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Perspective

History as grounds for interdisciplinarity: promoting sustainable woodlands via an integrative ecological and socio-cultural perspective

Heather Anne Swanson,[1,2,13,*] Jens-Christian Svenning,[2,3,4,13,*] Alark Saxena,[2,4,5,13,*] Robert Muscarella,[3,4,6] Janet Franklin,[7] Matteo Garbelotto,[8] Andrew S. Mathews,[9] Osamu Saito,[10] Annik E. Schnitzler,[11] Josep M. Serra-Diaz,[12] and Anna L. Tsing[1,9]
[1]Anthropology Department, Aarhus University, Moesgaard Alle 20, 8270 Højbjerg, Denmark
[2]Aarhus University Research on the Anthropocene, Aarhus C, Denmark
[3]Center for Biodiversity Dynamics in a Changing World (BIOCHANGE), Department of Biology, Aarhus University, Ny Munkegade 114, 8000 Aarhus C, Denmark
[4]Section for Ecoinformatics and Biodiversity, Department of Biology, Aarhus University, Ny Munkegade 114, 8000 Aarhus C, Denmark
[5]School of Forestry, Northern Arizona University, Flagstaff, AZ, USA
[6]Plant Ecology and Evolution, Evolutionary Biology Centre, Uppsala University, 75236 Uppsala, Sweden
[7]Department of Botany and Plant Sciences, University of California Riverside, Riverside, CA, USA
[8]Department of Environmental Science, Policy and Management, University of California Berkeley, Berkeley, CA, USA
[9]Department of Anthropology, University of California, Santa Cruz, CA, USA
[10]Institute for Global Environmental Strategies (IGES), Hayama, Kanagawa, Japan
[11]Laboratoire Interdisciplinaire des Environnements Continentaux, LIEC - UMR 7360 CNRS, Université de Lorraine - UFR Sci FA, Campus Bridoux, France
[12]Université de Lorraine, AgroParisTech, INRAE, Silva, 5400 Nancy, France
[13]These authors contributed equally
*Correspondence: ikshswanson@cas.au.dk (H.A.S.), svenning@bios.au.dk (J.-C.S.), alark.saxena@nau.edu (A.S.)
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SUMMARY

While calls for interdisciplinary research in environmental contexts are common, it often remains a struggle to integrate humanities/qualitative social sciences insights with those of bio-physical approaches. We propose that cross-disciplinary historical perspectives can open new avenues for collaboration among social and natural scientists while expanding visions of possible future environments and management scenarios. We make these arguments through attention to woodlands, which are under pressure from complex socio-ecological stressors that can best be understood from interdisciplinary perspectives. By combining deep ecological and shallower social historical approaches, we show how history can both enrich our understandings of woodland pasts and provide a ground for better combining the case-based insights of humanistic history with those of deep-time ecological history. We conclude that such interdisciplinary historical approaches are important not only for research, but also for management (especially rewilding and scenario-building), as the surprisingly large range of past changes reminds us that future conditions can be more varied than typically acknowledged.

INTRODUCTION

There is no shortage of articles about the challenges of interdisciplinary collaboration across different epistemologies and methods of the natural sciences, social sciences, and humanities.[1–5] Yet, despite a general consensus that socio-environmental problems demand cross-disciplinary thinking, the challenges of collaboration continue. Although far from a panacea, we argue that *historical approaches* to socio-ecological change provide possibilities for better integrating insights from diverse disciplinary perspectives, while simultaneously addressing the urgent need for better understandings of past ecological and socio-ecological pathways alongside ongoing dynamism. While there is already growing attention to the importance of historical research in ecology and socio-ecological systems scholarship (SES),[6,7] we illustrate that efforts to bring together deep ecological (multiple thousands to million years) and shallower social historical (centuries) perspectives can simultaneously improve knowledge about socio-ecological change and facilitate cross-disciplinary collaboration. Natural science-affiliated deep-time histories and humanities-associated social histories can individually improve understandings of environmental change, but each perspective is insufficient on its own: shallow histories miss core ecological dynamics and potentials, while deep-time histories are insufficient for addressing the complex socio-ecological dilemmas that we are likely to face in coming decades and centuries.

As we emphasize the overall importance of historical approaches, we place a special focus on the value of the humanities and qualitative social sciences because researchers often struggle to make substantial use of qualitative findings and social theory concepts within interdisciplinary projects with bio-physical roots. While SES has held out the promise of disciplinary integration, many of the potential benefits from incorporating research from more humanistic disciplines remain unrealized.[8] Yet, the humanities and qualitative social sciences are valuable in relation to Anthropocene environmental challenges in two ways: they can contribute to data-based understandings of more recent historical events, with a focus on the rapidity and contingency of social changes, and they can foster more creative and expansive visions about the range of possible futures in both academic and management[9] contexts.

