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A General Introduction to Historical Ecology

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Since the second half of the 19th century, several human and social sciences have increasingly incorporated the environment when interpreting human practices and behavior. At the same time, ecological sciences have paid increasing attention to human factors and history when analyzing biodiversity and functioning of forest ecosystems and landscapes. Historical ecology emerged in this context.

How ecological systems have changed over time and how past human activities impacted these dynamics are long-standing research questions in ecology. But the emergence of historical ecology as a discipline aiming at answering these questions is more recent. Though many definitions have been given in the literature, we can simply define historical ecology, after Russel (1997), as the field of ecology which aims to reconstruct the history of ecosystems and landscapes in order to analyze how past events have impacted present days biodiversity and ecosystem functioning. This includes causes and consequences of interactions between humans and the environment (Beller et al. 2017), and as such, this definition is quite close to the one used by anthropologists: an interdisciplinary research program concerned with comprehending temporal and spatial dimensions in the relationships of human societies to local environments and the cumulative global effects of these relationships (Balée 2006). Historical ecology does not exclude any time period a priori, even if most studies focused on historical times (i.e. for which written records are available, even if the date varies among regions around the world).

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1.1. The roots of historical ecology

We can trace the roots of historical ecology back to several “undisciplined” scientists, who paved non-conventional roads from their respective discipline, independently from each other. An extensive review can be found in Szabó’s epistemological essay (Szabó 2015). Seeking in the past the drivers of current ecological patterns is an old idea. For example, in the 14th century, Dante already described the historical degradation of Mediterranean forests. Later, in the 18th century, German foresters compared old records of forests to recent ones in order to highlight the degradation of forest ecosystems (Stisser 1737), while in England, Barrington published the first paper about indigenous versus introduced tree species in 1769. Georges Perkins Marsh is usually considered as one of the early pioneers of modern historical ecology, with the publication of his seminal book “*The Earth as Modified by Human Action*” in 1874, though the term “historical ecology” explicitly appeared in Tubbs’ book on the New Forest (1968).

Several disciplines have independently contributed to the emergence of historical ecology:

– *Forest history*, sometimes labeled historical biogeography of forests. The French historian Alfred Maury may be considered as the founder of this school, with his remarkable thesis on the French forests from the pre-Roman to the modern times (Maury 1850).

– *Historical geography*, especially through the French geographer Vidal de la Blache, who launched the journal *Annales de Géographie* in 1891. This journal published a large number of regional naturalist monographs focusing on landscapes as human-made structures.

– *Ecology* and, more precisely, the field of *paleoecology*, which aims to reconstruct past ecological communities and their dynamics in response to natural and anthropogenic drivers using proxies such as pollens and macro-remains.

– *Rural history*, for which the French historians Fèbvre and Bloch were among the pioneers via the journal *Annales d’Histoire économique et sociale* they launched in 1929. This journal published a large number of papers dealing with impacts of the environment on human activities and landscape planning.

– *Landscape archaeology*, with the seminal work of Hoskins in England, published in 1955. This school was the first to use innovative tools such as aerial photographs to detect and map archaeological artifacts at broader spatial scales, such as former Roman *villae* in croplands. More recently, *environmental archaeology* extended the scope of landscape archaeology to the reconstruction of the relationships between past societies and the environments they lived in, using a wide range of proxies and covering the whole Quaternary era (Wilkinson and Stevens 2003).

– *Environmental history*, which roots in social science and ethnology, and aims to study human interaction with the natural world over time. Interestingly, environmental history emerged in North America with Nash (1967), and mostly makes use of written sources and oral surveys.

In the second half of the 20th century, these various approaches progressively converged and the old partition between disciplines tended to relax: time makes historical ecology more and more a multidiscipline.

1.2. A multidisciplinary approach of socio-ecosystems

Current research projects in historical ecology most often rely on multidisciplinary approaches, i.e. they involve already long-established disciplines to focus on a joint topic or object. Most often, this object is a given ecosystem or landscape, which is considered a socio-ecosystem (Redman et al. 2004). Socio-ecosystems are hybrid systems: they are patterned by the interaction between natural drivers (e.g. geomorphology, soil types, natural vegetation) and anthropogenic drivers (e.g. landscape planning, land-use, resource exploitation). A typical example is former orchards that experienced secondary succession following abandonment (see Chapter 15). Investigating the history of socio-ecosystems thus requires the analysis of two types of archives: ecological archives (e.g. soils, plant remains) and human archives (e.g. written sources, archaeological remains).

