Global and Planetary Change 161 (2018) 66–81

Contents lists available at ScienceDirect

Global and Planetary Change

journal homepage: www.elsevier.com/locate/gloplacha

Early to mid-Holocene spatiotemporal vegetation changes and tsunami impact in a paradigmatic coastal transitional system (Doñana National Park, southwestern Europe)

Saúl Manzano[a,*], José S. Carrión[a], Lourdes López-Merino[b], Juan Ochando[a], Manuel Munuera[a], Santiago Fernández[a], Penélope González-Sampériz[c]

[a] Department of Plant Biology, Faculty of Biology, University of Murcia, 30100 Murcia, Spain
[b] Institute of Environment, Health and Societies, Brunel University London, Uxbridge UB8 3PH, UK
[c] Instituto Pireanico de Ecología, CSIC, Av. Montañana 1005, 50059, Zaragoza, Spain

ARTICLE INFO

Keywords:
Holocene
Transitional systems
High-energy events
Vegetation dynamics
Estuary
Tsunami
Refuge
Resilience
Biogeography
Aquatic plants

ABSTRACT

The southern European Doñana wetlands host a highly biodiverse landscape mosaic of complex transitional ecosystems. It is one of the largest protected natural sites in Europe, nowadays endangered by intensive agricultural practices, and more recently tourism and human-induced fires. Its present-day spatial heterogeneity has been deeply investigated for the last three decades. However, a long-term perspective has not been applied systematically to this unique landscape. In this new study, a palaeoecological approach was selected in order to unravel patterns of landscape dynamism comparing dry upland and aquatic ecosystems. A 709 cm-long sediment core was retrieved and a multi-proxy approach applied (palynological, microcharcoal, grain size, magnetic susceptibility, loss-on-ignition and multivariate statistical analyses). Pollen signatures show how sensitive aquatic wetland vegetation was to environmental changes while terrestrial vegetation was stable at millennial scale. The impact of several high energy events punctuates the Early and Middle Holocene sequence, two of which relate to the local tsunami record (~6.6 and ~9.1 cal. kyr BP). Contrasting impacts of these two events in the aquatic and upland ecosystems show the importance of landscape configuration and the contingent history as key elements for coastal protection.

1. Introduction

Transitional systems such as coastal wetlands are amongst the Earth's most diverse and productive ecosystems (Newton et al., 2012, 2014). They play a significant role in carbon sequestration (Barbier et al., 2011), and provide numerous ecosystem services to humans, such as provisioning (e.g. raw material supply), regulation (e.g. biogeochemical cycling, water purification) and coastal protection services. Furthermore, coastal wetlands also attenuate erosion and the impact of waves and extreme climatic hazards on the coastline (Barbier et al., 2011). However, coastal areas are amongst the world's most populated areas and they concentrate increasing human pressures, threatening their diverse and unique ecosystems (Newton et al., 2012). In addition, understanding the role of transitional systems as buffers of extreme wave events (storms and tsunamis) is of interest for the inhabitants of coastal areas. Deep knowledge of coastal wetlands is thus, of hallmark importance. Certainly, the management of coastal wetlands can only be effective considering the interactions between the physical environment and the biological communities.

A paradigmatic case of transitional system in the westernmost part of Europe is Doñana, located in the mouth of the Guadalquivir (Southwestern Spain). This region, exhibiting a variable geomorphology (Rodríguez Ramírez, 1997), and large floristic (García Murillo et al., 2014; López Albacete, 2009; Rivas Martínez et al., 1980) and faunal (Díaz-Paniagua et al., 2015) richness, is protected under the Doñana National Park (DNP) ever since 1969. It is also an UNESCO biosphere reserve, an UNESCO World Heritage, and a Ramsar Wetland Site (Sousa et al., 2009). Hallmark in the DNP are the Guadalquivir River marshlands, amongst the biggest and most significant European wetlands, due to their seasonal character, high plant diversity, and their role as route for Palaearctic avian migrations (Martí and del Moral, 2002; Rendón et al., 2008).

