

Although the rate of fertility was fundamental for human survival through evolution, our knowledge about biological and cultural influences to fertility is still very fragmented. At the other side, understanding of human fertility is very important not only if we want to investigate prehistoric fertility but also if we want to understand causes for fertility decrease or increase today. This poster suggest new methodological framework for further studies of prehistoric fertility by using bio-archaeological approach. New framework should include: 1) direct biological evidences about fertility from human bones; 2) investigation of correlation between nutrition and fertility through isotopic and trace element evidences from bones; 3) more evidences about influence of prehistoric culture to fertility through investigation of community concern to pregnancy, delivery and neonatal care. This poster present bioarheological framework to the investigation of fertility at the Danube Gorges population (10000-5500 BC).



T04S023 - CONCEPTS AND METHODS FOR EXPLORING SUSTAINABILITY AND RESILIENCE IN THE ARCHAEOLOGICAL RECORD

Organizers: **Nicola Whitehouse** (University of Plymouth, Plymouth), **Carlo Citter** (University of Siena, Siena), **Cinzia Tavernari** (Abdullah Gül University, Kayseri)

Human-environment relationships remain a critical research focus in archaeology and offer rich opportunities to explore and understand how communities react, adapt and respond to environmental, social and resource changes. Concepts of sustainability and resilience are terms that are frequently used in the context of ecology and geography; are these useful to archaeologists? How might we define archaeological sustainability and resilience? Definitions of ecological resilience, for instance, include an ability to 'bounce back' to a previous state or are defined by systems that are adaptable, with good coping mechanisms. Are any of these concepts useful within an archaeological context? What examples of sustainability and resilience may be found in the archaeological record? Recently, the use of technologies such as GIS and new approaches such as predictive modeling based on deductive analysis and agent based modeling offer exciting ways by which multiple lines of evidence may be brought together to test ideas of ecological, social and resource resilience and sustainability. In this session we invite papers that (i) focus on some of the theoretical debates and questions associated with the concepts of sustainability and resilience in the archaeological record; how might resilience be registered within the archaeological record, might this differ between different societies and socio-economic systems and are these useful concepts for archaeology to explore? What do we mean by 'cultural resilience'? (ii) explore novel methods and different approaches to the study of these themes and especially the use of new technologies. Do these methodological approaches provide new insights and reliable results into how humans managed resources, created sustainable systems and reacted to environmental and social changes? (iii) focus on specific case studies of sustainability and resilience in the archaeological record and explore the types of data that might be useful within the context of this debate. How do archaeologists best engage with these debates to ensure that the archaeological record is interpreted with the necessary expertise?

ORAL PRESENTATIONS

Long-Term Histories of Continuity and Change around the North Pacific Rim: Resilience or Isolation?

Mark Hudson (University of West Kyushu, Kanzaki), **Kara Hoover** (University of Alaska Fairbanks, Fairbanks), **Takamune Kawashima** (Yamaguchi University, Yamaguchi), **Mami Aoyama** (University of West Kyushu, Kanzaki)

Archaeological research on sustainability and resilience often begins with specific sites and sequences, but how can we extend such studies to examine larger regional patterns? This is a broader problem for resilience theory: can increased resilience in, say, the northern Mediterranean be achieved without weakening resilience to the south? This paper analyzes prehistoric to recent resilience around the North Pacific rim from Okinawa to California. Until European colonization, this region was characterized by socially complex societies that often resisted or remained resilient to outside changes for long periods. Despite massive social transformations in the nineteenth and twentieth centuries, some North Pacific societies can be said to retain high levels of resilience into the present day. This paper will use approaches from archaeology, biological anthropology and the health sciences to attempt to ascertain shared factors that both supported and weakened resilience around the North Pacific.

Water and Soils Historical Management in Sierra Nevada. Peasant Strategies to Transform a Mediterranean Mountain into a Vegetable Garden (Granada-Almería, Spain)

José María Martín Civantos (University of Granada, Granada)

When intensive irrigation systems are introduced, a very different option becomes available, in which the social management carries out an equal or more important role than that of the physical conditions. Therefore, when this strategy circulates and eventually becomes preferential, the social organization centered around labor, takes on a fundamental

importance. This agricultural model has to do with a social perspective, perhaps the least logical of the economic options possible in most of the mountainous or semi-arid zones. This is the case of the southeastern part of the Iberian Peninsula, where we can find many of this historical landscapes fossilized and still in use in a very diversified environment. Sierra Nevada (Granada-Almería, Spain), is a good example of this transformation since the Arab-Berber conquest in the VIIIth century. The system becomes extremely complex since it includes not only surface and underground water, but also soils, slopes, cultivated plants, forest or cattle. Mountain was transformed into a vegetable garden, and this social option has been maintained and preferential until now, when agrarian crisis and global change framework have questioned this landscape survival. The paper is part of the MEMOLA project, funded by 7FP-European Commission.

