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Fire Ecology in Africa

Fire is a rapid chemical oxidative reaction that generates heat and light and produces a range of chemical products. It requires an ignition, suitable fuel to burn, and oxygen. Despite the wide availability of these necessary factors in the absence of humans, and clear evidence that fires had been burning vegetation for a hundred million years before the evolution of vertebrate herbivores, it has long been the prejudice of Northern Hemisphere ecologists that fire is essentially an anthropogenic “disturbance” of natural ecosystems. More specifically, it has been argued that fire disturbs the natural succession of vegetation in areas with sufficient rainfall and good soils, to a “climax” vegetation of forest. The study of the effects of fire on ecosystems has languished, the dominant view being that it is climate and soils that determine the character and limits of biomes. In this schema, fires were dependent on climate, which also determined the vegetation types and cycles.

The advent of satellite imagery and Dynamic Global Vegetation Models (DGVMs) solidified doubts about the sufficiency of this conception, and since the early 2000s fire ecology or pyrogeographical studies have entered the mainstream in ecology. The limitations of simple satellite analyses only looking at fire extent, and failures of DGVMs to account for actual plant distributions in fire-prone regions, stimulated South African evolutionary ecologist William Bond to begin to question what he sees as a long-held historical misinterpretation of the fire-prone landscapes of the Global South.[1]

Archibald and colleagues analyzed global data sets on five key characteristics of fire regimes—size, frequency, intensity, season, and extent—in relation to human activity, climate, and biomes. They identified five global syndromes of fire regimes, or pyromes. A good analogy for a fire regime is a local climate regime, with its characteristic seasons, kinds of storms, prevailing winds, and so forth. For sub-Saharan Africa, the most widely distributed pyrome is frequent, cool, small fires ignited by people, contrasting with lightning-ignited frequent, intense, large fires in Australia, both in tropical grasslands but with strikingly different human densities. This different approach to mapping fires is notable in that it doesn't fit neatly with biomes or climate or soil types but emerges from specific sets of interactions between them—mostly vegetation types and climatic factors. One of the five pyromes (intermediate, cool, small fires: ICS) recognizes that humans are the drivers of a globally apparent, unique pyrome representing human modifications of fire characteristics (widespread in woody vegetation except in boreal forests).[2]

This somewhat lengthy preamble is necessary because ideas about fire in African landscapes have played a major role in shaping expert understanding of its ecological effects, and management applications, and early 21st-century research suggests that many of them were mistaken. African ecologists suggest we need to think differently about open ecosystems in particular, that is, those not dominated by trees, and why large open ecosystems persist (notably across Africa) in regions where, according to climate- or soil-oriented theories, forests should exist. In a synthesis of recent thinking, Bond argues that open ecosystems are not determined by vegetation's response to determining abiotic factors (soil and climate): rather, we should be thinking about interactions and feedbacks between abiotic factors and vegetation, fire, and herbivores.[3] Humans impact on all of these. Indeed, fire use is implicated in humans' first landscape-level modifications of landscapes, regarded by Glikson as the spark igniting the Early Anthropocene. Certainly, industrial fire use fuels the CO_2-driven global warming characteristic of the Late Anthropocene.[4]

Over the past 40 years, ecological thinking has overturned the paradigm of "nature in stable equilibrium" and the idea that vegetation progresses linearly from simple forms through evolving complexity to a natural and stable climax state, usually forest. It has been recognized that alternative stable states can exist under the same environmental conditions, for example, forest alongside savanna, or shrublands. These can persist for millennia: paleoecological studies have shown that some grasslands—long presumed to have been created or favored by human practices such as burning for grazing, or clearing trees for farming, charcoal, or iron smelting—are in fact ancient, and the invading vegetation is trees and shrubs. The boundaries between pyrophilic and pyrophobic (fire-intolerant) vegetation types have proved to be surprisingly resilient, patches of forest persisting in fire-prone savannas. Bond distinguishes between three kinds of fire systems: brown world systems (grasslands, with little fire) where herbivores dominate and maintain the system in its current state; black world systems (savannas) where fires are the main consumer of vegetation; and green world systems (forests) where resources (climate and soils) determine forest occurrence and fires are limited.[5]

Hominin Fire

At longer timescales, forest has been more widespread during warm, wet interglacials, with less savanna and less burning, and deserts have expanded during cool, dry glacial periods, also reducing fires. Fire is absent from most arid landscapes, which lack suitable and continuous fuel. In Africa's few Mediterranean-type ecosystems across parts of North Africa and in South Africa's Fynbos Biome, vegetation grows during the wet winters then dries out over the long summers, when hot windy conditions provide good fire weather. In contrast to these drought-driven fire regimes in woody systems, fires in grassy systems tend to be rains-driven. Most (around 70 percent) of vegetation fires across Africa occur in savanna and grassland regions, where rainfall is mostly summer rainfall or bimodal, with natural ignitions linked to seasonal thunderstorms and lightning. Humans have altered natural fire regimes following spring rains, to late dry season burning, but bimodal peaks within fire seasons are often seen, possibly linked to early- and late-season burning for pastoral and agricultural practices.[6]

In Africa, the continent with the longest continuous history of human fire use, hominins first began to use lightning fires *c*. 1.5 million years ago (mya), likely for foraging at first, catching prey flushed out by the flames (as do chimpanzees and birds of prey). This conceivably increased fire spread but did not influence fire season. Key sites providing evidence for early hominin fire use include those at East Turkana (Koobi Fora) and Chesowanja near Lake Baringo in Kenya, Gadep in Ethiopia, and Swartkrans and Wonderwerk caves in South Africa.[7]

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1 William J. Bond, *Open Ecosystems: Ecology and Evolution beyond the Forest Edge* (Oxford: Oxford University Press, 2019).

2 Sally Archibald et al., "Defining Pyromes and Global Syndromes of Fire Regimes," *Proceedings of the Natural Academy of Sciences USA* 110 (2013): 6442–6447.

3 Bond, *Open Ecosystems*.

4 Andrew Glikson, "Fire and Human Evolution: The Deep-Time Blueprints of the Anthropocene," *Anthropocene* 3 (2013): 89–92.

5 Bond, *Open Ecosystems*.

6 Johan G. Goldammer and Cornelis de Ronde, eds., *Wildland Fire Management Handbook for Sub-Sahara Africa* (Freiberg, Germany: Global Fire Monitoring Centre, 2004); and William F. Cooke, Brigitte Koffi, and Jean-Marie Gregoire, "Seasonality of Vegetation Fires in Africa from Remote

Sensing Data and Application of a Global Chemistry Model," *Journal of Geophysical Research* 101 (1996): 21,051–21,065.

[7] John A. J. Gowlett, "The Discovery of Fire by Humans: A Long and Convoluted Process," *Philosophical Transactions of the Royal Society B* 371 (2016): 20150164; and Sally Archibald, A. Carla Staver, and Simon A. Levin, "Evolution of Human-Driven Fire Regimes in Africa," *Proceedings of the National Academy of Sciences of the United States of America* 109 (2012): 847–852.