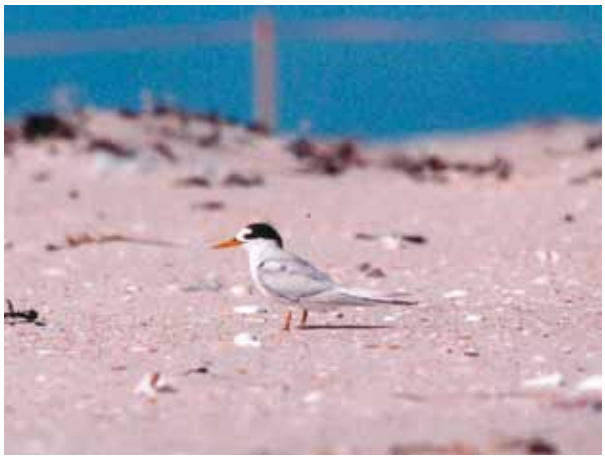
In New Zealand, birds which feed and nest in the backshore or dunes include the variable oystercatcher (*Haematopus unicolour*), New Zealand dotterel (*Charadrius obscurus*), banded dotterel (*Charadrius bicinctus*) and the Caspian tern (*Sterna caspia*). These species all have inconspicuous nests and highly camouflaged eggs, making them vulnerable to being run over by vehicles. Predation of eggs (for example by mustelids - stoats, weasels and ferrets) is a major factor in nesting failure in some areas. However, the impact of vehicles running over nests and eggs, and disturbing birds during breeding season is likely to contribute to the overall nest failure rate.

Anecdotal evidence suggests that high levels of mortality may occur for species such as dotterel and fairy tern without direct management controls. However, if controls are implemented these biodiversity losses can begin to be addressed. For example, in South Africa, Cherry (2005) identified a clear correlation between an increase in local oystercatcher populations as a consequence of a ban imposed several years earlier on four-wheeldrive vehicles on beaches.



New Zealand Dotterel eggs are around 3 cm long and look like small rocks.They are difficult to see and avoid.
(Photo:Coastline Consultants)

New Zealand Dotterels especially vulnerable to vehicles.They lay their eggs directly on the sand.
(Photo: Coastline Consultants)



Endangered fairy terns on Pakiri Beach need protection.

Photo courtesy A. Hogan

Fragmentation and weed spread

Jalava (2004) describes two other types of potential impact on biodiversity. Firstly, habitat fragmentation from vehicle-induced dune breaches and blow-outs resulting in disruption of vegetation and accelerated sea or wind erosion. Previously contiguous areas of beach/dune habitat can be converted into isolated patches of vegetation. This in turn can lead to an increased ecological vulnerability – particularly for regionally indigenous species. One example of this is the concern for the *Pimela* and *Sebaea ovata* in the dunes of the Manawatu area (Ogle, 2002). Secondly, Jalava (2004) highlights the potential for vehicles to act as vectors that spread alien or invasive pest plant species. This can occur by the physical transportation of seeds or plant material into new areas or by disrupting the existing indigenous vegetation cover to such an extent that new or invasive species can become established where they previously may not have survived.

Weed species in dune areas are having a negative effect throughout New Zealand. Once established, many weed species can be costly to control and difficult to eradicate.

3. Social and other impacts

Conflicts with other users

The New Zealand public has a long history of access to and use of the beaches and foreshore. This access has been multi-purpose, e.g. collection of kai moana; travel along the coast; boat launching; fishing and other recreational pursuits. New Zealanders highly value and believe they have a right to visit the foreshore (Booth and Doody 2004). Quite simply, everyone goes to the beach!

Conflicts between vehicle users on beaches and pedestrians are major issues for managing beach access. These include:

- vehicles driving between pedestrians;
- vehicles crossing over dunes into pedestrian areas;
- dangerous driving;
- noise even in relatively remote coastal areas; and
- loss of overall beach experience.

The use of vehicles often conflicts with non-motorised activities on beaches (Oregon Parks and Recreation Department, 2004). For example, the noise of an ORVs engine expands the real and perceived impact beyond the range of its physical presence (Lindberg and Crook, 1979). This has occurred at Karioitahi beach west of Auckland where increased vehicle use has significantly compromised the experience of other beach users and at times raised serious safety concerns (Greg Lowe, formerly Franklin District Council, pers. comm).