Sustainable and Unsustainable Angkorian Water Management

Kasper Hanus (University of Sydney, Sydney), **Terry Lustig** (University of Sydney, Sydney), **Damian Evans** (University of Sydney, Sydney)

The importance of water management to Angkor's centre at the northwestern end of the Tonle Sap was epitomized by Groslier in his description of Angkor as 'le cité hydraulique'. His thesis was that Angkor's fate was largely influenced by its ability to manage its water resources effectively, and that once it could no longer install new water infrastructure (from the 13th century) "the city is dead". While few scholars would now agree that the deterioration of its water system was the sole cause of Angkor's decline, all would agree that its water played an important role in sustaining it as the centre for six centuries. This contrasts strongly with the period when the centre of Angkor's administration was at Koh Ker, a period of only about 16 years. The cause of Koh Ker's period as the seat of the king being so short has long been speculated on, but now that the area has been surveyed by LIDAR, it has become clear that a crucial factor was the unsustainability of some vital hydraulic infrastructure. Given that both declines were for the same society, these two cases can be compared and contrasted using measures of resilience, without the complication of cultural diversity.

Cultural Resilience Concept as an Instrument of Interdisciplinary Studies of Human Response to Global Climate Change in the Black Sea Region on the Pleistocene-Holocene Boundary

Olena Smyntyna (Odessa National I.I. Mechnikov University, Odessa)

Environmental, cultural, social and historical consequences of global climate changes on the Pleistocene-Holocene boundary accompanied with the Black Sea level rise are subject of alluring discussions since the Black Sea deluge hypothesis was put forward by W. Ryan and W. Pittman in 1997. During last years intensification of multidisciplinary field studies in the region as well as substantial update of theoretical frames of empirical data interpretation and prehistoric reconstructions have revealed methodological, regional and disciplinary peculiarities of conceptualization of different forms of human responses to global climate change in the Black Sea – Mediterranean 'corridor' (further – 'Corridor') during Holocene. Purpose of current contribution is to apply cultural resilience theory for production of new vision of paleohistorical, economic, demographic and other process took place at North-Western Pontic region during X-XI mill. BP in the light of 2 key issues: human migrations influenced by the sea level change and spread of productive economy. As the result, it is demonstrated that peculiarities of subsistence strategies and basic directions of human displacement in the region provoked by global climate change and the sea level rise could be viewed as peculiar mechanisms of 'bounce back' of local hunter-gatherers societies to their previous state.

Archaeology and Environment Over the Long Term of a Landscape Near Châteaugiron (Brittany-France). History of the Territory's Development and Methodological Reflection

Isabelle Catteddu (INRAP – University of Paris I, Cesson-Sévigné)

The multiscale and interdisciplinary reading of archaeological data from excavations conducted over large surface areas are renewing the study of diachronic settlements, but also the study of landscapes, field systems, environment, and agro-pastoral practices. This critical approach has been carried out on the site of Châteaugiron (Brittany, France) : a recent excavation, conducted over a surface area of 25 hectares, which revealed settlements dating from the 3rd millennium BC to the present day. On this site, but also as part of a larger area of research, we had the opportunity of a study using transversal regards and disciplines (archaeology, archaeogeography, geology, geomorphology, history, bioarchaeology....). Multiplying analytical scales permitted an examination in the form of "scenarii" of the questions of inheritance, transmission, creation and transformation, resilience, sustainability, resource management, environmental adaptability, etc. We also revisited the issue of the evolution of field systems over the long term, together with an analysis of rural habitat within its environment, via the study of its rhythms, ruptures and continuities. The studies regularly bring to light transformations of the landscape rather than discontinuities. They remind us of the need to increase levels of analysis to understand the dynamics of these occupations.

