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Pathways to Research

Sustainability

Anthromes: Understanding Global and Regional Sustainability Transformations

by Erle C. Ellis and John E. Quinn
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Human use of land, including agriculture, cities, and other sustained direct interactions with environments, has shaped our planet for more than 12,000 years. Anthromes represent the global patterns of these landscapes shaped by human inhabitation and land use as dense settlements, villages, croplands, rangelands, and cultured lands, with wildlands representing landscapes without human populations or intensive land use. By generalizing across a wide array of social and ecological patterns and their changes over time, anthromes offer valuable insights for conservation and sustainable use of the biosphere and help to broaden understanding of our relationships with the landscapes we've shaped and sustained across the planet.

Keywords
social-ecological systems, global, Anthropocene

Introduction

Ecosystems, from local to global scales, can no longer be described or understood without the legacy of human transformations (Ellis, 2015). These transformations are not a new phenomenon; human use of landscapes to procure and produce food,

fiber, fuel, and other resources has shaped ecosystems across most of Earth's land surface for at least 12,000 years (Ellis et al., 2021). Intensive agricultural land use now covers forty percent of ice-free land area (Foley et al., 2005). Though the cities and towns where most people live cover far less land area, they have outsized influences on the landscapes around them and even those far away (Foley et al., 2005; McDonald et al., 2016; Díaz et al., 2019). Even landscapes that remain less intensively used are altered by human influences, including climate change, environmental pollution, species invasions, and legacies of past land use (Foley et al., 2005; Hobbs et al., 2009; Ellis et al., 2015). Consequently, the environmental, conservation, and sustainability sciences require a global, regional, and local understanding of the ecological patterns and processes of landscapes created and sustained by human societies (Waters et al., 2016; Stephens et al., 2019; Ellis, 2021).

Anthromes, or anthropogenic biomes, serve as a global framework for understanding and strategizing sustainable futures for the landscapes that sustain people and the rest of life on land. Anthromes characterize the globally significant social and ecological patterns created by sustained direct human interactions with ecosystems, including agriculture, grazing, urbanization, and other land uses (Ellis & Ramankutty, 2008). Major groups of anthromes include dense settlements, villages, croplands, rangelands, and cultured lands, and these have been mapped across Earth's land surface at selected time intervals over the past 12,000 years (see Figure 1). Wildlands, defined as landscapes without evidence of human populations or intensive use of land in existing global datasets, are also represented in anthrome maps. In this way, anthromes reflect the planetary history of human reshaping of Earth's terrestrial ecology through a relatively simple set of global categories that integrate human systems into global ecosystem mapping.

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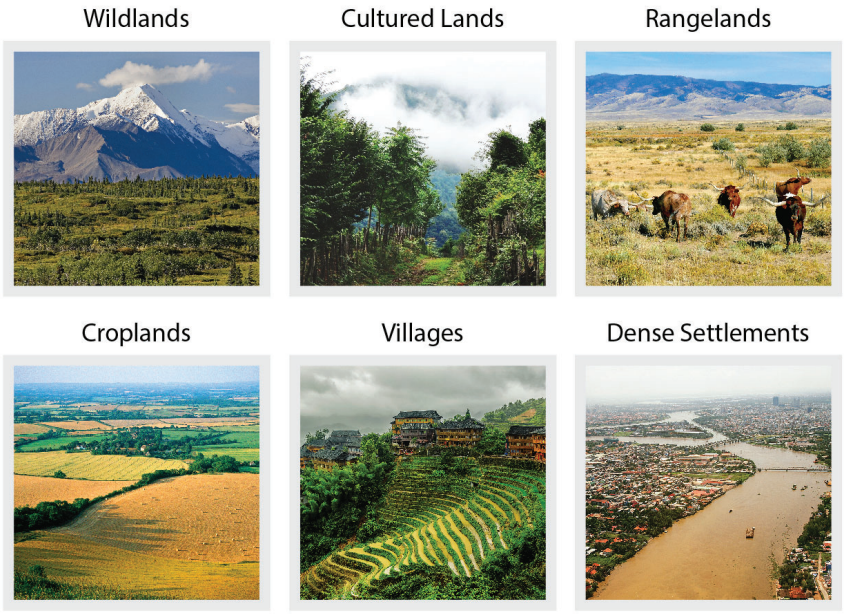

Figure 1: Examples of major anthrome groups.