The second point is especially important here: we desperately need visions of socio-ecological futures that are not grounded in "most likely" scenarios. Instead, we need broader visions of both possible negative outcomes to be avoided and more sustainable alternatives that might be fostered. This is where the methods of the humanities and qualitative social sciences take on special importance. Rather than searching for universal principles, these fields have developed methods for examining singular cases—the contingent, situated, and quirky—in rich contextual detail. While this approach has often been seen as a barrier to integration with natural science methods, given that the latter are more focused on regularities we suggest that it can instead be a key tool within transdisciplinary environmental thinking and management. Attention to contingent and idiosyncratic histories, as well as to multiple ways of conceptualizing them within different epistemological and ontological practices, expands our imaginations of possible futures. One can clearly see the power of diverse imaginaries within literary traditions, where Indigenous, queer, feminist, and Afro-futurisms offer qualitatively different future visions from those found in most mainstream science fiction.[10] Diverse historical approaches open up similar imaginative possibilities: by exploring the wider-than-acknowledged ranges of social practices, formations, and changes in the past and present, they show that the world *can be* more different in the future than environmental researchers and managers often realize, because it already *has been* and *is* more varied than usually acknowledged.[11] Global environmental assessments, especially those that rely on scenario-building, such as that of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), have already identified the need for more expansive and creative imaginations of possible futures, both dangerous and promising.[12–16] A powerful way to meet this challenge, we suggest, is to combine the deep-time and humanities/social science modes of research to craft imaginative practices that are empirically rigorous at the same time that they integrate knowledges that are sometimes difficult to convert into datasets, especially those grounded in specific historical occurrences and in diverse forms of human understanding and experience of such happenings.

We make these arguments through attention to *woodlands histories and management* for both substantive and methodological reasons. First, woodlands are crucially important for Earth's rich biodiversity, the functioning of the Earth system and its biosphere, and for human well-being.[17] At the same time, the challenges that woodlands face—increasing pressure from resource demands, human-driven climate change, and other anthropogenic stressors—would clearly benefit from additional interdisciplinary attention. Second, we assert that it is methodologically important to develop our arguments about how a particular mode of historical thinking might aid interdisciplinary collaboration through an empirical example rather than in abstract theoretical space. We do so because our arguments themselves center on the significance of the specificities, details, and contingencies that are most visible within grounded cases.

We propose that a stronger historical understanding of woodlands on multiple timescales, grounded in cross-disciplinary analysis, is important to the challenge of fostering woodland sustainability in the Anthropocene. While sustainability is a contested term in both the social and natural sciences,[18] we here use it to signal a general commitment to fostering livable worlds for diverse people and non-human beings. The mode of historical thinking that we develop in this article combines insights from the natural and social sciences in a new way: natural science research on past woodlands helps us to understand the dynamics of self-willed woodlands as well as the patterns of human-driven woodland change, while social science research on past woodlands helps us to understand the contingency, rapidity, and intersectionality of social processes that shape woodlands. With this emphasis, we aim to draw on and revitalize established traditions of historical ecology and environmental history.[19,20] Simultaneously, we also seek to add a new focus on how history may also hold particular potential as a foundation for new forms of interdisciplinarity. As other scholars have noted, there are multiple ways of being interdisciplinary, with collaborations functioning via different interdisciplinary "sieves."[21] We thus fashion our interdisciplinary sieve through more serious attention to the historical approaches of the humanistic and qualitative social sciences, to address the ongoing challenge of better bringing such approaches into dialogue with bio-physical aspects of environmental science research.

In the following sections, we describe (1) what histories can tell us about the basis for woodland biodiversity and functioning and the dynamics and drivers of woodland change; (2) how more careful attention to these histories can aid in the promotion of woodland sustainability; and (3) how such an approach to history opens possibilities for new modes of interdisciplinary collaboration.

To do this, our analysis intentionally moves across multiple spatial and temporal scales, as we take seriously the shared insight across SES (especially cross-scale dynamics highlighted in work on panarchy) and humanities/social science approaches that any particular place or environmental challenge is shaped by a combination of multiple temporalities and layered spatial connections.[6,22] We thus examine deep-time histories of self-willed woodlands and *longue durée* relations among peoples and woodlands alongside more recent histories of commercialization and industrialization, drawing on the joint expertise of scholars with backgrounds in ecology, plant pathology, conservation, forestry, environmental history, and anthropology.

In the final section of the article, we consider what joint natural and social science attention to histories can contribute toward facilitating sustainable woodland futures. Case-based historical studies, we argue, provide resources for improving our ability to think not only mechanistically (focused on processes), but also more creatively and expansively about ecological futures in the Anthropocene. Due to the rapidity, intensity, and scales of change in the Anthropocene, simply projecting forward based on the limited time data is insufficient. The challenge of achieving sustainability within the Anthropocene needs imaginaries and

Box 1. What are woodlands, and why not forest?

