Peer reviewed Science about vehicles on coastal areas and marshes
off-road vehicle coastal impacts - Google Scholar

A selection of representative articles

1.From P.E. Hosier:

Recreational Off-Road Vehicle Impacts in Coastal North Carolina. “The most disturbing feature of ORV effects in the dune system is the extremely low level of impact necessary to disturb the vegetation and the sands. Our studies show that vegetation is completely destroyed on a dune with only 100 passes. One to five passes heal slowly and are visible for at least a year. Following disruption of the vegetation, wind action mobilizes the sand and enlarges the initial impact area.”

2.From Thomas A. Schlacher Darren Richardson Ian McLean Impacts of Off-Road Vehicles (ORVs) on Macrobenthic Assemblages on Sandy Beaches Environmental Management (2008) 41:878–892

“Macrobenthic assemblages on ORV-impacted beaches had significantly fewer species at substantially reduced densities, resulting in marked shifts in community composition and structure. These shifts were particularly strong on the middle and upper shore where vehicle traffic was concentrated. Strong effects of ORVs were detectable in all seasons, but increased towards the summer months as a result of heavier traffic volumes. This study provides clear evidence that ORVs can have substantial impacts on sandy beach invertebrates that are manifested throughout the whole community.

3. From Anders, Fred J., and Stephen P. Leatherman. "Effects of off-road vehicles on coastal foredunes at Fire Island, New York, USA.Environmental Management 11 (1987): 45-52.

“Monitoring of foredune vegetation through sequential quadrat surveys and construction of seaward limit maps showed a significant loss of vegetation resulting from ORV impacting. Loss of vegetation resulted in an alteration of the natural foredune profile, which could increase dune erosion during storm wave attack.”

4. From Brodhead, J. M., and P. J. Godfrey. "Off road vehicle impact in Cape Cod National Seashore: disruption and recovery of dune vegetation." International Journal of Biometeorology 21 (1977): 299-306.

“Preliminary evidence suggests that a single summer season of driving (300–700 passes) on a confined track through dense stands of Ammophila breviligulata, Arctostaphylos uva-ursi, and Deschampsia flexuosa, can completely destroy the above-ground portions but leave adequate underground roots and rhizomes for a small amount of vegetative regrowth after cessation of impact in the late summer and fall.

5. From J.F.Kelly Effects of human activities (raking, scraping, off-road vehicles) and natural resource protections on the spatial distributionof beach vegetation and related shoreline features in New Jersey. J Coast Conserv (2014) 18:383–398(2014)

“In terms of off-road vehicle use, beaches with all-year recreational ORVs had the least amount of vegetation (6 %), followed by off-season ORV (15 %), and government only ORV (31 %) …ORV activities reduced beach vegetation by 86 % (all- year), 61 % (off-season), and 21 % (government only) on average, with percent cover of vegetation being 2x greater on protected beaches than ORV beaches overall, and 7x greater than on beaches subject to all-year recreational ORV use.

On Cape Cod, Massachusetts, off-road vehicles were shown to destroy beach vegetation and prevent embryonic dune development by crushing mature plants and root systems, as well as the seeds, seedlings, and root fragments germinating in the drift line, and disturbing the wrack debris (Broadhead and Godfrey 1977; Leatherman and Godfrey 1979; Zaremba et al. 1979). Lateral expansion of the foredune was also suppressed by breaking dune grass rhizomes, a factor also observed at Fire Island, New York (Anders and Leatherman 1987). Gilbertson (1977) reported that extensive off-road vehicle use in South Australia had slowed or prevented the development of foredunes by impacting pioneer plants growing in the drift line, including species such as sea rocket (Cakile maritima) and sea spurge (Euphorbia paralias) (Stephenson 1999). On Padre Island, Texas, backshore areas subjected to either short- or long-term heavy vehicular traffic had lower root and shoot production, percent cover, and diversity of vegetation compared to unimpacted areas (McAtee and Drawe 1980).”

6. From: Stephen R Leatherman and Paul J. Godfrey Final Report Contract No. CX-1600-5-0001 The Impact of Off·Road Vehicles on Coastal Ecosystems in Cape Cod National Seashore: An Overview

“We have concluded that there is no "carrying capacity" for vehicular impact on coastal ecosystems. Even low-level impacts can result in severe environmental degradation. The most naturally unstable areas, such as the intertidal ocean beach, tend to be the least susceptible to damage. (However, this does not imply that there are no negative effects from ORV impact in this zone.) Dunes can be quickly devegetated by vehicular passage, resulting in blowouts and sand migration. Of all the ecosystems evaluated, the salt marshes and intertidal sand flats are the least tolerant of ORV impacts. This highly productive and complex system should be closed to all vehicles. “

7. From J. Kelleway ECOLOGICAL IMPACTS OF RECREATIONAL VEHICLE USE ON SALTMARSHES OF THE GEORGES RIVER, SYDNEY WETLANDS (Australia) 22(2) Ecological impacts of recreational vehicle use

“The field study showed that vegetation cover, soil compaction, soil moisture, and mollusc and crab distributions were all adversely affected by vehicle use. In *Sarcocornia* communities the impacts were most severe in areas of high track density, though single track areas also showed significant effects. *Juncus* communities generally showed less damage, due in part to

morphological characteristics of the dominant plant species. In both community types vehicle ruts and excavations were prone to waterlogging, could alter vegetation composition and facilitate the breeding of mosquitoes and spread of mangroves. Recommendations are made for the control of vehicle use and restoration of damaged saltmarshes."

