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journal homepage: <http://www.elsevier.com/locate/rama>Forum: Social-Ecological System Archetypes for European Rangelands[☆]Tibor Hartel^{a,b,*}, Nora Fagerholm^{c,d}, Mario Torralba^e, Ágnes Balázsi^b, Tobias Plieninger^e^a Babes-Bolyai University, Hungarian Department of Biology and Ecology, Strada Clinicilor 5-7, Cluj-Napoca, Romania^b Ecosystem Service Laboratory–Sapientia Hungarian University of Transylvania, Cluj-Napoca, Romania^c Department of Geosciences and Natural Resource Management, University of Copenhagen, Denmark^d Department of Geography and Geology, University of Turku, Finland^e Social-Ecological Interactions in Agricultural Systems, University of Göttingen and University of Kassel, Germany

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ABSTRACT

Rangelands in Europe are imprinted by livestock production and embedded in mosaic landscapes of grasslands, croplands, woodlands, and settlements. They developed as social-ecological systems: People managed rangelands in order to maintain or enhance their ecosystem services, which in turn supported their well-being. The appreciation of ecosystem services provided by rangelands depends on the broad, socioeconomic aspirations and abilities of the managers and the capital available to achieve these aspirations. Here we propose four archetypal social-ecological system representations for European rangelands along the dimensions of socioeconomic aspirations (i.e., oriented toward conventional or sustainable production) and available financial capital (i.e., low or high) to employ farming technologies on rangelands. The four archetypes are *aspiration misfit*, *pockets of sustainability*, *techno-dependence*, and *money dependent sustainability*. We describe the landscape physiognomy, ecosystem service appreciation, and management-related synergies and trade-offs in ecosystem services supply related to each archetype and formulate a number of research questions to document and further understand them as social-ecological systems. We include the importance of urbanization, land grabbing, and institutional networks in shaping the social-ecological archetypes of rangelands and the relationship between our social-ecological archetypes and the resilience and transformability of rangelands.

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Introduction

People depend on ecosystems. Ecosystems provide not only essential commodities such as food and timber but also sustain human well-being through providing opportunities for economic and social development (Rockström et al., 2009). The rangeland systems of Europe are important components of agricultural landscapes. They occur together with meadows, croplands, woodlands, and settlements. Rangeland management in Europe was traditionally multifunctional; it centered around livestock grazing as a main activity but also included hay making in order to provide winter supplements for livestock and provision of habitat for game hunting (Oppermann, 2014). Woody vegetation, whether scattered

or clumped (Plieninger et al., 2015), as well as other natural vegetation types like small wetlands (Hartel and von Wehrden, 2013), and infrastructure components like small buildings and fences were also valued and maintained within these rangelands. In various biocultural regions of Europe, rangeland and cropping systems often co-occur in landscape mosaics and are closely interlinked in social (e.g., when rangelands and croplands occur within a single operation, which is relatively common) and ecological terms (e.g., when a species depends on both grassland and cultivated habitats) (van Zanten et al., 2014; van der Zanden et al., 2016). Rangelands have crucial importance for environmental sustainability and in particular for biodiversity conservation in Europe. Currently ≈40% of the European Union is covered by farmland (Eurostat, 2013), out of which ≈34% is considered permanent pasture and meadow (i.e., rangeland systems) (Eurostat, 2013). The exceptional biodiversity value of European rangelands lies in their high proportion of native vegetation and significant structural complexity at multiple spatial scales including silvopastoral grazing systems. These natural and cultural features are important for defining the sociocultural and ecological identity of rangelands, yet they are highly vulnerable to loss when land management becomes more specialized and monofunctional. Our main goal in this paper is to propose social-ecological archetypes for

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understanding current European rangelands and identifying their potential for sustainability.

Recent research addressing Pan-European typologies and changes in farming landscapes has focused on landscape structure and configuration (e.g., land cover maps, field size), and management intensity (e.g., chemical inputs) (Levers et al., 2018; van der Zanden et al., 2016). Other studies linked biodiversity and ecosystem service provision with habitat quality and land use across Europe (Maes et al., 2012) or specific regions of Europe (Ruijs et al., 2013). Bürgi et al. (2012) proposed a driving forces framework for understanding changes in the structure, ecosystem service provision, and resilience of farming landscapes. Engler et al. (2018) proposed a social-ecological typology for rangeland systems using socioeconomic properties and rainfall variability and included Mediterranean Europe in their assessments. Building on these insights, we propose four social-ecological archetypes of European rangeland systems. Here, we refer to system archetypes as general, formal, flexible, simple, and largely qualitative models (Bennett et al., 2005, p. 950) that capture the driving forces of landscape change while providing insights into change trajectories (Levers et al., 2018).

First, we argue why the concept of social-ecological systems is useful to understanding the rangeland systems of Europe. Second, we define a matrix that will be used to identify the social-ecological system archetypes. Third, we provide descriptions of four proposed social-ecological system archetypes for European rangelands based on physiognomy, ecosystem service appreciation by managers and institutions involved in rangeland management, and ecosystem service synergies and trade-offs resulting from management. Finally, we discuss the implications of our archetypes for studying European rangelands and, more broadly, agricultural landscapes. While in this forum paper we refer to rangelands, we believe that our approach can be related to other European agricultural landscapes and also to human-dominated landscapes as a whole.