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The first map of anthromes was calculated from spatial data for global vegetation cover, land use patterns, and human populations (Ellis & Ramankutty, 2008). The goal was to produce a global map of human-shaped ecology analogous to the global maps of biomes and ecoregions shaped by natural patterns of temperature, precipitation, elevation, and other environmental conditions. However, unlike maps of biomes and ecoregions, in which each map unit represents a single type of ecosystem, anthromes represent the global patterns of human-shaped ecology in terms of different kinds of heterogeneous landscape mosaics produced by people through multiple land uses and land covers. This approach was improved in 2010 to map historical changes in anthromes globally from 1700 to 2000, highlighting how human societies shaped landscapes in recent history (Ellis et al., 2010).

Researchers, conservationists, land planners, ecologists, and educators use anthrome maps to understand the biosphere in its human-altered form in textbooks and atlases (e.g., Chapin et al., 2012, National Geographic Society, 2014); for conservation (Martin et al., 2014; Quinn et al., 2017; Dinerstein et al., 2017); in relation to the global patterns of Indigenous peoples' land (Garnett et al., 2018); genetic diversity (Miraldo et al., 2016); the distribution of plants, mammals, and amphibians (Ellis et al., 2012; Brum et al., 2013; Pekin & Pijanowski, 2012); and to

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examine the types of field sites that ecologists study (Martin et al., 2012).

More recently, anthromes have been mapped even further back in time, from 10,000 BCE to 2017 (see Figure 2). These maps evidence the deep history and vast extent of human transformation of ecology across the planet, and the legacy of these past changes in shaping biodiversity today (Ellis et al., 2021), including current variations in the diversity of birds, mammals, and amphibians between anthromes globally and regionally (Quinn et al., 2021).

