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Coastal dune fields in Ireland: rapid regional response to climatic change

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Coastal dunes represent dynamic geomorphological landforms that respond to changes in climatic regimes. Their surfaces are typically a mosaic of vegetated and unvegetated areas in varying proportions. Their spatial and temporal evolution as landforms is dependent on sediment supply, antecedent morphology, accommodation space, and physical forcing parameters such as wind speed and direction. Coastal dune fields, once established, contain a sedimentary record of former environmental conditions. Since sediment supply along European coastlines is largely finite, with a general paucity of new marine sediment feeding contemporary dune sediment budgets, coastal dune fields can broadly be classified as 'relict' features indicative of former periods of sediment abundance. Contemporary (decadal) morphological behaviour is therefore driven mainly by changes in climate which affects precipitation, temperature and wind stress over dune landforms at any coastal dune site. This paper examines recent historical-scale changes in the stability of coastal dune systems on the west and north coasts of Ireland using aerial photographic evidence alongside climatic data to investigate trends in dune stability since the 1950's. A regional scale analysis of dune sites and a detailed case study using image analysis indicate a widespread pattern of progressive sealing of dune fields by vegetation growth in recent decades. The unvegetated sand surface was used as a proxy for instability of the dunes and this was compared with climatic records (wind, temperature and precipitation) which were analysed for corresponding trends that might explain dune field behaviour. Results show that since the 1940s, dune fields along the entire western and northern coast of Ireland have seen a rapid reduction in bare surface areas (instability) of over 80% in some instances. At Portstewart, Co. Londonderry, the reduction in bare sand across the entire dune site between 1964 and 2004 was between 86-96%. Within this, major episodes of re-sealing took place in the period between 1964 to 1975 and 1983 to 2004 where reductions in exposed sand surface area of 44-67% and 55-76% respectfully were recorded across the dune surface. Interestingly, in many areas where re-sealing has taken place, this has been accompanied by net shoreline accretion of up to 30-40m in places. Sediment in effect looks to be accumulating at the coast with little new throughput of sediment into inland areas. The low frequency of significant storm events occurring within this period may have added to the coastal accretion. Additionally, in recent decades (1985 to 2005) the growing season (number of consecutive days when temperature > 5 ^{0}C) has seen a dramatic increase of 84% combined with a 60% reduction in the number of frost days. This is likely to have driven dramatic regional increases in dune vegetation growth and it is this period which coincides with particularly rapid resealing events across all dune sites studied. This preliminary work demonstrates (i) that coastal dune systems have a particularly high sensitivity to climatic shifts and the relatively fast response is manifest in dramatic re-vegetation patterns; and (ii) the pattern is evident on a regional scale. Morphologically this vegetation growth phase modifies the contemporary dune dynamics, fixing and preserving relict landforms and stabilizing the dunes until subsequent changes in climatic trends cause vegetation deterioration which reinstates dune mobility, redistributing sediment within the system. The results demonstrate the rapid response of coastal dunes to climatic shifts over a very short timescale (circa 5-10 years), suggesting a closely linked process-response relationship of dune morphodynamics and short-term climatic change. The work has important implications for management of coastal dunes since stabilisation and reductions in bare sand area, whether natural or forced, is a significant parameter in management approaches, particularly on a short-term timescale.