European Rangelands as Social-Ecological Systems

There is wide agreement that the social-ecological systems framework provides novel perspectives for understanding the coevolution of human societies and ecosystems (Folke, 2006). Through various actions and technologies and driven by the benefits to be obtained from ecosystem services, humans influence the biophysical structure, as well as the ecological processes of ecosystems, in order to extract the ecosystem services that they need for their well-being. Through modifications in biophysical structures and ecosystem processes, human action influences the potential of rangelands for ecosystem service delivery via social-ecological feedback mechanisms (Kant and Wu, 2013). A social-ecological systems perspective can be valuable for guiding rangeland systems through rapid changes by stimulating resilience and adaptation. Key concepts of this framework that are relevant for rangeland management include 1) coupling of social and ecological systems, 2) key variables, 3) adaptive cycles, 4) regime shifts, 5) cascading effects, 6) ecosystem stewardship and collaboration, 7) social capital, and 8) traditional ecological knowledge (Plieninger and Bieling, 2013).

European rangelands today result from the centuries-long interactions between human societies and natural ecosystems. Over time, human societies learned to maintain the capacity of rangelands to provide a wide range of ecosystem services, for example, by controlling shrubs and adjusting grazing and mowing activities to facilitate natural seeding (Hartel and Plieninger, 2014; Sutcliffe et al., 2014). Today, the natural values of European rangelands strongly depend on the application of extensive management practices such as mowing and grazing, and several species and habitats of conservation interest are negatively affected by either land abandonment or agricultural intensification (Bergmeier et al., 2010; Halada et al., 2011).

With advancing technologies and increasing demand for food and other resources, the links between societies and rangelands have changed substantially in the past two centuries. In Europe, traditional,

multifunctional rangelands are frequently transformed into monofunctional, intensive open pastures, large-scale arable fields, or timber forests (Hartel and Plieninger, 2014). Other rangelands are converted into urban and infrastructural areas, while rangelands from less productive areas are abandoned (Stoate et al., 2009). These massive changes have influenced the potential of rangeland ecosystems to deliver goods and services to people. For example, the physical removal of trees from many European rangelands has compromised the supply of ecosystem services from these trees, such as shade for livestock, and production of fruit and fodder. At the same time, many rangelands, such as the silvopastoral systems (wood-pastures) of Romania (Hartel et al., 2016) and the dehesa of Spain (Torralba et al., 2017), have largely maintained their traditional structure and function, providing enormous natural and sociocultural value. Hotspots of European rangelands with substantial coverage of silvopastoral rangelands are located in Spain and Portugal, but also in France, Romania, Italy, Greece, and Bulgaria (Plieninger et al., 2015). While these traditional rangelands are increasingly valued by society, their future sustainability is challenged by policy misfits and ongoing processes of land-use change.

Defining Archetypes for European Rangelands

Humans drive landscape change either directly by changing land cover by farming, conversion, or other actions or indirectly through public policies, markets, and demographic trends (Hersperger et al., 2010). Related to this, we propose defining archetypes for European rangelands on the basis of two main drivers of social-ecological change: socioeconomic aspiration and financial capital. An aspiration is a subjectively established goal for achievement based on an individual's assessment of past performance of a familiar task (Starbuck, 1963). Socioeconomic aspirations can determine the decisions and actions of actors, both individuals and institutions. Socioeconomic aspirations are major endogenous drivers of change in human societies (Ray, 2004) and have substantial influence on the ways how agricultural landscapes are managed (Leavy and Smith, 2010), as well as on ecosystem service delivery.

We consider two extremes for an axis of the socioeconomic aspirations related to rangeland management for particular operations: 1) a *production-oriented* aspiration, which means that agricultural yield is of primary importance in deciding management interventions, while ecosystem structures and functions that have no direct relevance for production are considered less important, and often removed, and 2) an *environmental sustainability* aspiration (simplified as sustainability-oriented aspiration), which means that ecosystem structures and functions generating a wide range of goods and services are valued by either the farmer and/or the system incentivizing farming and maintained by management. Most silvopastoral and rangeland operations fall between these two poles in their aspirations.

Within the socioeconomic context of Europe, access to financial capital is of key importance for achieving the socioeconomic aspirations of producers because through financial capital, producers can access or maintain other forms of capital, including natural, human, social, and manufactured (Palomo et al., 2016). Thus, financial capital provides opportunities for moving toward the desired socioeconomic aspirations, and within the context of rangeland managers and their value systems, it influences rangeland management. When the available financial capital is relatively low and/or the access to financial capital by farmers is limited, we assume that access to modern farming technologies is generally restricted and agriculture relies relatively more on human and animal power and is done mostly for subsistence. When financial capital is accessible, we assume that technology, if opted for, will be more accessible and large-scale intensive agriculture will be more probable. Hereafter we recognize two poles for the axis of the financial capital available to producers—*low* (does not allow capital intensive production) and *high* (allows capital intensive production). Most silvopastoral operations will fall between these two extremes.

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