We use the term woodland due to its breadth of usage, also covering semi-open ecosystems with substantial presence of trees (defined as tall-growing, free-standing woody plants) in addition to close-canopied woody ecosystems. In contrast, the term forest is generally ex- or implicitly assumed to refer to closed-canopy tree-dominated ecosystems. We see this as advantageous as these ecosystems all have trees as a key functional component, as these may often represent alternative or intergrading ecosystem states in the same landscape, and as the natural state of many forests include more semi-open areas than conventionally envisioned.[26] As defined here, woodlands include the more densely wooded savannas, with savannas defined as ecosystems with an open tree component and an unbroken grassy field-layer. Importantly, with the term woodland we hope to avoid the misunderstanding that restoration (reforestation) should generally target uniformly dense tree stands. This issue is especially problematic for savanna-like systems,[27] but also important in denser woodland system, which also have many species associated to semi-open conditions.[28,29] Woodlands are purely defined in terms of their structure and include both natural and semi-natural woodlands produced completely or predominantly by non-human processes as well as more or less human-shaped or even human-controlled, even industrial plantations. However, when we are not referring to natural/semi-natural woodlands we will explicitly note this.

shifts in practice that are beyond current standard approaches.[23] It will require a long-term, interdisciplinary view, coupling potential future developments in society and the Earth system with woodland socio-ecological dynamics. Environmental decision making for the long-term requires dealing with a variety of uncertainties that are not only epistemic and stochastic in nature, but are also associated to multiple stakeholders with diverse sets of values operating in a dynamic administrative, economic, political, and legal environment. Through the case of woodlands, we argue that it is important to recognize the potential of ecological and social histories to prompt a wider array of future imaginaries to inform policy and management decisions for woodlands at scales from global to local.

We aim for a mode of interdisciplinarity that brings deep-time ecological and archeological insights about shifts in woodlands together with shorter-time social transformations to more substantially consider the deep roots of woodland biodiversity, effects of past climate change, and prehistoric human-biodiversity interactions—acts that require thinking across geologic and industrial timescales. We stress this combination because, as mentioned above, existing interdisciplinary collaborations have often simplified and limited our understandings of human social processes, especially those of social change, leading researchers and managers to assume that certain institutions and practices are "human nature" when they are instead historically contingent (path dependent). Examining human processes via site-specific case methods is especially important to noticing the extensive diversity, unexpected qualities, and rapid pace of social changes from the 19th century onward. When combined with stronger understanding of deep-time ecological shifts, these short-term histories can expand our imaginaries of possible social changes and management choices (emergence) beyond the narrow range usually presented as rational and commonsensical.

WOODLANDS AND THEIR HISTORIES

Woodlands are a key site for exploring how social and ecological histories are entangled with each other. Plants constitute >80% of the total biomass on Earth,[24] with the dominant contribution from woodlands, here defined as any terrestrial ecosystem characterized by a substantial presence of trees (Box 1; Figure 1). The broad geographic distribution of woodlands, their biomass and productivity, and their deep evolutionary history have resulted in a stunning array of woodland-associated species that span all kingdoms of life; indeed, woodlands harbor a majority of Earth's terrestrial biodiversity.[17] Woodlands exhibit complex dynamics, and are often associated with non-linear and interactive processes, long lag times, and complex trophic interactions. At the same time, woodlands also play crucial roles for the climate system at local to global scales.[25]

Recent research emphasizes the particularly high value of "intact" forest ecosystems—i.e., "relatively unmanaged" woodlands with low levels of human damage or pressure—for biodiversity, as well as for human health, freshwater resources, Indigenous cultural diversity, and carbon storage.[17] However, the majority of modern-day woodlands have been influenced and often simplified to a non-trivial degree by humans.[30,31] Semi-open woodlands have been a key human habitat since the dawn of hominins, while closed-canopy tropical rainforests in Africa and Asia have a shallower history of inhabitation, nevertheless going back at least 50,000 years.[32,33] Woodlands have been important to people in diverse ways in their everyday lives, as well as to a wide range of state, feudal, and international initiatives, e.g., empire-building,[34] development projects, and climate change mitigation efforts.[35]

Although humans have always affected the ecosystems with which they come into contact, with this impact increasing through history,[36] the past 75 years have seen a vertiginous increase in the scale of such impacts.[37] Within a comparable time frame, the wealth and benefits from resources extracted from woodlands have become progressively more displaced with diminishing returns to local populations,[38] while the spread of exotic pests and pathogens has also increased.[39] Widespread deforestation, typically associated with particular modes of transnational economy, and woodland degradation, along with the spread of modern forestry and industrial plantations, have been detrimental to woodland biodiversity, functioning, and many ecosystem services. These processes have been spatially and temporally uneven, with some areas experiencing so-called forest transitions, shifts from net deforestation to net reforestation.[40] Furthermore, while industrial forestry is expanding,[41] there is also increasing interest in restoring woodlands as autonomous, self-willed ecosystems[42] (i.e., without ongoing human control).

