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# A DPSIR analysis of aeolian sand dune mobilization along the coast of Manawatu-Wanganui in New Zealand

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Coastal sand dunes are multifunctional landscapes with rich biodiversity and provide ecological goods and services. They play a dual role as a sediment sink or a source to maintain the long-term stability of a coastal system. These landscapes have been affected by human settlements, economic activities and recreational purposes. Sand dunes in the Manawatu-Wanganui region, in New Zealand, have been subjected to such forcings during Maori settlements and, in particular, since the establishment of Europeans since 1840. Consequently, dunes have evolved from a transgressive system to a parabolic one, while the rate of dune drifting is still observed to be one of the highest in the world.

Because this was a problem for populations living in the area, there were several attempts to arrest dune drifting. Using the Driver-Pressure-State-Impact-Response (DPSIR) cyclic framework, we analyzed these interventions during two-time frames: 1) from the 19th to 20th century and 2) during the early 21st century. We checked for data in historical records and literature including the Parliamentary debates of New Zealand. Historical evolutionary trends were inferred by analyzing a series of maps since 1773. The present-day impacts were derived from a series of georeferenced google images from 1983 using the ESRI ArcGIS tools. The coastal management responses were obtained through scientific literature and reports of the Horizon Regional Council.

According to the analysis, drivers of dune drift before the 21st century were 1) settlements resulting in burning shrubs, deforestation, grazing, agriculture, mining, and building, 2) introduction of non-native animals. The pressures were: 1) mobile dunes and 2) blowouts. The assessment of the state of the environment included: 1) soil fertility, 2) habitat quality, 3) river navigability and 4) air quality. The assessed impacts were 1) increase of wasteland and loss of fertility, 2) foredune erosion, 3) impact on transportation and 4) creation of swamps as river mouths were closed. The management responses included 1) introduction of 1903 and 1908 Sand Drift acts for reclamation of affected areas, 2) introduction of exotic vegetation (e.g. Marram grass) and 3) foredune building using sand trapping fences.

The main drivers of the 21st century are 1) intensive urbanization, 2) introduction of exotic vegetation and 3) global fossil fuel burning. The invasive character of marram resulted in the loss of biodiversity. The coastline erosion due to sea-level rise during the 21st century will be moderated due to its progradational nature. The study revealed a significant spatial variability of the rate of dune drift. The responses include 1) a consolidated “One Plan” as mandated by 1991

Resource Management Act; 2) removal of exotic vegetation to support native biodiversity by enhancing natural processes of dunes (a paradigm shift in dune management); 3) enhancing awareness while encouraging the public participation in mitigating measures.

In conclusion, historical data combined with DPSIR framework tools showed that management interventions should be implemented considering long-term and interdisciplinary analysis to better understand the systems' evolution and the full consequences of human actions.

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