Among ecological archives, soil is probably the most relevant one. Soils can keep the memory of past environmental conditions for a very long time, and provide historical ecologists with a number of physical, chemical and biological proxies (see Chapter 7). Depending on their properties, they can preserve plant remains (e.g. pollen, seeds and fruits, charcoals, phytoliths; e.g. Schoonmaker and Foster 1991; Feiss et al. 2017) and animal remains (Fitzpatrick and Keegan 2007), as well as their DNA (Rawlence et al. 2014; Birks and Birks 2016; see also Chapter 18). Even land-uses that took place a very long time ago left an imprint in soil properties, which often still impact the current vegetation. For example, former Roman settlements usually harbor a luxuriant vegetation dominated by eutrophic, neutrophilous species, while on former Roman cultivated fields, the vegetation is more scattered and dominated by acidophilous species (Dupouey et al. 2002; Plue et al. 2008; see also Chapter 14). Many case studies have been published for a range of regions of Western Europe, all with similar results, so that some plant communities are even used as indicators in field archaeological surveys (Decocq 2004) and can guide targeted archaeological excavations. However, soil is a palimpsest and its biological activity typically clouds the vertical layering of deposits, rendering difficult the reconstruction of accurate time sequences, especially when a single proxy is investigated (e.g. soil charcoals; Feiss et al. (2017), but see Chapter 9). It is thus necessary to integrate several proxies with contrasted spatio-temporal resolution to get accurate time reconstructions (see Chapter 8), and to cross-reference the information with other ecological archives, such as botanical indicators (see Chapters 10–12) and also human archives.

Regarding human archives, the availability of written sources is limited and both their quantity and quality decrease as we go further back in the past. For example, maps and cadasters allow us to reconstruct landscape changes over the last few centuries, but with a low reliability for the most ancient ones (see Chapter 4). Aerial photography allows us to cover only the last few decades but still with important insights into fast-changing landscapes (see Chapter 5). Aside comparing the same site at different times, remote sensing techniques can be used to seek archaeological artifacts over extended areas, by evidencing vegetation (e.g. aerial photography) or microtopographic (e.g. LiDAR) anomalies that the landscape has inherited from past human activities (Challis et al. 2008; Beck 2011, see also Chapter 6). Archaeological excavations greatly help in interpreting past human–ecosystem interactions but are more rarely implemented in historical ecology projects, since they can cover only restricted areas (but see Chapter 16).

1.3. Recent trends in historical ecology

Over the last few decades, studies in historical ecology have shifted from purely qualitative and descriptive to more quantitative and mechanistic. Old concepts have been revisited and novel insights have emerged. A typical example is the concept of *ancient woodlands*. A number of descriptive studies, mostly from British plant ecologists (Rackham 1980; Peterken 1981), evidenced differences in plant species composition between ancient woodlands (i.e. woodlands that have continuously existed since the date of the oldest available map, which usually dates back to the end of the 18th century in most countries; Hermy and Verheyen 2007) and recent woodlands (i.e. woodlands that have established on former agricultural lands, within the last two centuries). Today, the concept of *ancient forest species* has largely permeated vegetation science and conservation biology (see Chapters 10 and 12). Now, historical ecology turns to understand the underlying mechanisms. Experimental studies, mostly conducted in Belgium for Europe and at the Harvard forest for North America, counterintuitively revealed that these compositional differences were primarily explained by species' dispersal capacities, rather than by habitat quality. In other words, ancient forest species such as *Anemone nemorosa*, *Oxalis acetosella* or *Hyacinthoides non-scripta* in Europe hardly colonize recent forest patches, not because they cannot establish but because diaspores hardly disperse from source populations to recently created forest habitats, especially in fragmented landscapes. In comparison, shade-tolerant species that are not dispersal-limited (e.g. *Urtica dioica*, *Galium aparine* or *Veronica hederifolia*) can colonize recent and ancient forests equally well. This colonization capacity has even been quantified by an index ranging from minus 100 to 100 (reviewed in Flinn and Vellend 2005; Hermy and Verheyen 2007). This example illustrates an important step in the development of historical ecology as a science, since process-based hypotheses are now experimentally tested.

Historical ecology also leads to hot debates in ecology. A remarkable example is the controversy about what the primeval European forest used to look like. The dominant idea has long been the *closed-canopy forest hypothesis*, mostly based on the forest dynamics observed in nature reserves, once any significant human pressure is removed, as well as on pollen records. This hypothesis has been convincingly challenged by the *savannah hypothesis* introduced by Rackham (1998) and further supported by a number of arguments reviewed in Vera (2000). The main argument of the latter hypothesis is that many species of big herbivores used to graze in forests (e.g. buffalos, aurochs, wild horses), and likely maintain the forested areas quite open. Most of these species went extinct in the early Medieval times, so that natural succession conducted to closed-canopy forests with a typically shade-tolerant understory flora. Beyond the fact that these hypotheses are still controversial (e.g. Birks 2005), both emerged as a result of historical ecology approaches of forests (see also Chapter 13).

Furthermore, historical ecology tackles timely topics in ecology, for example the impact of global climate changes on ecosystems. Progress in ecoinformatic has rendered possible the use of large database compiling old ecological records. For example, at least since the end of the 19th century, vegetation scientists have accumulated millions of vegetation relevés worldwide. When these relevés can be relocalized, it is possible to resurvey the same plots decades later (e.g. Verheyen et al. 2017). The comparison between old and new relevés then makes it possible to quantify vegetation changes and subsequently infer the drivers of these changes, by using trait-based approaches (e.g. Closset-Kopp et al. 2019) or by computing correlation with measured changes in environmental factors (e.g. Perring et al. 2016). Although inferring processes from resurvey studies is not trivial (see Chapter 2), legacy studies led to important results, for example: the overriding influence of canopy closure on atmospheric nitrogen deposits in explaining vegetation eutrophication (Verheyen et al. 2012); the importance of land-use