Deep history of woodlands

Looking to deep history across 10^4- to 10^7-year timescales is vital for understanding the risks and potentials of present woodlands. The past provides insight to the ecological dynamics that have

Figure 1. Examples of a broad definition of woodlands, historical legacies in woodlands, and active use of historical information in woodland management

(A) Tropical rainforest in Puerto Rico; (B) massive old pedunculated oak (*Quercus robur*) in Bialowieza forest in Poland, Europe's largest remaining lowland semi-natural woodland area; (C) recently unmanaged hemi-boreal forest in Sweden; (D) feral urban woodland with many non-native species (such as the Canary Island date palm (*Phoenix canariensis*) in Buenos Aires, Argentina; (E) unmanaged temperate woodland near Aarhus, Denmark, with active hydrological rewilding; (F) spontaneous open floodplain woodland re-establishment in a Dutch rewilding area with restored large herbivores; (G) extinct Eurasian straight-tusked elephant (*Palaeoloxodon antiquus*), a temperate woodland proboscidean, highlighting how woodlands worldwide have been affected by human-linked megafauna extinctions and associated trophic downgrading; (H) active trophic rewilding with European bison (*Bison bonasus*) in Lille Vildmose, Denmark; (I) coastal redwoods (*Sequoia sempervirens*) as relicts of past climate change losses, which have affected woodlands in many parts of the world (Santa Cruz, California). Photographers: (A and C) R. Muscarella; (B, D, and I) J.-C. Svenning.

produced woodland biodiversity in self-willed ecosystems through millions of years. Furthermore, as past woodlands have been exposed to strong environmental alterations, looking back can provide us with a better basis for forecasting the consequences of future changes. On shallower, but still long 10^2- 10^4-year timescales, it also elucidates the pathways through which diverse human-natural interactions have shaped the structure and function of woodlands. Importantly, a historical approach is crucial for overcoming "shifting baseline syndrome," whereby successive generations tend to accept the state of the environment in which they grew up as normal, despite past change.[43,44]

Woodlands of the deep past

While woodlands have always experienced dynamism on varying spatial and timescales, the tree species and most other woodland-associated organisms found in woodlands today have generally existed as genetically and morphologically recognizable species for hundreds of thousands to millions of years.[45] Understanding how woodland ecosystems have functioned at the timescales over which current woodland biodiversity has evolved is fundamental for their management,[46,47] especially as self-willed ecosystems.

One pattern emerging from studies of deep-time woodlands is the consistent presence of rich megafaunas, including high diversity (and likely high abundance) of large herbivores.[48–51] Diverse large-herbivore faunas strongly influence ecosystem structure and function,[52] including by generating and maintaining open and semi-open habitats within woodland ecosystems[51] as well as by shaping woodlands in more subtle, but important ways.[53,54]

Massive climate changes during the late Cenozoic had major impacts on woodlands. Widespread cooling and drying caused woodland retraction and regional extinctions in various areas. Severe extinctions were seen during the first glacial periods in areas subject to strong climate change (e.g., Europe),[55] with further losses when glacial cycles became deeper during the Middle Pleistocene. During subsequent glacial cycles, relatively few extinctions occurred, likely reflecting previous sorting.[56] Overall, major climate change has had strong and sometimes rapid impacts on woodlands, notably in terms of restructuring species composition and triggering local to regional extirpation.[57] When climate shifts promoted woodland expansion, tree-line edge expansions often lagged by hundreds of years,[58] and many woodland species have experienced strong immigration lags due to dispersal limitation during >10,000 years of relatively stable climate.[59] These dynamics have concentrated woodland species diversity in areas with relatively stable climates.[60]

HOLOCENE RE-SHAPING

Woodlands have been places for an exceptionally large range of human activities, including dwelling, hunting, fuel collection, agriculture, animal grazing, industrial extraction, and recreation. As people have interacted with woodlands, they have also shaped them.[61] People also shape woodlands unintentionally, as livelihood practices re-distribute seeds, symbionts, and pathogens, create light gaps, limit the quantities of old and senescent trees, and encourage some species over others, exploiting various abilities of plants acquired over much longer timescales, as in coppicing or fire response.[62–65]