Despite the ecological importance of the DNP, its long-term environmental history is poorly known. The great extension, complexity and heterogeneity of the Guadalquivir's marshlands, the secular history of human intervention, and the difficulty of recovering and

* Corresponding author.
E-mail address: saul.manzano@um.es (S. Manzano).

https://doi.org/10.1016/j.gloplacha.2017.12.013
Received 4 September 2017; Received in revised form 1 December 2017; Accepted 8 December 2017
Available online 11 December 2017
0921-8181/

Mar. Geol. 263, 120–122.
Rodríguez-Vidal, J., Bardají, T., Zazo, C., Goy, J.L., Borja, F., Dabrio, C.J., Lario, J., Cáceres, L.M., Ruiz, F., Abad, M., 2014. Coastal dunes and marshes in Doñana National Park. In: Gutiérrez, F., Gutiérrez, M. (Eds.), Landscapes and Landforms of Spain. World Geomorphological Landscapes. Springer, Dordretch.
Ruiz, F., Rodríguez-Ramírez, A., Cáceres, L.M., Rodríguez-Vidal, J., Yañez, C., Clemente, L., González-Regalado, M.L., Abad, M., De Andrés, J.R., 2002. Cambios paleoambientales en la desembocadura del río Guadalquivir durante el Holoceno reciente. Geogaceta 31, 167–170.
Ruiz, F., Pozo, M., Carretero, M.I., Abad, M., González-Regalado, M.L., Muñoz, J.M., Rodríguez-Vidal, J., Cáceres, L.M., Pendón, J.G., Prudêncio, M.I., Dias, M.I., 2010. Birth, evolution and death of a lagoon, Late Pleistocene to Holocene palaeoenvironmental reconstruction of the Doñana National Park (SW Spain). In: Friedman, A.G. (Ed.), Lagoons: Biology, Management and Environmental Impact. Nove Science Publishers.
Saenz Laín, C., 1982. Polen de la flora de Doñana (Huelva, España). Lazaroa 2, 191–270.
Sánchez Castillo, P.M., Díaz-Paniagua, C. (coord.), 2015. Diversidad Morfológica y estrategias reproductoras en algas filamentosas de las marismas y lagunas de Doñana. In: El Sistema de Lagunas Temporales de Doñana, una red de hábitats acuáticos singulares, Madrid. Organismo Autónomo de Parques Nacionales. Ministerio de Agricultura, Alimentación y Medio Ambiente978-84-8014-880-1, .
Scott, J.T., Marcarelli, A.M., Whitton, B., 2012. Cyanobacteria in freshwater benthic environments. In: Ecology of Cyanobacteria II: Their Diversity in Space and Time. Springer.
Siver, P.A., Sandgren, C.D., Smol, J.P., Kristiansen, J., 1995. The distribution of chrysophytes along environmental gradients: their use as biological indicators. In: Chrysophyte Algae. Cambridge University Press, Cambridge, pp. 232–268.
Smolders, A.P.J., Lucassen, E.C.H.E.T., Roelofs, J.G.M., 2002. The isoetid environment biogeochemistry and threats. Aquat. Bot. 73, 325–350.
Soares, A.M.M., Dias, J.M.A., 2006. Coastal upwelling and radiocarbon—evidence for temporal fluctuations in ocean reservoir effect off Portugal during the Holocene. Radiocarbon 48 (1), 45–60.
Sousa, A., García-Murillo, P., Morales, J., García-Barrón, L., 2009. Anthropogenic and natural effects on the coastal lagoons in the southwest of Spain (Doñana National Park). ICES J. Mar. Sci. 66, 1508–1514.
Stevenson, A.C., 1984. Studies on the vegetational history of SW Spain III. Palynological investigations at El Asperillo, Huelva. J. Biogeogr. 11, 527–551.
Stevenson, A.C., 1985. Studies in the vegetational history of S.W. Spain. II. Palynological investigations at Laguna de las Madres, Huelva. J. Biogeogr. 12, 243–268.
