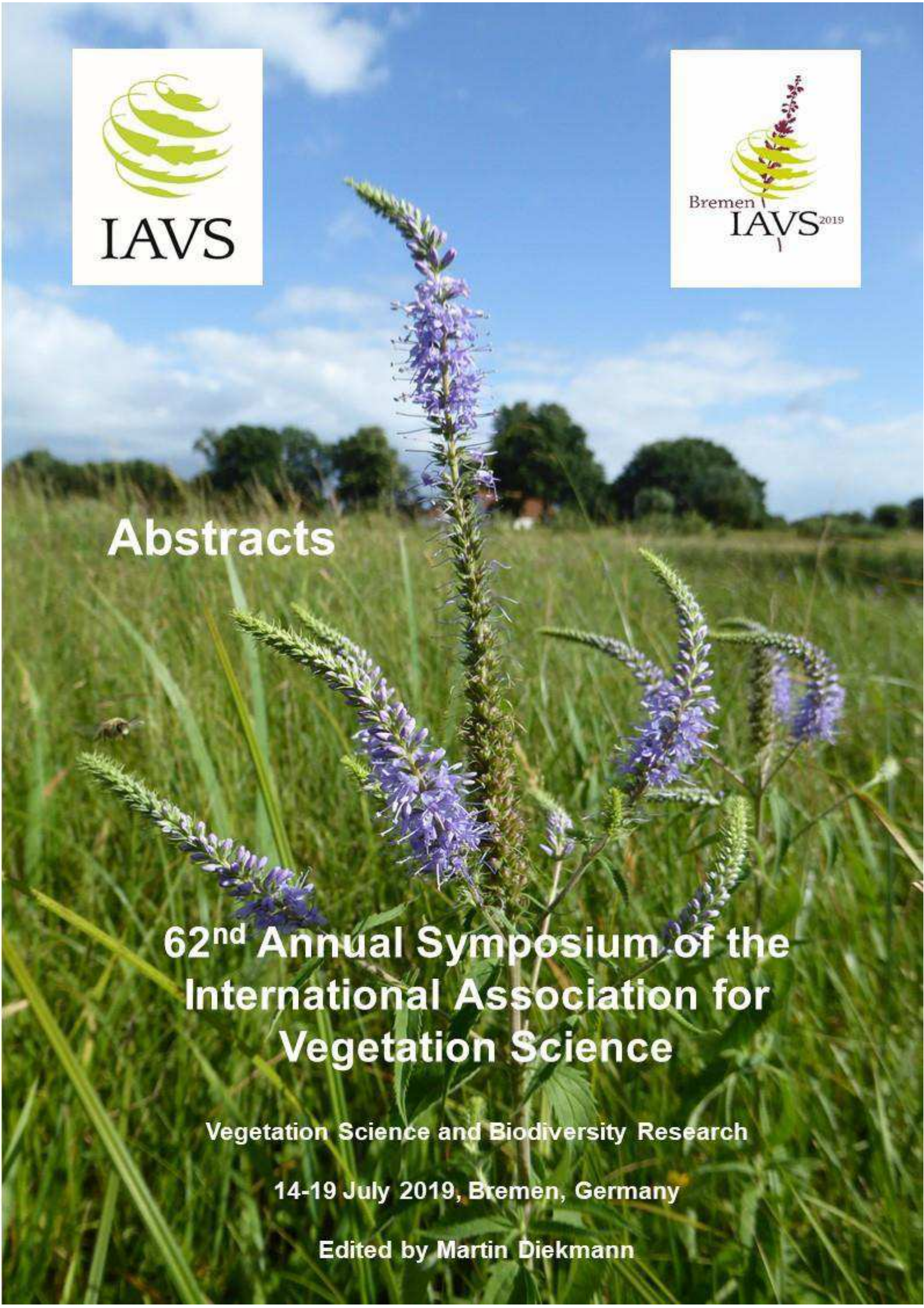

Abstracts

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UAV-based monitoring of eco-morphological processes in Mediterranean coastal dunes

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Although highly endangered, coastal dunes deliver a wide range of ecosystem services resulting from a complex interaction of eco-morphological processes. Following EU Directives, monitoring schemes are urgently needed to quantify spatial changes in these functions alongside the severe degradation exerted by human pressure. In these ecosystems, vegetation distribution and biomass together with topographic features have been widely recognized as key spatial variables to quantify the ecomorphological pattern along the sea-inland gradient. However, field monitoring approaches are labor intense and often fails to capture the coastal such patterns.

In this regard, in situ sensing from small Unmanned Aerial Vehicles (UAV) carrying lightweight cameras, besides collecting multispectral images able to capture vegetation patterns, represents an emerging low-cost alternative to traditional photogrammetry or active sensor technologies (i.e. LIDAR) to generate high resolution topographic reconstruction from large sets of multi-angle images using structure-form motion (SfM) and multi view-stereo analysis algorithms.

We analyzed the eco-morphological spatial pattern along the sea-inland gradient in two coastal dune sites in Central Italy characterized by low (site 1) and high (site 2) human pressure, respectively. Specifically, by the processing of UAV images, we derived NDVI and topographic variables at very fine scale (0.5 m) for a 250 m wide strip starting from the coastline toward inland. To map the heterogeneity of such gradient, the Rao Q' index was applied to NDVI and topographic variables (elevation, slope and curvature). In particular, thanks to the multidimensional meaning of the Rao Q' index, the variability of the three topographical variables was synthetized into a single layer. We then inspected how the NDVI and topographic Rao Q' index values change as a function of the distance from the sea within the two coastal sites. Site 1 featured a varying trend of heterogeneity values along the sea-inland gradient. The maximum level of eco-morphological heterogeneity occurred at intermediate distances from the sea and the lowest at the end of the gradient where the extreme physical stress exerted by the sea is weaker and dunes are more stable and vegetation homogenously distributed. On the contrary, site 2 featured constant values of heterogeneity along the gradient, highlighting a possibly disrupted eco-morphological gradient due to the high human pressure.
We demonstrate that monitoring and quantification of the eco-morphological gradient of coastal dunes at a very fine scale can be made over management-relevant extents through UAVs. Moreover, Rao Q' index applied to sensing imagery successfully captured the differences in the eco-morphological heterogeneity for the two sites. Our approach supports frequent surveys and can deliver data for spatial monitoring of key coastal functions and services.