Welcome to the Pyrocene

A fire creature remakes a fire planet.

By Stephen J. Pyne

Lightning sets fire to a pine tree in Boulder, Colorado

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Earth is a fire planet, the only one we know. Yet there was a time when it did not burn. The oldest fossil charcoal dates back to the early Devonian Period, roughly 420 million years ago, not long after vascular plants colonized the continents. But that was long after the planet itself formed, 4.5 billion years ago. Earth burns now because it acquired life. Life in the oceans filled the atmosphere with oxygen. Life on land piled fuels. Lightning strikes, the occasional volcano, and the rare extraterrestrial impact then ignited fires.

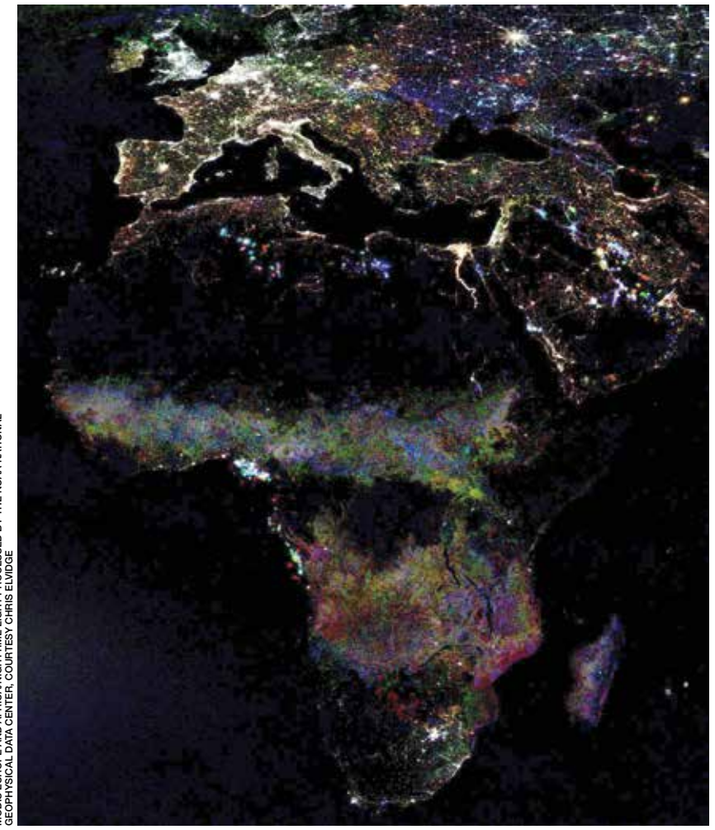
People raised in urban and industrial societies tend to experience fire within built environments—contained in torches and hearths, or burning wild through structures. But the fundamental story of fire is how it burns in living landscapes, taking apart what photosynthesis puts together. It is an ecological process to which life must adapt, while biological evolution enables and shapes it in turn. Hurricanes and floods can occur without a particle of life present. Fire cannot. It more resembles a locust infestation than an ice storm.

Plant species and communities adapt to fire as they would to rain or sunlight. Some have evolved thick bark or fleshy leaves that shield them from heat; others require heat to propagate, like those with cones whose wax must melt in flame to free seeds. Such species can create conditions that promote fire, and they can suffer from its absence. To say of a species that it is adapted to fire is like saying it is adapted to rain. More accurately, it responds to fire's patterns, or what is known as a fire regime. A fire regime is a statistical concept like climate. Just as a given climate can hold many types of storms that come in rough rhythms, so a fire regime can contain many types of fires in particular arrangements.

Fire and rain do interact, for what underlies the cadence of fire is a rhythm of wetting and drying. It has to be wet enough to grow fuels, then dry enough to allow them to burn. Forests burn during droughts, deserts after deluges. Places with routine patterns of wet and dry, such as monsoonal climates, burn regularly; dry-summer ("Mediterranean") climates have ideal wet-dry rhythms, though they often fail to connect with lightning, since thunderstorms occur unpredictably.