Concepts and Methods for Exploring the Forms of Landscapes in the Long Term: The Case of French

Archaeogeography

Magali Watteaux (University of Rennes 2, Rennes)

Recent researches in Archaeogeography have shown that it is impossible to offer a faithful reconstruction of ancient morphological networks (networks of roads, of plots of land and of habitats) despite the increasing accumulation of archaeological data. Indeed, one studies less what things were, because that goal seems increasingly difficult to achieve, than what things have become. Before hope to achieve eventually one particular old object in its form and its historical functions, we must spend more and more time to study the conditions of its transmission to us, in the long term. However, these transmissions are neither linear nor simple but deeply complex and dynamics: we speak to characterize this phenomenon about “transmission” (transmission despite and through transformations). At the heart of this new way in approaching the question of the sustainability of landscapes, there is the concept of resilience, borrowed from geographers. This revolution in the ways of thinking about inherited spatial forms requires to do otherwise: - the need to take into account the contemporary states and to break down barriers between academic periods; - the need to go through a long process of sorting through heritages before expecting any reconstitution; - the need to exceed the level of modeling (the object of the study of archaeologists) to work on the form; - the need to exit the limits of the excavations and to implement a methodology based on multi-scale approach. So, Archaeogeography is the discipline that studies the memory of the forms of landscapes because they are memory objects that are transmitted as they are transformed in the time-space. Archaeological data offer the specific advantage of dating some key moments in the history of these forms. This presentation will provide an opportunity to present this discipline, its objectives, tools and results that illustrate some of the phenomena of resilience of some elements of landscapes.

Location Preference Analysis in Early Roman Colonial Landscapes

Anita Casarotto (Faculty of Archaeology, Leiden University, Leiden)

As has become clear after critical restudy of the evidence dated to the 3rd century BC, the conventional view of Roman colonies as small copies of Rome that radically transformed the conquered lands is less straightforward than has usually been assumed. One central question regards early colonial settlement organization in Central-Southern Italy and its socio-economic rationale. On the admittedly scarce evidence currently available, it is not to be excluded that the first colonists had actually opted for a less invasive and more environmentally sustainable settlement model. Arguably, they may have preferred a multiple-core nucleated settlement system, rather than farms built on their own land plots resulting in an impressive ordered rural territory. Such an alternative model would thus have looked more like the non-urbanized indigenious pattern, within which clusters of sites such as villages played a key role. The issue of both settlement patterns and significant differences (if any) in location preferences between early-colonial and native communities is approached here by applying quantitative spatial analysis and GIS-based predictive modelling. To illustrate how such a location preference analysis may help clarify the character of early Roman expansion, the case of the colony of Venusia is presented.

Evaluating the Environmental Sustainability of Settlements through Cumulative Cost Surfaces. Towns and Castles in Medieval Tuscany

Carlo Citter (University of Siena, Siena)

Cumulative cost surfaces have been the core of the least cost path analysis for decades. Recently, some researchers found cumulative cost surfaces helpful in a broader evaluation process. In particular, they proved to raise many brand new questions to challenge the archaeological and historical datasets in terms of environmental sustainability. The main goal of this paper is to evaluate whether the territory controlled by towns and castles could sustain -i.e. to produce enough food - the people that presumably used to live within it. I shall present some case studies from medieval Tuscany, and the procedures adopted.

Routes and Roads' Resilience in the Longue Durée - The Southern Upper Rhine Region from the Late Iron Age to the Early Middle Ages

Sophie Hueglin (Newcastle University, Newcastle)

The Southern Upper Rhine region or Regio TriRhena – as it is called by politicians today – is one of the main European axes of communication and transportation. The Rhine valley and Belfort gap shape together with the mountain barriers of the Vosges, the Black Forest and the Jura natural corridors running North-South and West-East meeting at the so called “knee” of River Rhine at Basle (CH). The area was continuously settled since the early Neolithic period and thus would be perfectly suited for landscape archaeology in the Longue Durée. But the region is divided between three nations: Germany, France and Switzerland. This means, that there are not only two different languages, several political entities and three geographical coordinate systems, but also various scientific approaches in archaeology to be considered. Previous studies in the region's historical infrastructure, land use and settlement distribution in relation to landscape features were mostly confined to modern borders. Being based on different standards and not using the same methodological approach their

results cannot be compared or brought together easily. This paper will point out the potential in viewing the region as a whole. As a first approach analyzed least-cost paths between settlements will be compared with archaeological remains of road systems. Based on data from the Late Iron Age to the Early Middle Ages traffic infrastructure's long-term sustainability and resilience will be looked at.