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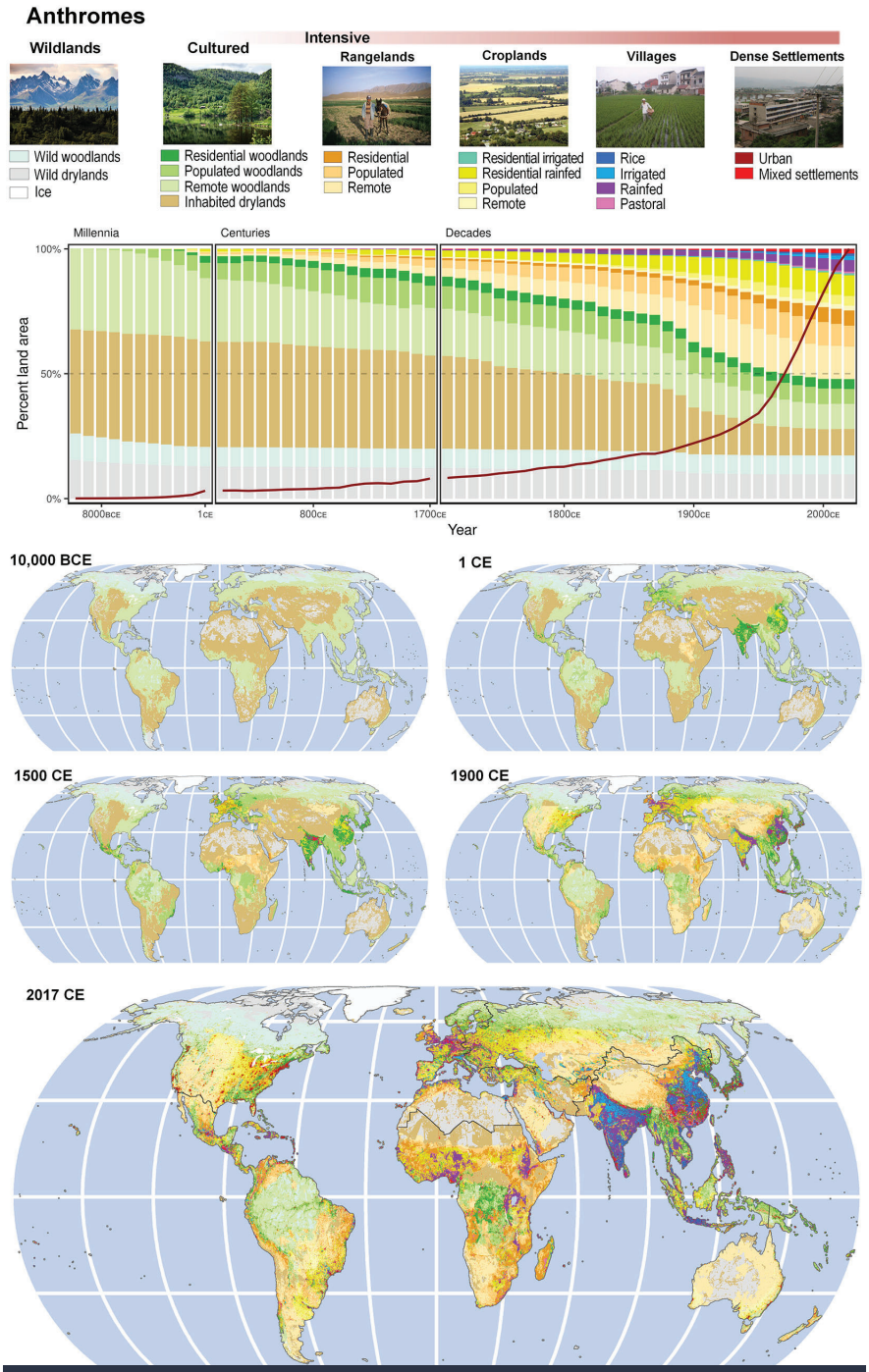

Figure 2: Global timeline and maps of anthromes, 10,000 BCE to 2017 CE.

The red line is global population. Map in Eckert 4 projection (BCE: Before the Common Era, CE: Common Era).
Source: Adapted from Ellis et al. (2021).

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Anthromes along a Gradient of Transformation and Intensification

Anthromes vary in land use intensity and population density. These variations are made explicit through five major anthrome groups: dense settlements, villages, croplands, rangelands, and cultured lands, with wildlands remaining in areas without human populations or intensive use. The landscapes of cultured anthromes are the least intensively transformed, with a majority remaining without intensive human use, though they may be modified through low-intensity uses that maintain vegetation cover, such as hunting and foraging, second-growth forests and forestry, non-timber forest products, and large suburban parks. These anthromes are also lightly populated and remain mostly in frontier, rural, and suburban landscapes. The spatial extent of cultured anthromes has declined by more than half from their peak 10,000 years ago, when they covered nearly 75 percent of ice-free land, mostly through the appropriation, colonization, and intensification of use in landscapes already inhabited and used by prior societies (Ellis et al., 2021). Rates and amounts of conversion from cultured lands to more intensively used anthromes vary greatly in different world regions, but in 2017, cultured anthromes were still the largest group of anthromes globally, covering about 30 percent of ice-free land (see Figure 3).