The Earth is vast, its "pyrogeography" varied and changing over geologic history. The upshot is that fire can appear lumpy in time and space. Some places burn annually, some not at all. Some intervals are flush with flame, some seem little more than pilot lights for more robust moments of conflagration. The Earth itself swings into and out of fire ages as it does ice ages. The Devonian only flickered with flame; the Permian Period, beginning about 300 million years ago, overflowed with it. Atmospheric oxygen levels have been higher or lower than today's 21 percent norm, from perhaps 15 percent in the Devonian to as much as 35 percent in the Permian.

The geologic record is rich in fire residues and transitions. Some coalbeds from the Carboniferous Period, which preceded the Permian, hold up to 70 percent fossil charcoal, called *fusain*. The 66-million-year-old "K-T" boundary be-



MODIS EUROPE AND AFRICA/NIGHTTIME LIGHT PROCESSED BY THE NOAA NATIONAL GEOPHYSICAL DATA CENTER, COURTESY CHRIS ELVIDGE

Satellite image of Europe and Africa at night: The bright lights come from the burning of fossil fuels or from such sources as nuclear or hydroelectric power that rely indirectly on industrial combustion. The pale lights of Subsahara Africa mainly reflect the burning of surface biomass. The two kinds of fires generally compete, co-existing in a region only during a period of technological transition.

tween the Cretaceous and Paleogene periods is marked not only by iridium from the meteorite that wiped out the dinosaurs but also by fusain. The appearance of grasses in the Miocene, 23 million years ago, encouraged fire to spread in ways that damp-loving woody species could not.

Because Earth has life, and has had it so long, it has abundant stuff to burn. Living landscapes burn, half-buried peat burns, coal burns, even oil and gases escaping to the surface from deep rock burn. During mostly its history, Earth amassed more that could burn than did burn. It took something else to bring flame and fuel into closer alignment: a fire broker.

The genus *Homo* completed the cycle of fire for the circle of life. Life had long controlled oxygen and fuel; now it acquired the capacity to control ignition. As hominin species developed, so too did their ability to spread sparks. At one time not only early *H. sapiens* may have played with fire, but also Neanderthals and other members of our genus. But eventually we *sapiens* became fire's monopolists.

Fire brought us power. We got small guts and big heads because we learned to cook food. We went to the top of the food chain because we learned to cook landscapes. Now we have become a geologic force because we have begun to cook the planet. What we can't do directly with fire, we do indirectly. Fire allows us to cook sand, mud, ore, wood, and tar, yielding the products and technology to make tougher spears, metal tools and weapons, and machines that drive turbines and hurl projectiles. Without fire we are what so many origin myths portray, a minor species whose cleverness has no means to express itself.

Our alliance with fire may be our first Faustian bargain. Our environmental power is fundamentally a firepower. Yet fire, which thrived nicely without us, has also gained. We have expanded fire's domain, recoded its ecological patches and pulses, carried it to places that could never burn on their own, exhumed fuels from deep time and hurled their effluent into the future, even left the planet on plumes of fire. Our pact has rewired Earth's combustion characteristics. Together we have transformed what might have been another interglacial epoch into a fire age. The Pleistocene has yielded to a Pyrocene.

That did not happen instantly. The power of landscape fire derives from its capacity to propagate, and that resides in the topography, vegetation, and atmospheric conditions. People can kindle a spark, but the environment determines whether and how it will spread, and with what effects. We can improve the odds by the timing and placement of ignition, but nature imposes limits. A highly combustible prairie won't burn if it is covered with snow, or if mist replaces wind, or if stalks are flush with moisture and recent rain. We can bring fire to sites that have a suitable wet-dry cycle but lack consistent ignition. We can't force fire onto places that can't receive it.

That still leaves much of Earth open to anthropogenic burning to improve foraging and hunting and to protect against unwanted wildfires. Whether in Australian spinifex grassland, Siberian pine forest, or American oak-hickory forest, a common pattern emerges. Ignition follows routes of travel and those sites where people pause to extract some goods—whitetail deer, blueberries, or camas roots. The resulting lines of fire and fields of fire evolve over time and repeat across each year's seasons; together they provide a matrix within which any fire, of any origin, must burn. The most amenable landscapes are those rich in grass, which are annually available and which can respond quickly. For aboriginal economies the usual formula is to burn early, burn light, burn often. Unless marine resources are abundant, an unburnable site is an unusable one.