8. From: Ploughe LW and Fraser LH (2022) Find New Roads™? A Systematic Review on the Impacts of Off-Road Vehicle Activity on Soil, Vegetation, and Wildlife. Front. Ecol. Evol. 9:805707. doi: 10.3389/fevo.2021.805707

"Impacts of ORV Activities on Vegetation

ORV activity was found to greatly reduce vegetative cover in all the habitats studied, including coastal (Hosier and Eaton, 1980; Anders and Leatherman, 1987; Schlacher et al., 2008b; Kelly, 2014), desert (Luckenbach and Bury, 1983; McGrann et al., 2005; Al-Awadhi, 2013; Dewidar et al., 2016; Knisley et al., 2018; Assaeed et al., 2019; Cheung et al., 2021), and grassland/shrubland habitats (Wilshire et al., 1978; Kinugasa et al., 2015). Vegetation loss tended to increase with increasing levels of ORV use (Rickard and Brown, 1974; Kutiel et al., 2000; Kelly, 2014), vehicle weight (Ahlstrand and Racine, 1993), and in the weeks and months following ORV disturbance (Kutiel et al., 2000). Vegetative cover is plays an important role as a shielding boundary between the soil and atmosphere and is not only important for regulating sediment availability for atmospheric dust emission, but in regulating surface albedo and surface temperature (Al-Awadhi, 2013; Al-Awadhi et al., 2014; Cheung et al., 2021). Increased soil exposure resulting from ORV traffic were found to increase daytime surface temperatures in a desert (Cheung et al., 2021) and in a grassland (Webb et al., 2013) "

9. From: Johanna Blakely, Wendy McWilliam, and Don Royds "Extent and Intensity of Vehicle-use Impacts within a Saltmarsh Conservation Area under a Management Strategy," Natural Areas Journal 42(1), 56-68, (19 January 2022)

Abstract
Saltmarshes provide multiple ecosystem services, and some have been preserved as conservation areas. Studies indicate recreation-related vehicle use may be significantly degrading them. Saltmarshes have a low resistance and resilience to recreation-related trampling impacts; however, little is known about those associated with vehicle use under a specific management strategy. Drone imagery and GIS spatial analysis were used to determine the area and intensity of direct vehicle impacts within a New Zealand saltmarsh. The management plan allows vehicle entry as long as it does not substantially impact cultural, ecological, or mahinga kai (or food cultivation) values. It limits impacts of vehicles by meeting two goals: limiting the area of vehicle use to formal road corridors, and limiting particularly damaging behaviors of use, including entering the saltmarsh when conditions are wet, traveling more than 10 km per hour, and using traction equipment. Results demonstrated substantial impacts. Tire tracks were present in 66% of quadrats sampled, and were distributed across the length and breadth of the saltmarsh, covering 17% (approximately 207 ha) of the 1225 ha saltmarsh. About a third of these quadrats had track covers of 11–50%. Furthermore, particularly damaging vehicle use behaviors were widely evidenced, including deeply rutted mud, water channel initiation, and substantial loss and fragmentation of vegetation communities. Vehicle use is clearly eroding at least some of the

cultural, ecological, and/or mahinga kai values for which the saltmarsh was conserved. While there are many indirect and direct measures for improving the current management strategy, none is likely to result in substantial reductions in vehicle impacts given the low resistance and resilience of saltmarshes to trampling. An alternative strategy that would lead to substantial reductions, and eventual recovery of the saltmarsh, would be to allow existing recreational activities, but deny vehicle entry.

10. From: G.J. Blionis & S.J. Woodin Vehicle track damage to salt marsh soil and vegetation at Culbin Sands, NE Scotland Pages 205-219 Botanical Journal of Scotland Volume 51, 1999 - Issue 2

"The effects of 3 year old vehicle tracks on salt marsh soil and vegetation within Culbin Sands SSSI on the Moray Firth, Scotland were investigated. Vehicle tracks destroyed the organic layer which was present in the later successional communities. Soil penetration resistance and bulk density were increased, and moisture content and salinity were decreased inside all the tracks, thus soil characteristics were shifted towards those typical of lower marsh zones. Penetration resistance within tracks reached levels which may inhibit root elongation. Vegetation inside tracks remained in earlier successional stages than the surrounding communities, particularly on the lower marsh where recovery may be slowed by repeated disturbance by tidal water. Vegetation on the mid and upper marsh showed less successional shift, but was still changed, being more diverse within the tracks. There was also a significant amount of bare ground within these tracks, which could facilitate erosion. Effects of vehicle tracks thus vary between salt marsh zones, but are damaging wherever they occur; there appears to be no 'less damaging' route on which vehicles could be directed."