Humans likely already influenced woodlands in the Pleistocene, with early humans using woodlands for a range of foraging activities.[66] While less intensive than later uses, humans likely heavily affected woodland ecosystems, notably via megafauna losses and fire use.[67] Exemplifying this, around 41,000 years ago abundant megafauna suddenly disappeared from a Queensland savanna ecosystem associated with human expansion across Australia, leading to an increase in fire and a loss of formerly common fire-sensitive trees.[50] These processes generally intensified during the Holocene with stronger effects from the rise of agriculture and associated increases in human populations and demands, albeit with substantial regional variations in lifeways and impacts on woodlands.[68] In many systems of sedentary farming, woodlands provide resource areas for grazing, green manure, firewood, and other needs. Early agriculture often removed woodlands, with the earliest documented deforestation occurring in Syria approximately 10,000 years ago,[69] continuing throughout the Holocene to the present, leading to an 18%–36% forest loss.[70] Loss of megafauna has been widespread and strongly linked to increasing human population densities,[71] with likely strong consequences for woodland ecosystem functioning. Many more subtle changes also occurred: examples include the loss of fire-sensitive silver fir (*Abies alba*) from Mediterranean lowlands due to anthropogenic burning of the landscape,[72] human-dispersal of preferred plants, such as the honey locust (*Gleditsia triacanthos*), in eastern North America,[73] the lasting promotion of useful tree species in much of Amazonia by pre-Columbian communities,[74,75] as well as the widespread loss of large, old trees.[27] As an exemplary case, bottomland forests of large floodplains have been particularly damaged by deforestation, defaunation, and loss of close links between the river and the riverine forests because of regular flooding. In Europe, 99% of riparian forests have disappeared, and very few large rivers have maintained a natural regime of flooding. As a result, these ecosystems have lost many of their original ecological and esthetic characteristics.[76]

Colonial economies, industrialization, and globalization

While human activities have long had major effects on woodlands, the dynamics and types of human-woodland relations changed substantially with European colonialism and the industrial revolution.[77] For example, the Americas experienced large-scale changes in forest cover following European colonization and mass deaths of Indigenous peoples via European-introduced diseases.[78] Later, deforestation (via increased fuelwood use and growth of the wooden ship industry) was arguably a major trigger for the industrial revolution and increased dependence on coal.[79,80] Since the 16th century, a system of tree cultivation based on plantations has come to dominate in many areas. While trees can be grown in many ways, silvicultural practices most associated with "modernity" have advocated monospecific (single-species) tree plantations, often using exotic species, and, since the 1950s, with considerable fossil-fuel-based inputs in the form of fertilizers, pesticides, and herbicides.[81]

A broad set of practices that coalesced in the mid-20th century (the start of the Great Acceleration in socio-economic and Earth system trends) continue to put woodlands under increasing pressure.[82] Much of the world is still undergoing massive conversion of woodlands to agricultural land and industrial plantations.[83,84] There is ongoing pressure to manage woodlands as industrial plantations for intensive timber production.[85,86] Species invasions as a result of globalized human transport increasingly threaten woodland integrity, most notably with non-native plants and pathogens inhibiting native species' performance and survival and altering ecosystem functioning.[87–90] More indirectly, woodlands continue to be affected by trophic downgrading[91] as defaunation trends have spread and deepened (described as Earth's sixth mass extinction),[92] with faunal loss and simplification affecting woodland structure, composition, and functioning.[93] For example, in parts of North America, faunal simplification (including loss of predators), along with declining Indigenous hunting due to European colonization, have resulted in increased abundance of one or a few species of medium-sized ungulates and declines in browse-sensitive plants.[94] Furthermore, large losses of smaller organisms,[95] such as insects (e.g., plant pollinators),[96,97] also pose a risk to the sustainability of the woodlands.

Ultimately, these pressures are societally driven, shaped not only by local and national socio-political conditions, but also by global connections and trade. Shipping of woodland and agricultural products (e.g., rosewood, mahogany, ivory, palm oil) influences land-use change far from points of consumption. Other prominent factors in present woodland form are property ownership regimes, political and economic structures, and ongoing colonial legacies.[98] Failure to uphold Indigenous rights has fostered woodland capitalization, extraction, and conversion to plantations. Structural adjustment practices, liberalization, and export promotion also alter woodland use by increasing conversion to agricultural crops, such as soy, oil palm, coffee, and cocoa.[99] Concentration of ownership, development plans, corruption, and new incentive structures (e.g., REDD+) also have profound impacts on woodlands.[100] (REDD+ stands for reducing emissions from deforestation and forest degradation. The (+) signifies the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks.) Economic practices not directly linked to forests, such as transcontinental shipping, also remake forests by increasing introductions of pests and pathogens.

Cases of plant pests and pathogens are particularly important for demonstrating the importance of contingent social events, such as the popularity of certain ornamental plants, to changes in woodlands. Considering threats to North American woodlands alone, through the last 100 years, a variety of social processes have generated outbreaks of pathogens, such as Dutch elm disease, White Pine Blister Rust, and Sudden Oak Death. The exotic plant trade and industrial plant nurseries,[101] as well as nurseries specialized in the production of plant stock for restoration,[102,103] plantation forestry,[104] and even military activities,[105] have fostered great rates of introduction and spread of pathogenic fungi and water molds. Plant production facilities have also provided sites where introduced and native fungi can become more aggressive through interspecific hybridization or through the development of resistance to fungicides, as seen for the alder hybrid *Phytophthora*[106] and for some strains of the Sudden Oak