Resilient Road Networks and Sustainable Route Facilities: A Case Study from Medieval Near East

Cinzia Tavernari (Abdullah Gül University, Kayseri)

Exploiting the results of several years of historical and archaeological research and mainly using GIS based methods (Least Cost Path and Cumulative Cost Surface), this contribution provides new insights on the development of road networks and the dynamics of the founding of wayside caravanserais in the Near East during the High Middle Ages. Notably a period of significant political upheavals in the Near East, the High Middle Ages (XI-XIV c.) provides an ideal chronological frame in which to investigate the resilience of one of the main routes of the region, namely the Cairo-Damascus road. How did the path of this paramount route cope with the constant turmoil that characterized the medieval period? Was the track influenced mostly by geographic features or by the political situation? In the present paper, I shall also consider the issue of caravanserais' sustainability. The question if caravanserais represented sustainable equipment is crucial for an improved understanding of both the spatial distribution of the edifices and the longevity of the institution. To achieve this result, I will evaluate the resources needed to keep the caravanserais running as charitable institutions and how many travellers they could lodge free of charge.

The Resilience of Travel Culture along the North-Western Caspian Corridor and Its Archaeological and Environmental Signatures

Irina Shingiray (Boston University, Boston), **Dmitriy Buvaev** (Russian Academy of Science – Kalmyk Branch)

This paper will address the resilience of local knowledge which was necessary in order to travel along the northern semi-desert portion of the Western Caspian corridor which connected the Middle East with the Northern Eurasia via the Caucasus. This passageway was mentioned by Strabo and medieval Islamic geographers as the "Wilderness Way." Because of the highly dynamic nature of this landscape, including the seasonal variability of water, plants, and dunal topography, local knowledge and service along this route produced a characteristic travel culture over the long term. This resilient travel culture has its particular archaeological signatures and its own corpus of "folklore" which demonstrate the closely-knit interaction between people and landscape in this territory. Our extensive fieldwork in the region, the application of GIS and RS to monitor the dynamics of sand massifs, the coastal line of the Caspian, and the shifting networks of the old and new road system along that corridor, coupled with research of the local knowledge, politics, and folklore over the long term allows us to talk about the resilience of this travel culture and existence of the official and unofficial (sub-culture) of travel in this region from antiquity to modern times.

Modeling Sustainability and Resilience through the Investigation of Critical Habitats: A View from the US Southwest

Michael Heilen (Statistical Research Inc., Haymarket), **Jeffrey H. Altschul** (Statistical Research Inc., Haymarket)

Cultural and ecological landscapes are the result of a deep history of human-environment interactions, historical contingencies, and adaptive cycles. The diachronic, trans-disciplinary, and spatially-explicit perspective of archaeology permits investigation of the sustainability of cultural and ecological systems and their resilience to perturbations at multiple temporal and spatial scales. GIS-based archaeological modeling approaches are increasingly important in evaluating such relationships, including investigation of how changes in subsistence and land use relate to spatial and temporal variation in cultural and environmental variables. Locational modeling approaches, for example, frequently use environmental characteristics as independent variables to predict variation in site location according to time, environment, and site type. Conversely, archaeological modeling approaches can also make use of site location data and particular site types and attributes to identify critical ecological habitats of the past. This approach permits systematic investigation of the role that critical habitats have played through time and among cultures in the sustainability and resilience of land use systems. In this paper, we explore this concept using several case studies from the US Southwest to show which habitats figured most prominently in sustainable land use systems and which habitats became important during periods of dramatic cultural and environmental change.

