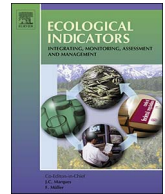


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Indigenous livestock breeds as indicators for cultural ecosystem services: A spatial analysis within the Alpine Space

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ABSTRACT

Great changes have occurred in livestock management in recent decades that have been due to increased specialization and mechanization. In combination with a strong focus on high-yielding breeds and breeds that mainly offer provisioning ecosystem services, these changes have led to a considerable decline in the diversity of indigenous livestock breeds. The cultural benefits provided by locally adapted breeds and their genetic diversity have mostly been neglected. In this study, we aimed to identify the areas of origin of indigenous domesticated animal breeds in the Alpine Space (European Alps), in order to derive a spatially explicit index representing the breeds' contribution to cultural heritage and identity. We compiled a database of the breeds of 14 domestic species that included all of the autochthonous breeds of the Alpine Space that could be cross-referenced in multiple sources. By overlaying the areas of origin of each breed with an administrative boundary layer, we derived an area-wide cultural ecosystem services (CES) index. We identified 261 breeds, with breeds of cattle, goats, sheep, and pigeons as the most frequently identified. The spatial distribution of specific breed groups indicated high variability in the Alpine Space. We found that some regions had no local breeds originating from them, whereas others were characterized by high breed diversity; it typically depended on region-specific breeding and extinction history. In terms of CES provision, the highest potential for cultural benefits was observed in the eastern Alps, with regional hotspots in Bavaria (DE), Tyrol (AT), and Salzburg (AT). The Veneto region (IT) also had high CES index values, which was mainly caused by highly diverse poultry breeds. The spatial distribution of CES provision in the Alpine Space highlights the heterogeneous nature of socio-ecological functioning, and contributes to the identification of critical areas of CES supply. It reveals an untapped potential for economic initiatives that involve marketing and labelling unique agricultural products from this region. If the branding of such products was limited to their place of origin, such initiatives could contribute to the long-term conservation of endangered breeds, and, consequently, constitute a promising conservation strategy.

1. Introduction

Great changes in livestock production systems over the last century, which have mainly been connected with agricultural industrialization, mechanization, and globalization, have led to the abandonment of many local animal breeds (BMELV, 2008; FAO, 2007; Steinfeld, 2006). The history of animal husbandry in the Alps is directly linked to permanent human settlement, which started around 5000 BCE, when Neolithic farmers reached the southern and eastern foothills (Pucher, 2010). Animal breeds were originally selected according to their functions, and only those that adapted best to the environment, husbandry conditions, and the demands of their holders survived (Jaritz,

2014). Breeding for valuable traits, such as the ability to adjust to steep slopes, narrow trails, scree, snow, ice, relatively high ultraviolet radiation, and low food availability, led to a high diversity of domestic animal breeds in the Alps (Jaritz et al., 2010). However, today's livestock production has changed from a resource-driven activity bound to local conditions and environments to one driven by demand, which is typically separate from local geographical or other constraints (FAO, 2011; Steinfeld et al., 2006). Consequently, highly specialized traits in domestic animal breeds often became obsolete in emerging, high-input-based farming systems (Mendelsohn, 2003; Tisdell, 2003), leading to a progressive replacement of traditional multipurpose breeds with high-yielding breeds (Ugarte et al., 2001; Zander et al., 2013) and more

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profit-oriented farming.

The non-material benefits generated by local breeds, such as their sociocultural importance and educational and recreational contributions, have gained recognition in recent decades (Hoffmann et al., 2014; Mendelsohn, 2003). These benefits are of crucial importance for the territorial development of mountain regions, because they directly influence small-scale land management practices, and, consequently, ecological functioning (Tasser et al., 2007). However, the quantification and evaluation of these cultural values is challenging, as they are often intangible and typically not recognized by markets. Moreover, they rarely influence the economic and strategic decisions made by farmers (Swinton et al., 2007). In this context, the ecosystem services (ES) concept could offer a suitable framework to assess the cultural values tied to local breeds, from both an ecological and a socioeconomic standpoint, and contribute to decision-making and developing sustainable land-management strategies. Commonly, ES are defined as the direct and indirect contributions of ecosystems to human well-being (De Groot et al., 2010). Several typologies of ES classification, such as the Millennium Ecosystem Assessment (MEA, 2005) and the TEEB study (2010), have been developed since the ES concept gained popularity in the research community in the early 2000s. For this reason, the Common International Classification of Ecosystem Services (CICES) approach was developed to operate with different ES classification systems, and to provide a common framework to classify ecosystem outputs that are dependent on living processes. CICES organizes ES into three main sections: provisioning services, regulating services, and cultural services. It also provides multiple subcategories for different ecosystem outputs (Haines-Young and Potschin, 2013), which facilitate ES assessments and mapping.