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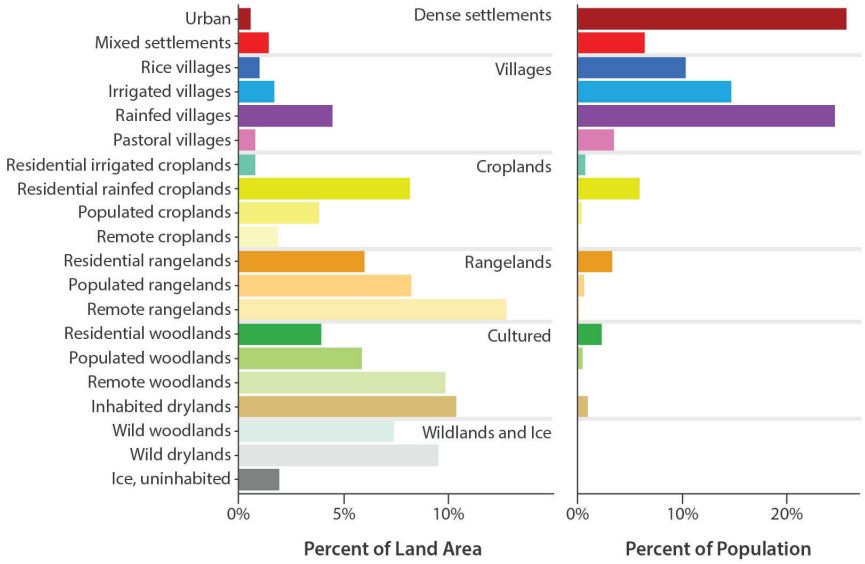

Figure 3: Distribution of land area and human populations within anthromes in 2017 CE.

Cropland and rangeland anthromes are characterized by moderate human populations and intensive use for food, fiber, and fuel production. They covered 15 and 27 percent of ice-free land, respectively, in 2017 (see Figure 2). The spatial extent of croplands and rangelands anthromes has remained comparably constant over the last fifty years, though irrigated cropland anthromes are continuing to expand as of 2017. In most cropland anthromes, arable farm fields are the dominant land cover type. These arable fields produce grains, fibers, fruits, and other agricultural commodities. Interspersed among arable crop fields, the landscapes of cropland anthromes also include a heterogeneous mix of managed and unmanaged patches of vegetation, including annual plants, shrubs, and tree cover as well as human settlements, roads, and other infrastructures (Quinn et al., 2014). Rangeland anthromes, which are more extensive than croplands and almost as extensive as cultured lands, are shaped by land use for domestic ungulate livestock and the economic pressures associated with extensive livestock production systems (Chen et al., 2015). The extent of rangelands tripled in the decades between 1700 and 1900. They are located mostly in dryer regions of the planet, with lower net primary productivity resulting from moisture limitations. In general, outside of woodland regions where deforestation may precede pasture management, rangelands are less transformed by their use to sustain livestock than croplands are, and they also tend to have lower human population densities

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than other anthromes.

Dense settlements and villages, the two most populous anthrome groups, where 80 percent of people live today, cover less than 10 percent of global ice-free land—an extent achieved around the end of the twentieth century. Urban and mixed settlements anthromes are the most densely populated and intensively transformed, with most of their area converted into cities, suburbs, and industrial infrastructure. Village anthromes, which are most common in Asia and Europe, are densely populated agricultural landscapes. They also tend to be some of the most intensively used and agronomically productive landscapes on the planet while also sustaining large human populations in villages, towns, and small cities. Many of these landscapes have been managed intensively by subsistence farmers for hundreds of years or longer. Even today, though village population densities are significantly lower than urban and mixed settlement anthromes, the global extent and total populations of village anthromes are significantly greater than those of the dense settlements.

Some areas of the planet still remain without direct evidence of human populations or intensive use of land in global datasets. These uninhabited landscapes, or wildlands, have always been rare (Ellis et al., 2021). Even 10,000 years ago, they covered, at most, one-quarter of Earth’s ice-free land area, and this area has changed little over time. The reason is simple. Wildlands occur mostly in relatively low productivity areas, like steep slopes and high mountains, and in biomes, like deserts, and tundra, where human populations are either extremely sparse or generally engage in more mobile land use and habitation practices. This relative mobility of human populations has tended to evade detection in global mapping efforts, making it likely that improvements in global datasets achieved through archaeological and anthropological research may yet reveal that many areas now mapped as wildlands are, in fact, cultured anthromes and have been since prehistory (Stephens et al., 2019; Morrison et al., 2021; Ellis, 2021).