Using Resiliency Model Concepts to Explore Human-Environment Interactions: Environmental Variability and Adaptive Cycles of Change in Cappadocia (Turkey) during the Last 10,000 Years

Samantha L. Allcock (School of Applied Sciences, Bournemouth University, Bournemouth)

Recent developments in how palaeoenvironmental and archaeological data sets could be combined and integrated have

included the application of adaptive response and resilience behaviour concepts (Nelson et al., 2007 *Ann. Rev. Environment and Resources* 32, 395-419; Redman, 2005 *Am. Anthropologist* 107, 70-77). The question of socio-economic adaptation and adjustability, as identifiable in the archaeological record, might therefore be examined in light of variable and longer-term environmental and climatic changes. A 'resilience theory' conceptual framework is used here to assess and characterise the changing periods of human occupation and coincident climatic and environmental changes identified from XRF core scanning of Nar Lake sediments and archaeological settlement data from Cappadocia, Turkey. The adaptive model applied in the Cappadocian context identified links at different scales of analysis including four macro scale cycles. At no point throughout the Holocene were climatic and environmental variability seen as the sole drivers of societal change but there were periods when they became important factors in shaping levels of societal resilience. For instance towards the end of LBA, climate (in this case sustained aridity) may have put added stress on communities at times of already dwindling resilience levels and led to major societal re-organisation.

Ecological Resilience and Early Agriculture

Nicola Whitehouse (University of Plymouth, Plymouth)

Concepts of resilience have been developed within the ecological sphere to examine how animal and plant species, communities and ecosystems cope with disturbance and their ability to 'bounce' back to a previous state or recover from a period of environmental perturbation. Resilience has also become a preoccupation within social science, examining how resilient are human populations and societies to change – whether internally or externally derived. There have, however, been limited attempts to examine concepts of resilience within a long time frame, drawing upon the archaeological record. Archaeology offers the advantage of not only providing a long term perspective of how communities cope (or not) with perturbation and the traits associated with such communities, but also the opportunity to link concepts of social and ecological resilience, since as a discipline archaeology often works at the interface of ecology and human ecology. This allows us to potentially explore not only the direct effects of environmental perturbations, but also indirect effects and feedback effects upon the human ecosystem. In this contribution I will explore some of these ideas by examining how early agriculture affected Neolithic ecosystems and vegetation, its ecological impacts and recoveries and how these in turn affected the ecological and social resilience of human populations. What was the resilience of the ecosystems that humans were modifying as agriculture developed and how did this change across time? How do we measure this? Did the ecological interactions associated with agricultural activities impact upon ecosystem function and dynamics and if so, did this impact upon human decision making processes and social spheres? These issues will be examined by reference to the Neolithic in Ireland and adjacent areas.

Sustaining Herds? Animal Demography and Vulnerability in Neolithic Europe

Sarah B. McClure (Department of Anthropology, Pennsylvania State University, State College), **James W. Wood** (Department of Anthropology, Pennsylvania State University, State College)

Addressing sustainability and resilience in the archaeological record rests largely on questions of scale. The intensity of human activity and its effects on local and regional environments are at the core of ecological approaches investigating the spread of farming into Europe, including models of niche construction and human behavioural ecology. Despite interest in animal domesticates as key components of these models, little attention has been given to the demographic and biological underpinnings of Neolithic herds. In this paper we assess to what extent Neolithic herds were sustainable and the potential, scale-dependent vulnerabilities for herd survival. Models based on modern domestic, feral, and wild species-specific fertility and mortality and age-specific herd structures provide the framework for identifying factors related to herd size, vulnerability, and sustainability. We then illustrate the archaeological implications of this work through case studies from the Balkans and central Europe and explore cultural risk minimization strategies that may have been called upon to mitigate vulnerabilities.

Island Biogeography and Human Resilience during the Bronze Age in the Aeolian Archipelago

Girolamo Fiorentino (Department of Cultural Heritage, University of Salento, Lecce), **Valentina Caracuta** (Department of Cultural Heritage, University of Salento, Lecce), **Cosimo D'Oronzo** (University of Salento, Lecce), **Maria Clara Martinelli** (Regional Board of the Archaeological Park of Aeolian Islands, Archaeological Museum L. Bernabò Brea, Lipari, Messina)

The Aeolian Archipelago, located in the southern Tyrrhenian Sea west of Calabria and north of Sicily, consists of 10 islands and islets, of which only 7 are populated. Lack of perennial water resources and a dearth of arable land limit the possibility of extensive agriculture, exposing human communities to the risk of famine and starvation. The carrying capacity of the island system, defined as the potential to sustain a certain human population in equilibrium, is not only determined by environmental parameters, since cultural variables have always influenced human dynamics in the archipelago. The Aeolian Archipelago has a long history of human occupation, beginning during the Neolithic, while during the Bronze Age, the Aeolians prospered thanks to maritime commerce with the Aegean. The opportunity to integrate human history with

environmental developments during the Bronze Age prompted our adoption of a combined approach using carbon isotope analyses and ^{14}C dating from archaeobotanical remains to identify trends in rainfall variation during the 2nd millennium BC. Thanks to the high chronological resolution ensured by the use of AMS techniques, climate signals were integrated with the history of Aeolian communities and the resilience of settlers to the harsh environment was evaluated.