Death pathogen, respectively.[107] We note that that, while native forest pests can act as keystone species promoting woodland biodiversity through generation of environmental heterogeneity,[108,109] escalating rates of forest pathogen invasions raise concerns, given that exotic pests and pathogens have been documented to cause loss of native biodiversity and simplification of tree composition.[110] In the Global South, forest pathogens are also an issue, but have not been as extensively researched.[111]

Political economies of woodland dynamics

Political-economic processes also strongly affect woodland dynamics. In many tropical regions, patterns of transnational resource extraction continue to make deforestation a dominant pattern. In contrast, in Europe, eastern North America, and other areas, the abandonment of cultivated lands has contributed to woodland expansion in recent decades. Parts of India and Africa have still other patterns, where rural people have engaged in active protection and reforestation efforts.[112–114]

In some cases, abandoned lands provide conditions that often lead to tree establishment and the eventual autonomous development of woodlands.[115] Many iconic examples of this phenomenon exist, especially in Europe and eastern North America,[116,117] in areas formerly occupied by extensive agriculture, grazing, or other human land use.[118] These unmanaged ecosystems can provide numerous benefits to people and other organisms, including carbon sequestration, air and water purification, and biodiversity habitat.[35] Ecologically, natural and "feral" woodlands (those with self-willed dynamics in areas that were formerly farmland, managed woods, or industrial areas) are more biodiverse and more effective at carbon sequestration than plantation forests, and thus achieving sustainable futures for woodlands should acknowledge the benefits of these ecosystems, along with policies for "unmanagement" or rewilding.[41] Policy actions and economic incentives can positively aid such efforts, e.g., through active restoration of functional megafaunas to enhance the biodiversity value of feral woodlands.[119] However, they can also negatively affect the diversity of woodlands that emerge on abandoned lands, i.e., when tracts are used for plantation-style tree-planting projects composed of one or a few types of trees, rather than more ecologically robust arrangements.[120]

While appreciating the potential value of feral woodlands, it is also important to develop in-depth understandings of the multiple social and ecological processes intertwined with land abandonment at global, regional, and local scales. Agricultural intensification and rural-to-urban immigration have caused some areas to shift from net deforestation to net reforestation, but such processes are not without other consequences, including increased production in some regions and increased fire risk in others.[121–123] Agricultural intensification, for example, has led to a 700% increase in fertilizer use[124] and a several-fold increase in pesticide use[125] in the past five decades,[126] as well as growing concerns about global phosphorous scarcity,[127] eutrophication, soil degradation, and microbial losses.[102] Furthermore, the human health impacts of agricultural intensification have been poorly studied.[128]

Because processes of abandonment are often intersectional and multiscalar, historical and ethnographic attention can provide important insights about site-specific and region-specific drivers and effects. The case of Japanese satoyama forests offers one example of how regional and local histories are essential for understanding the complicated relations of land abandonment and afforestation. After World War II, fossil fuels were substituted for charcoal and firewood. At the same time, rapid industrial development led young people to leave the countryside for urban centers en masse. One result was significantly less woodland use, and thus the rapid growth and northward spread of dense, shady woodlands of evergreen oaks and laurels, which replaced deciduous oaks and pines with a comparatively open forest structure. This led to declines in many culturally significant species of trees, forbs, birds, insects, and fungi. This increasing forest wildness was not celebrated, but was associated with ecological endangerment and loss. In the 1970s, citizen's movements began to take up the cause of woodland revitalization via the intensification of forest use, which is understood to have joint benefits to human and non-human worlds, allowing intergenerational interaction in work and education and reestablishing particular pine woodland assemblages.[129] This case shows how different histories produce different relations to forest regrowth such that feral dynamics are not always a desired outcome from a societal perspective.

Overall, industrial centralization, agricultural intensification, and outsourcing have been key drivers of woodland changes. While these processes work at many scales, they have had long-distance effects:[130] for example, Japanese corporate structures, timber pricing, and domestic consumption practices have exacerbated deforestation in tropical Southeast Asia, while the increased shipping that accompanies outsourcing has led to increases in introduced organisms, including forest pathogens.[131] This nexus of ecosystems, trade, and industry (and the accelerating spread of new pathogens) is important to explicitly include in environmental policy, along with the impact of mass mortality of foundational species, with related impacts on carbon storage and other ecosystem properties. At the same time, it is important to consider other effects of social and institutional forms, such as how the multi-national corporations intertwined with such trade can affect governmental policies in ways that further threaten woodland sustainability (e.g., fast-tracking forest clearance for mining commercial agriculture and other industrial projects).[132,133]

Importance of social histories to present and future woodland challenges

Attention to past political-economic changes is important for considering uncertainties in present management and future woodland management, as social dynamics have as much uncertainty as ecological relations. Active rewilding (restoration to promote self-managing complex ecosystems) and rewilding by default (land abandonment and unmanagement) both have dynamics that are complex and variable.[42] While the abandonment of agricultural and forestry land provides opportunities for return of natural ecological dynamics, including wildlife comebacks, spontaneous reforestation,[134] and the emergence of self-willed woodlands with associated floristic, faunal, and fungal diversities, these ecological dynamics will not be the same as in the past. While such dynamics bring many benefits, they may also generate new sets