Anthromes as a Tool to Improve Conservation and Sustainability

Human transformation of ecosystems is causing alarming declines in biodiversity (Díaz et al., 2019; Rosenberg et al., 2019; Raven & Wagner, 2021). With anthromes covering more than three-quarters of the terrestrial biosphere, it is critical that we

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understand the human context of biodiversity conservation and sustainability efforts (Martin et al., 2014). Fortunately, there is evidence that even in the most densely populated and transformed anthromes, many species can still thrive because anthrome landscapes are rarely used intensively across their entire extent, leaving many patches of habitat for other species (e.g., Schulte et al., 2017; Ramalho & Hobbs, 2012; Ellis, 2021). These conservation opportunities within the working landscapes of anthromes are at least as important as large, protected areas for many species, and some of the highest biodiversity areas of the world, rich in bird, mammal, and amphibian species, are found in the landscapes of villages and other intensively used anthromes (Quinn et al., 2021). There is also evidence that these high levels of biodiversity are not a coincidence but may actually have been shaped and sustained by Indigenous societies in the past (Bliege Bird & Nimmo, 2018; Ellis et al., 2021; Ellis, 2021; Fletcher et al., 2021).

As with losses of biodiversity, the consequences of global climate change, environmental pollution, species invasions, land use for agriculture and settlements, and other human transformations of environments are reshaping the future of Earth’s ecology. Understanding and mitigating the negative impacts of these transformations require global frameworks that integrate human social processes with the ecology of landscapes. Anthromes reflect how ecological and social systems have long interacted to shape land use and land cover across landscapes as they exist today, offering a spatially explicit representation of the biosphere that aligns with sustainability frameworks that consider the role of human relationships with nature (Liu et al., 2007; Ostrom, 2009). This integration of social and ecological systems encourages greater engagement with diverse groups of stakeholders and a better understanding of how actors and institutions are working together (or not) to manage landscapes. For example, recognizing the deep history of land use by Indigenous peoples and others who have lived in, managed, and sustained the ecology of landscapes for generations can help to avoid environmental solutions that might disempower or disadvantage local communities, like conservation programs that exclude local people or payments for forest conservation (Lynch & Talbott, 1995; Garnett et al., 2018; Cole & Hart, 2021; Ellis et al., 2021; Fletcher et al., 2021).

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Human habitation and biodiversity are not necessarily incompatible, with many human societies choosing to sustain and promote biodiverse landscapes in the anthromes in which they live.
Photo courtesy Getty Images.

As our societies discuss conservation and sustainability pathways for the future, anthromes are playing an increasing role in this conversation (Pörtner et al., 2021; Obura et al., 2021). Anthrome histories show that human transformation of ecology is neither new nor inevitably harmful, enabling a deeper understanding of the human role in shaping nature at local, regional, and global scales over the long term (Ellis et al., 2021; Fletcher et al., 2021). This deeper integration of people and nature is critical to support strategies for conservation and sustainable land use for the future in ways that embrace the pluralistic values of nature (Allen et al., 2018; Ellis, 2019; Díaz et al., 2019).

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About the Author

Erle Ellis is a professor of geography and environmental systems at the University of Maryland, Baltimore County (UMBC), where he directs the Anthroecology Laboratory. His research investigates the ecology of human landscapes at local to global scales toward informing sustainable stewardship of the Anthropocene biosphere. He teaches environmental science at UMBC and has taught ecology at Harvard's Graduate School of Design. His first book, *Anthropocene: A Very Short Introduction*, was published in 2018. More about his work at the Anthroecology Laboratory can be found here: https://anthroecology.org/people/ellis.

John Quinn is an associate professor of biology at Furman University in Greenville, South Carolina. At Furman, he leads the CHESS Lab, an interdisciplinary collaboration of faculty and students from across the university. His research considers landscapes and soundscapes as coupled human–natural systems across scales with the objective of providing evidence-based solutions for decision-makers. He teaches a diverse range of classes at the interface of biology and sustainability. More about his work at the CHESS Lab can be found here: https://johnquinniv.wixsite.com/johnquinniv.

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