Late Antique Husbandry in the South-Eastern Alps Amid the Chaos of a Crumbling Empire

Borut Toškan (Institute of Archaeology of the Research Centre SAZU, Ljubljana)

In the area of south-eastern Alps the term Late Antiquity excellently expresses the time which is characteristically still Roman, and yet, in addition to incorporating settlement, economic, social and even climatic changes, it is also defined by the emergence and propagation of Christianity as well as the partial presence of barbarian populations. Its character is reflected in the altered settlement pattern, in the radically changed burial rites, in the predominance of Early Christian architecture and of course, in the fine material finds. But what about resource resilience and sustainability during this politically and security unstable situation? By dealing with a variety of zooarchaeological methods and approaches, including biometry, mortality curves and butchery patterns, we tried to evaluate how change in the intensity of production, taxonomic richness of livestock (both in terms of species and phenotypes), local and long-distance supply systems as well as social stratification of the population were determined by the chaos of the crumbling empire. The results indicated Late Antique hill-top settlements to have been economically rather autarchic. The husbandry was based on small size animals of primitive local forms, with pig, poultry and/or sheep-husbandry progressively gaining more and more ground on expanse of cattle.

Charcoal Burning Platforms are Good Indicators to Measure the Sustainability of Forest Resources. The Case of the Medieval Metallurgical Forest on Mount Lozère (French Massif Central)

Sandrine Paradis-Grenouillet (Geolab UMR 6042 CNRS, Limoges), **Gabriel Servera-Vives** (University of Limoges in the laboratory UMR 6042 CNRS GEOLAB, Limoges), **Philippe Allée** (University of Limoges in the laboratory UMR 6042 CNRS GEOLAB, Limoges)

Wood has played a fundamental role in the evolution of human societies. Currently forested landscapes represent the ecological inheritance of centuries of forest management to supply the fuel necessary human activities. To meet their demands for firewood societies gradually modified, transformed and remodeled the landscapes they inhabited. Archaeological charcoal burning platforms provide an exceptional context of study to question the sustainability of wood resources. They are spatial indicators of forest presence and through wood charcoal analyses (determination of wood species and diameter) they bring precious information about the botanical composition and the forest management. Mount Lozère provides an exceptional archaeological context to study the human-environment interactions, particularly for the medieval period. This territory has known an important metallurgical activity from the 11th to the 15th century. Metallurgical activities have long been blamed for the disappearance of the woodland, but the botanical analyses show today the sustainable forest management of a beech coppice during four centuries (diameter and species of exploited wood haven't changed all over the period of metallurgical activities). This paper is an opportunity to highlight the interest of studying charcoal burning platforms (archaeological remains often neglected) to examine forestry practices and to assess the sustainability of natural resources.

POSTER

Assessment of Stability and Change in European Neolithic and Early Bronze Age Agricultural Systems

Sue Colledge (Institute of Archaeology UCL, London)

Contrary to the widely held assumption of the unimpeded growth of population after the initial introduction of farming in Europe, it has now been demonstrated that there were periodic fluctuations, resembling boom-and-bust patterns, in regional population densities (Shennan et al. 2013, Whitehouse et al. 2013). The aims of the EUROEVOL project (https://www.ucl.ac.uk/archaeology/research/directory/euroevol_shennan) are to assess to what extent these fluctuations are a reflection of changing patterns of economic growth and decline, and of relative stability of subsistence systems. Using a dataset of c.14,000 archaeobotanical records from over 300 Neolithic and early Bronze Age sites in northwestern Europe it is possible to explore the likely effects on regional demographics of agricultural innovations, over-exploitation of resources and increasing or decreasing yields in crop and livestock products. Diachronic patterns in the use of domestic cereal and pulse crops are compared in conjunction with associated weed taxa categorised according ecological indicator values (e.g., for soil fertility, water content, pH levels, etc.) to enhance understanding of the relationship between environmental conditions and different cultivation regimes.