Stevenson, A.C., Harrison, R.J., 1992. Ancient forests in Spain: a model for land use and dry forest management in south-west Spain from 4000 BC to 1900 AD. Proc. Prehist. Soc. 58, 227–247.
Stevenson, A.C., Moore, P.D., 1988. Studies in the vegetational history of S.W. Spain. IV. Palynological investigations of a valley mire at El Acebrón, Huelva. J. Biogeogr. 15, 339–361.
Stockmarr, J., 1971. Tablets with spores used in absolute pollen analysis. Pollen Spores 13, 615–621.
Tanner, W.F., 1991. Application of Suite Statistics to Stratigraphy and Sea Level Changes. In: Syvitski, J.P.M. (Ed.), Principles, Methods and Applications of Particle Size Analysis. Cambridge Univ. Press, Cambridge, pp. 283–292.
Uzquiano, P., Allué, E., Antolín, F., Burjachs, F., Picornel, L., Piqué, R., Zapata, L., 2015. All about yew: on the trail of *Taxus baccata* in southwest Europe by means of integrated palaeobotanical and archaeobotanical studies. Veg. Hist. Archaeobotany 24 (1), 229–247.
van Wijk, R.J., 1988. Ecological studies on *Potamogeton pectinatus* L. I. General characteristics, biomass production and life cycles under field conditions. Aquat. Bot. 31, 211–258.
van Wijk, R.J., van Goor, E.M.J., Verkley, J.A.C., 1988. Ecological studies on *Potamogeton pectinatus* L. II. Autoecological characteristics, with emphasis on salt tolerance, intraspecific variation and isoenzyme patterns. Aquat. Bot. 32, 239–260.
Wu, L., Dodge, L., 2005. Landscape Plant Salt Tolerance Selection Guide for Recycled Water Irrigation. A Special Report for the Elvenia J Slosson Endowment Fund University of California, Davis (Article. 40).
Yáñez, C., Rodríguez Ramírez, A., Carrión, J.S., 2006. Cambios en la Vegetación de la franja litoral de las marismas de Doñana durante el Holoceno reciente. An. Biol. 28, 85–94.
Yll, E.I., Zazo, C., Goy, J.L., Pérez Olbiol, R., Pantaleón-Cano, J., Civis, J., Dabrio, C., González, A., Borja, F., Soler, V., Lario, J., Luque, L., Sierro, F., González-Hernández, F.M., Lezine, A.M., Denèfle, M., Roure, J.M., Ruiz Zapata, B., 2003. Quaternary Palaeoenvironmental Changes in South Spain. In: Quaternary Climatic Changes and Environmental Crises in the Mediterranean Region. Publicaciones de la Universidad de Alcalá, Alcalá de Henares, pp. 201–213.
Zazo, C., Goy, J.L., Somoza, L., Dabrio, C.J., Belluomini, G., Impronta, S., Lario, J., Bardají, T., Silva, P.G., 1994. Holocene sequence of sea level fluctuations in relation to climatic trends in the Atlantic-Mediterranean linkage coast. J. Coast. Res. 10 (4), 933–945.
Zazo, C., Dabrio, C., González, A., Sierro, F., Yll, E.I., Goy, J.L., Luque, L., Panataleón-Cano, J., Soler, V., Roure, J.M., Lario, J., Hoyos, M., Borja, F., 1999. The record of the latter glacial and interglacial periods in the Guadalquivir marshlands (Mari López drilling, S.W. Spain). Geogaceta 26, 119–122.
Zazo, C., Dabrio, C.J., Goy, J.L., Lario, J., Cabero, A., Silva, P.G., Bardají, T., Mercier, N., Borja, F., Roquero, E., 2008. The coastal archives of the last 15 ka. In the Atlantic-Mediterranean Spanish linkage area: sea level and climate change. Quat. Int. 181, 72–87.
Zunzunegui, M., 1997. Respuestas de la Vegetación a Ambientes Fluctuantes en el Parque Nacional de Doñana (PhD Thesis). Universidad de Sevilla.