Changes in vehicle availability and recreational patterns

Motorised vehicle use on beaches has occurred since the 1920s. Historically, vehicle use on beaches was largely functional often providing access to farms and fishing spots. On some beaches there is a history of motor racing such as Muriwai beach on the west coast near Auckland. However, there were very few incidents of widespread concern associated with vehicle use until the popularity of four-wheeldrives escalated and vehicle numbers increased to a level where they began to impact on the beach environment and other beach users.

Modern vehicles are much faster, more capable of off-road travel, and more accessible to a wider group of society than in the past. The New Zealand Four Wheel Drive Association carried out a user survey in 2008 of their members. The results showed that 96% of respondents go to and/or drive on beaches.

In addition, there are now a wider range of recreation pursuits undertaken on beaches that conflict with motor vehicle use such as kite surfing and paragliding and beach volleyball.

Increased population pressure

The effect of changes in technology and population increases results in more people visiting and using beaches. The number of reported conflicts as a result of these changes has increased accordingly. For example, over the past five years, the use of vehicles on beaches has received national media attention with particular regard to motor accidents, safety issues and user conflicts.

From 2000-2008, the New Zealand Herald published around 40 individual articles related to the issue of vehicles on beaches. In 2008, a New Zealand Herald poll found that of over 3600 people who responded to a survey, 49% wanted a total ban of vehicles on beaches and 42%sought restrictions.

We can assume that the country's population will continue to increase. This has the potential to increase both the recreational pressure and user conflicts on our beaches.

Legitimate vehicle access

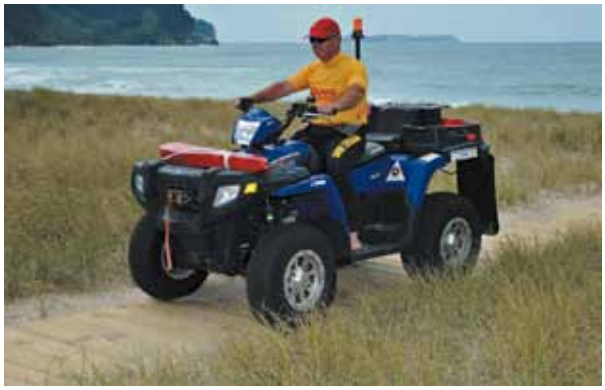
It is important to acknowledge that on many New Zealand beaches it remains vital that vehicles can use the beach. Surf lifesaving, boat launching and the use of emergency vehicles will need to be accounted for in future management strategies.

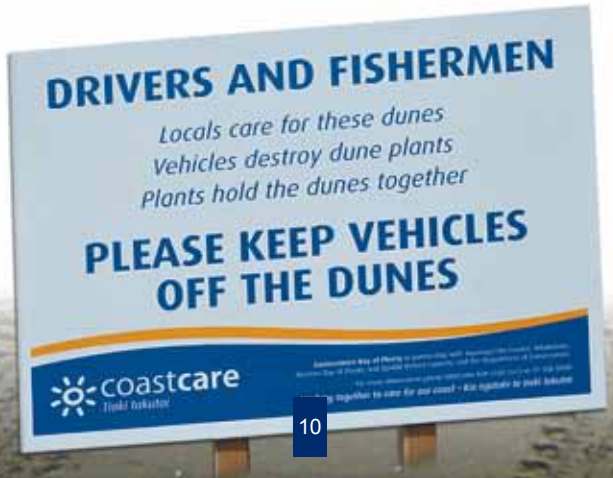
Increased fire risk

The presence of vehicles on beaches and dunes during dry periods increases the risk of fire (Ternyik, 1979). This problem is also difficult to manage along the beaches of Waiuku west of Auckland (Greg Lowe, pers. comm.) and in the Manawatu region (Dave Harrison, Horizons Regional Council, pers.

Infrastructure

The impacts associated with the construction of infrastructure to support vehicle use on beaches can impact on the environment with potential loss of natural character. Removal or modification of back dune areas for the construction of car parking or access points can be substantial. The capital costs of such infrastructure on dunes can be costly and will inevitably require ongoing maintenance.





Climate Change

Predicted effects of climate change including sea level rise and increased frequency and severity of storms will result in greater coastal erosion and flooding (Dahm et al. 2005). Managing the pressures of increasing human use including the use of vehicles on beaches will be a priority in protecting communities from coastal hazards, including climate change.

Involving coastal communities and vehicle users in the management and restoration of natural dunes has the potential to assist in the development of more resilient coastal communities better able to understand and to live sustainably with natural coastal processes, and to adapt to future change (Dahm et al., 2005).

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The mission of the Dunes Trust is:
"To see the majority of New Zealand dunes restored and sustainably managed using indigenous species by 2050".