Box 2. Case: historical dynamics of Italian chestnut woodlands

At the time of the Last Glacial Maximum (21,000 years bp), sweet chestnut *Castanea sativa* Mill was confined to refugia in the Mediterranean and Caucasus regions.[138] As a heavy-seeded species, its spatial distribution expanded slowly, reflecting strong dispersal limitation lasting to the present day.[59] Human cultivation increased its distribution dramatically, first as a multi-purpose timber tree during the Roman empire (first century CE), and then as a food source during the early middle ages (circa fifth century CE), when it became widespread in hills across Italy[139] and southern Europe.[140] Sweet chestnut was cultivated by peasant smallholders to produce chestnut flour, firewood, and construction timber. Chestnut cultivation in Italy decreased dramatically from about 800,000 ha in 1800 to about 200,000 ha in 2000.[141] Much of this decline was the result of the unintentional transport of pests and pathogens, likely through international trade in live plants. ''Ink disease,'' caused by the water molds *Phytophthora cambivora* (Petri) Buisman, and *Phytophthora cinnamomi* Rand, arrived in Italy in the 1840s. The first official reports of disease outbreaks were in the Monte Pisano (near the port of Livorno)[142] and Biella (near an important alpine pass to France).[143] The disease spread rapidly to devastate low-elevation chestnut orchards across Italy[144–146] causing a decline in cultivation area of 38%–82% in different regions of Tuscany between 1834 and 1929.[147] A historical ecology case study of the Monte Pisano found that where formerly chestnut was cultivated down almost to sea level, *Phytopthora* eliminated almost all chestnut below 500 m between 1869 and 1884,[148] producing a landscape dominated by maritime pine (*Pinus pinaster* Aiton). The destruction of chestnut forests accelerated rapid social change, pushing smallholders and tenant farmers to become industrial workers in water-powered mills in the area,[149] or emigrating to cities and the Americas. In the 1950s, rapid decline of sharecropping and pastoralism led to the abandonment of leaf litter raking for fertilizer. The resulting accumulation of dry vegetation caused increasingly large and intense fires from the 1970s onward, favoring further expansion of *P. pinaster* and other fire-tolerant species. Additional pathogens have been introduced by the intentional transport of live plants, in efforts to hybridize *Phytopthora*-resistant Japanese and Chinese chestnut species with *C. sativa,* introducing of the chestnut canker *Cryphonectria parasitica* (Murrill) M.E. Barr in the 1940s, and the chestnut gall wasp *Dryocosmus kuriphilus* in 2006, both native to East Asia. The case of chestnut's human-facilitated spread across the Mediterranean, and its more recent decline in the Monte Pisano, shows how international trade in living plant material, and socio-economic change can combine to produce major changes in woodlands. Thus, while understandings of climate change in deep-time perspective are essential, the present condition and possible futures of these woodlands must also be considered together with drivers of landscape change, such as rapid social change, introduced pests and pathogens, and forest fires.

of risks: e.g., local human-wildlife conflicts and potential increases (or reductions) in fire risks. Furthermore, interactions between distant places, sometimes called tele-coupling, can add additional complexities and uncertainties.[135,136] Notably, there may be concerns about global-level biodiversity impacts and transnational environmental justice as some regions experience rewilding and others increasing extraction and intensification. In addition, benefits from naturally re-growing woodlands may be lost if socio-economic conditions promote the re-conversion of previously abandoned lands to more intense land uses.

Interdisciplinary historical research and thinking do not eliminate or even reduce such uncertainties, but they alert us to a wider range of possible pathways and effects, and thus reforestation and restoration initiatives would be strengthened by more careful attention to multiscalar socio-ecological historical perspectives.[137] The importance of particular historical examples and the effects of social changes are concretely illustrated through the case of the expansion and decline of *Castanea sativa* (European chestnut) in Box 2, which also provides concrete examples of important but often overlooked social dynamics and their effects on woodlands.

WORKING WITH MULTIPLE HISTORIES

Ecological and social histories show that, while there are long-term dynamics that can provide stability in certain configurations, there are also cases where the convergence of ecological and social dynamics can generate rapid shifts, create surprises, and increase the amplitude of disturbances. Deep-time historical perspectives are clearly important given that the roots of Earth's species diversity extend much deeper than any land use more intensive than hunter-gathering and often much longer than even the presence of *Homo sapiens* within a given region. Hence, we need such perspectives to understand which ecological factors and ecosystem characteristics have allowed the development and long-term maintenance of current species, even across varied, often strong climate changes—information that should inform restoration and conservation actions or other management. More generally, the deep-time histories of woodlands also remind us of the strong ability of woodlands to regenerate if socio-political conditions allow for it, thus pointing to the possibilities of self-willed woodlands and rewilding even in highly degraded landscapes. They also provide clear evidence that biodiversity losses can leave legacies last thousands to millions of years.[55]