Such habitats are largely gifts of nature. If people want more, they have to change those circumstances. Since they can do little about terrain—mountains and ravines are not easily leveled or filled—or about weather—people can't conjure up droughts or winds—that leaves the surface vegetation. Change the flora, and you change the fuels, which means you change the character of fire. You can even burn sites that could not, under natural conditions, carry flames.

How? Slash woods or organic soils and let them dry. Drain peat. Irrigate fields. Grow fallow. Loose cattle, sheep, pigs, and burros to eat, trample, tear at, and otherwise open up woods or brush, altering local sunlight and wind that renders vegetation more burnable. Fire fertilizes and fumigates, releasing chemicals readily accessible to cultigens, purging the native flora that are now considered weeds, and reconfiguring the microclimate.

This, for fire history, is the significance of agriculture, which lays down an altered pattern of pyric patches and pulses. In some systems the farm cycles around the landscape; in others, where rotational planting is the norm, the landscape in effect cycles through a fixed plot of land. Regardless, farming and herding have rewritten the character of landscapes, recoded their fire regimes, and put fire well beyond its natural dominions. Agricultural burning accounts for the greatest extent of anthropogenic fire.

Outside of floodplains (where water serves the role of fire), agriculture is an exercise in fire ecology. Fire does what so many fire ceremonies declare: it promotes the good and purges the bad. This perspective can also explain the long-baffling practice of fallowing. Agronomists have hated fallow since ancient times. It takes vital lands out of production, and worse, it is burned to prepare a field for new crops. Instead, we might pick up the other end of the stick and think in terms of fire ecology. The fallow was not burned to remove it, it was grown in order to *be* burned. Fire was not an afterthought: it was the purpose of the rotation.

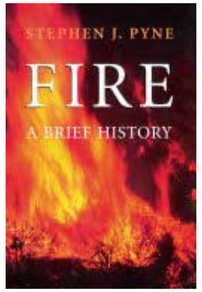
Yet this suite of fire practices, too, has limits. It is possible to coax or coerce only so much out of a site before it degrades. Using the natural powers of fire kept fire within broadly ecological boundaries. Fire seasons might be expanded but not ignored; recycling biomass (or its constituent parts) could not make endlessly more biomass. Instead of renewing, acting as a biotic perpetual-motion machine, agricultural and pastoral fires might simply run down. If we want more fire, we need more fuel.

For most of human history the quest for fire has meant a search for more stuff to burn. That dynamic changed when people found a way to burn fossil biomass, first as peat and coal, and then as oil and gas. We evaded the limits of living landscapes by burning lithic ones.

The old quest for combustion sources has yielded to a new one for carbon sinks. There is now a virtually unbounded cache of fuels. The problem is what to do with all the effluent. The new fires—consider them industrial combustion—burn in machines, not in landscapes. They can burn day and night, winter and summer, through dry and wet. The old biotic borders have dissolved. Earth's lithic landscape no longer underlies the living one: it overlays it. We are taking stuff out of the geologic past and flinging it into the geologic future. Even the cadences of Earth's orbital cycles and wobbles that shape the rhythms of glacial epochs cannot, it seems, contain humanity's untrammeled fires. Climate history has become a subset of fire history. Fire is not simply filling the void of an interglacial but asserting itself with the power of a distinctive fire age. The so-called Anthropocene, the age of humans, might as aptly be termed the Pyrocene.

Its most publicized expression is global warming, followed by acidifying oceans, both driven by increased carbon dioxide in the atmosphere. But the new combustion subtracts as well as adds; it does not play well with the other forms of burning. It removes fire from landscapes, much as it removes flame from houses and factories, leading to two paradoxes, that for all our new firepower, many landscapes suffer from a fire deficit, and that most of our attempts to suppress fire in living landscapes only encourage worse fires. We have too much bad fire, too little good fire, and too much combustion overall.

We have two grand narratives for fire. The Promethean speaks of fire as power, as something abstracted from its natural setting, perhaps by force, and then directed as human hand and mind wish. The Primeval speaks of fire as a companion on our journey, of humans as keystone species and stewards for reconciling fire with land. Our future and that of the Earth depend on which of these narrative paths we choose to follow.



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