Provisioning and regulating ES, such as the provisioning of nutrition and materials or the maintenance of cultural landscapes, can be attributed to livestock in general, and in some cases, to certain species. However, cultural services are more directly linked to local breeds. The sociocultural significance of local breeds has been highlighted in nearly every study on the subject. The variety of non-material benefits that humans obtain from local livestock breeds includes contributions to cultural heritage, identity, existence, bequest, and spiritual values, as well as important roles in education, recreation, and landscape aesthetics (Ayala et al., 2013; Bernués et al., 2014; Gandini and Villa, 2003; Hoffmann et al., 2014; Zander et al., 2013). Cultural importance is the most significant characteristic of traditional breeds in comparison with new, high-performance breeds. Although new breeds can provide most of the services and functions of their traditional counterparts, the cultural benefits and knowledge systems related to keeping traditional breeds cannot be substituted. Such knowledge and values would be permanently lost in the case of a breed's extinction (Hoffmann et al., 2014; Kugler et al., 2008). However, conservation strategies should not be unconditionally applied to all indigenous breeds, and in developing countries in particular, keeping livestock for food security should not be undermined by inappropriately invested conservation funds (Blasco, 2008). Also for this reason, proper ES assessments are needed to evaluate the whole spectrum of benefits provided by breeds, as well as their actual service delivery and demand. Such assessments are challenging to perform, because there are few suitable indicators available with which to measure cultural ecosystem services (CES) (Benayas et al., 2009; Hernández-Morcillo et al., 2013; MA, 2005). New, non-economic approaches might be needed to better capture CES (Chan et al., 2012), and expand the focus of assessments to a wide range of ecosystem outputs that cannot be measured by monetary or biophysical metrics alone (Satz et al., 2013).

The clear declines in the populations of indigenous breeds that have occurred worldwide (FAO, 2007, 2015) can also be observed across the European Alps. Over 80% of the indigenous farm animal breeds in Switzerland have become extinct (excluding poultry, dogs, and rabbits) (ProSpecieRara, 2016). Other Alpine countries probably have comparable extinction percentages, because similar agricultural and land-

management changes over the last two centuries have occurred there (Jeppen et al., 2015). The conservation of livestock biodiversity is strongly dependent on agricultural practices and management systems (Steinfeld et al., 2006), and productivity and sustainability need to be improved over the next 40 years in order to meet the world's demand for agricultural products (FAO, 2011). These two conflicting imperatives (higher, but more sustainable production) could perhaps be addressed through the concept of ES balancing, which considers both supply and demand (Tancoigne et al., 2014). In recent decades, great efforts have been made to improve our knowledge of livestock breeds worldwide. The Food and Agriculture Organization of the United Nations (FAO) launched the global Domestic Animal Diversity Information System (DAD-IS), which is specifically designed to link information from regional and national registers and spatially allocate breeds up to the national level. Its spatiotemporal coverage, however, is not satisfactory, mainly because of only sporadic updates and incomplete national inventories (FAO, 2015). The FAO commissioned a background study by Hoffmann et al. (2014) to collect existing information on ES provided by livestock breeds and species, and to test the potential of the ES framework to support conservation goals. The study identified multiple constraints to the provision of ES by livestock species and breeds that were mainly connected to economic drivers and a lack of recognition of non-material ES provided by livestock. The study identified a considerable gap in knowledge regarding ES provided at the breed level. Rodríguez-Ortega et al. (2014) analyzed the applicability of the ES concept to livestock farming systems, and found that the ES framework enabled the recognition of a variety of services related to services provisioned by livestock; their results should have major implications for future policy creation in the agro-environment sector. Ovaska and Soini (2016) further explored the ES framework and its ability to recognize ES obtained from indigenous livestock breeds and the perception of these services by stakeholders in Finland, who considered the cultural and historical benefits of domestic breeds highly important, but differed in their opinions on how such factors should influence current policy. The ES framework can overcome conservation challenges by raising the visibility of indigenous domestic breeds and promoting their continued breeding.

Autochthonous livestock breeds have only rarely been studied in the context of ES (Ovaska and Soini, 2016; Tancoigne et al., 2014). The methodological approaches of most livestock breed and trait valuation studies have been based on choice experiments and preference rankings (FAO, 2015). Total economic evaluation studies on single breeds or breed groups can elicit information on the types of ES that local livestock breeds provide (Martin-Collado et al., 2014; Weiler et al., 2014; Zander et al., 2013). Some studies have also considered schemes involving payments for ES that take livestock breeds into consideration (Narloch et al., 2011; Nill, 2011). In the present study, we assessed the potential sociocultural benefits conferred by farm animal breeds in the European Alps in terms of the CICES classification. We used 'cultural heritage and identity' as our reference ES, which is part of the "intellectual and representative interactions" group within the CICES division "Physical and intellectual interaction with biota and ecosystems" (Haines-Young and Potschin, 2013). Although indigenous breeds provide a variety of important provisioning and regulating ES (i.e., a supply of genuine dairy products and the maintenance of genetic biodiversity), our study specifically focused on the contribution of domestic animals to the CES potential of a region. To our knowledge, no spatial ES assessment has been conducted for native livestock breeds on a transnational level. For our analyses, we chose the Alpine Space as a pilot region because of the availability of reliable baseline data (Jaritz, 2014), the existence of a good knowledge base on the subject in the countries included (MIRBS, 2003), and the high cultural diversity of the region, which is visible in the variety of traditional farming practices still performed (Kugler, 2011). The main objectives of our study were to (1) create a comprehensive database of the existing indigenous livestock breeds in the Alpine Space, (2) identify and delineate their

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