At the same time, historical cases repeatedly demonstrate trajectories of woodland change that do not align with prevailing assumptions.[150] Paying attention to seemingly quirky pasts reminds us that conditions we take as givens are often less stable than we think, as the particularities of regional and site-specific social and natural processes intertwine to produce unique and surprising patterns. Attention to the effects of unforeseen social drivers is especially important, as scholarship on socio-environmental processes often suffers from a form of social ''shifting baseline syndrome,'' assuming that social, economic, and political dynamics are ''givens'' when they are often historically recent and in flux. Importantly, it shows how case studies of historical woodland change push us to consider a wider range of potential futures with greater attention to possibilities for radical and non-linear social and ecological transformation, and, in doing so, implicitly argues that scenario planning should more substantially engage with such forms of historical research. "The past is a foreign country,"[151] and in its strangeness it helps us to imagine strange futures.

For these reasons, we suggest that interdisciplinary woodland research should more robustly consider how to incorporate the insights of different modes of historical research within existing paradigms of scenario modeling and SES, as well as how to use historical thinking to expand, enrich, and shift some of their underlying assumptions.[118,152–155] Such historical perspectives will improve our understanding of the socio-ecological background for current woodland systems as well as potential futures.

POTENTIAL BENEFITS AND MANAGEMENT RELEVANCE

Imagination and creativity are essential to sustainable woodland futures. Because management is shaped by the particular imaginaries of its practitioners and itself shapes woodland futures by directing the socio-political practices that affect woodlands as complex social-ecological systems, it is important to consider how we might enrich and expand established visions to better address the challenges of environmental management in the Anthropocene. In these times of crisis, "business as usual" is not sufficient; researchers and managers alike need to do more than consider most likely outcomes if we are to dramatically alter the epoch's troubling trajectories.

While we assess this issue via our focus on woodlands, we also see our larger point about improving future imaginaries via interdisciplinary historical approaches as germane to many environmental management contexts, especially to large scenario-planning initiatives, which play an important role in transnational ecological management. IPBES reviews express a clear and well-articulated need for more robust and expansive scenarios that more substantially consider both social and ecological surprises.[12–15,156] Overall, we assert that the combined imaginative potential of deep-time ecological research and social history is key to addressing such limitations. Yet, we specially highlight the contributions of social history to management imaginaries, as researchers have particularly noted that rapid social changes (surprises)[157] are inadequately captured in the dominant scenario archetypes of many initiatives, such as the Intergovernmental Panel on Climate Change, Millennium Ecosystem Assessment, and Global Environment Outlook.[158] Furthermore, regional and global scenarios typically lack explicit consideration of the perspectives, knowledges, and rights of Indigenous peoples and local communities.[159]

While both the physical/natural and social sciences/humanities have moved beyond stable state paradigms and have actively embraced dynamic ones, scenarios still often lack clear articulation of social dynamism and diversity. This is precisely where more in-depth engagement with the humanities/qualitative social sciences can help by complexifying understandings of social histories and processes, including through their greater willingness to consider how people with diverse conceptualizations of history, such as Indigenous and other marginalized communities, experience and envision pasts, presents, and futures. This kind of research also improves understandings of power and agency. Such perspectives are essential to creating richer and more nuanced scenarios than those generated by the physical/natural and quantitative social sciences alone.

CONCLUSION

History, we assert, is a powerful ally: attention to the range and contingencies of past socio-ecological changes expands our imaginations of possible presents and futures. These points are relevant both for academic researchers involved in interdisciplinary projects, as well as for those actively engaged in management decisions and actions. While we are certain that historically grounded modes of interdisciplinarity will not be a panacea for the challenges of social-natural science collaborations across epistemological and methodological differences, we think that history offers a promising ground for new kinds of alliances. While qualitative case studies, which focus on particular histories and different ways of experiencing the world, are sometimes seen as difficult to integrate with other forms of socio-ecological research, we present an approach for more substantially incorporating their insights. Together, diverse social histories and deep-time ecological perspectives can challenge dominant paradigms and expand notions of the possible. This promise is why more focus on and investment in analytically sophisticated and interdisciplinary approaches to historical research is needed.

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All authors were involved in the conceptualization of the article and the drafting of the first blocks of text during a full-group workshop organized by A.S., H.A.S., R.M., J.-C.S., and A.L.T. All authors also provided comments on drafts. H.A.S., J.-C.S., and A.S., with some input from R.M., wrote and revised drafts and coordinated the overall article writing process. A.M. prepared Box 2. R.M. prepared figures. A.S. and H.A.S. managed the bibliography and final revisions. A.L.T. acquired funding, and also initiated, mobilized, and administered the project.

DECLARATION OF INTERESTS

J.-C.S. is a member of the *One Earth* advisory board.

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