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Examining the heritage and legacy of Indigenous land management in oak and pine forests of northeastern United States

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ABSTRACT

This paper examines the role of Indigenous people (Native American Indians) land-use and climate in the historical development of *Quercus* (oak) and *Pinus* (pine) forests of northeastern United States and changes associated with European settlement (circa 1600). Prior to European settlement vast areas of forests in coastal areas of the northeastern U.S. were dominated by oak and pine species. The role of periodic understory burning in the historical development of oak and pine forests and Indigenous agriculture has been debated by paleoecologists and fire-scar dendroecologists. As European populations rapidly expanded during the 18th Century and onward, much of the northeastern U.S. was impacted by extensive timber harvesting, land clearing, and severe fires. However, the westward movement of Europeans into the fertile Midwest during the 19th Century led to farm displacement and land abandonment in the Northeast. Starting in the 20th Century, a variety of ecological phenomena set in, including old field succession, chestnut blight, fire suppression, intensive deer browsing, and urbanization, resulting in dramatic changes in forest composition and the extent of open lands. These trends have culminated in recruitment failures of most oak and pine species on all but the most xeric sites. Instead, late successional mesic hardwoods such as *Acer* (maple) and *Fagus* (beech) are aggressively replacing oak and pine in a process known as mesophication. The leaf litter and woody debris of these replacement species are less flammable and more rapidly mineralized than that of the upland oak and pine, further suppressing fire. The trend toward increases in non-oak tree species will continue in fire-suppressed forests, rendering them less combustible for forest managers who wish to restore vital historic fires regimes. We conclude that the use of prescribed fire and agriculture by Native American Indians were profound and post-European changes in forest composition were mainly due to an alteration land-use (fire suppression) rather than climate change.

Key words: Native Americans, Fire, Land-use, Paleoecology, Anthropology

INTRODUCTION

During the middle and late Holocene, vegetation in the northeastern United States was impacted by a suite of global change phenomena, including Native American activities, the initiation and rapid expansion of Euro-American settlement, Native American depopulation, abrupt shifts and/or reversals in fire regimes, outbreaks of New World insects and disease, and significant climate change (Whitney 1994, Parshall and Foster 2002, Munoz et al. 2010). Circa 1400 until 1850, the northern hemisphere was experiencing the Little Ice Age (LIA) and the initial stages of European settlement took place during this climatic regime. The LIA was followed by abrupt warming associated primarily with the end of a natural cooling period coupled with increased anthropogenic modifications to atmospheric chemistry (IPCC 2013). Human populations and their impacts on vegetation through land use have also changed appreciably during the late Holocene (Abrams and Nowacki 2008, Nowacki et al. 2012, Munoz et al. 2014). Nevertheless, we still have only a marginal understanding of the role of climate and disturbance and their interactions with vegetation dynamics, past and present, for most regions. The importance of climate versus human impacts on pre-European ecosystems in eastern

North America is a highly debated issue (Oswald et al. 2020, Abrams and Nowacki 2020). One argument emphasizes the role of climate driving fire and vegetation dynamics, while another argues that human-caused disturbance, including intentional burning, has been the primary driver, particularly during the second half of the Holocene (Guyette et al. 2006, Nowacki and Abrams 2008, 2015). Thus, a more complete understanding of past human-fire-climate-vegetation dynamics and their anomalies is required.

THE FIRE-CLIMATE DEBATE

The study of fossil charcoal as an indicator of fire has helped elucidate disturbance regimes and their impacts in pollen interpretation (Patterson and Sassaman 1988). Charcoal data from sediment records can be used to provide information about past fire activity from local to global scales (Marlon et al. 2008). Nevertheless, the role of fire, including its origin, drivers, and extent in various forest types and regions, remains a contentious idea among scientists (Pinter et al. 2011, Marlon et al. 2013, Abrams and Nowacki 2008, 2015). Opinions differ about the roles and relative strength of climate versus human (anthropogenic) drivers of fire, including the Early Anthropocene Burning Hypothesis. It deals with the possibility that the early human use of fire was profound, frequent, and prevalent, resulting in it becoming an early ecological driver, despite relatively small populations in places (Ruddiman 2005, Abrams and Nowacki 2015). Other issues that need to be resolved are the extent of lightning as an ignition source and whether burning was localized or ubiquitous in various vegetation types in the eastern USA (Abrams and Nowacki 2008, Nowacki et al. 2012).

Paleoecological studies conducted in oak (*Quercus*) and pine (*Pinus*) forests the coastal regions of Northeastern U.S. indicate that: 1) prior to European settlement fire frequency and severity played a minor ecological role in these forests of southern New England and Long Island, NY; 2) fire was largely controlled by climate; 3) the region was dominated by closed-canopy, old-growth forests; and 4) that Native American people had little impact on fire or vegetation, including limited agricultural systems (Parshall and Foster 2002, Oswald et al. 2020). We disagree, at least in part, with these conclusions because of the large bodies of research that contradict their findings and that they are contrary to basic ecological requirements and conditions of oak and pine not only along the northeast U.S. coast but throughout the world (Nakagoshi et al. 1987, Curt et al. 2009, Gracia et al. 2002, Rodríguez-Trejo and Myers 2010). There has been so much written on this subject and it is not the point of this paper to review all the necessary literature. Rather we want to point out several of the major inconsistencies in the thinking of a substantial number of paleoecologists, including their main conclusion about the limited role of Native Americans in the genesis and maintenance of oak-pine ecosystems in the northeastern United States.

THE HISTORICAL ECOLOGY OF NORTHEAST OAK-PINE FORESTS

A tension zone divides northeastern United States into two prominent forest regions: conifer-northern hardwoods to the north and oak-pine systems to the south (Cogbill 2000, Thomas-Van Gundy et al. 2015) (Figure 1). Together with climate and soils, historic fire occurrence is presumed to have controlled the interface of these two major forest types. In the south, oak-pine communities are largely restricted to predominantly infertile, glacial-derived sandy soils along the Atlantic coast. It is part of a larger oak-dominated system that spans across the central portions of the Eastern Deciduous Forest (Hanberry and Nowacki 2016), and that includes pine (Thompson et al. 2013). Bromley (1935) noted the importance pitch pine (*P. rigida*) plains on light, sandy soils in the original forests of southeastern Massachusetts and Cape Cod, that also includes much of Long Island NY. Indeed, oak, followed by pine, dominated the pollen profiles reported by Oswald et al. (2020). Most forest ecologists believe that oak and pine are primarily light-demanding, disturbance-dependent genera that require frequent or periodic burning to sustain themselves over time (Bromley 1935, Abrams 1992, 2001). Due to their ecophysiological requirements, they would have been prevalent in more open conditions (savannas and woodlands; Hanberry et al. 2018, 2020) and only

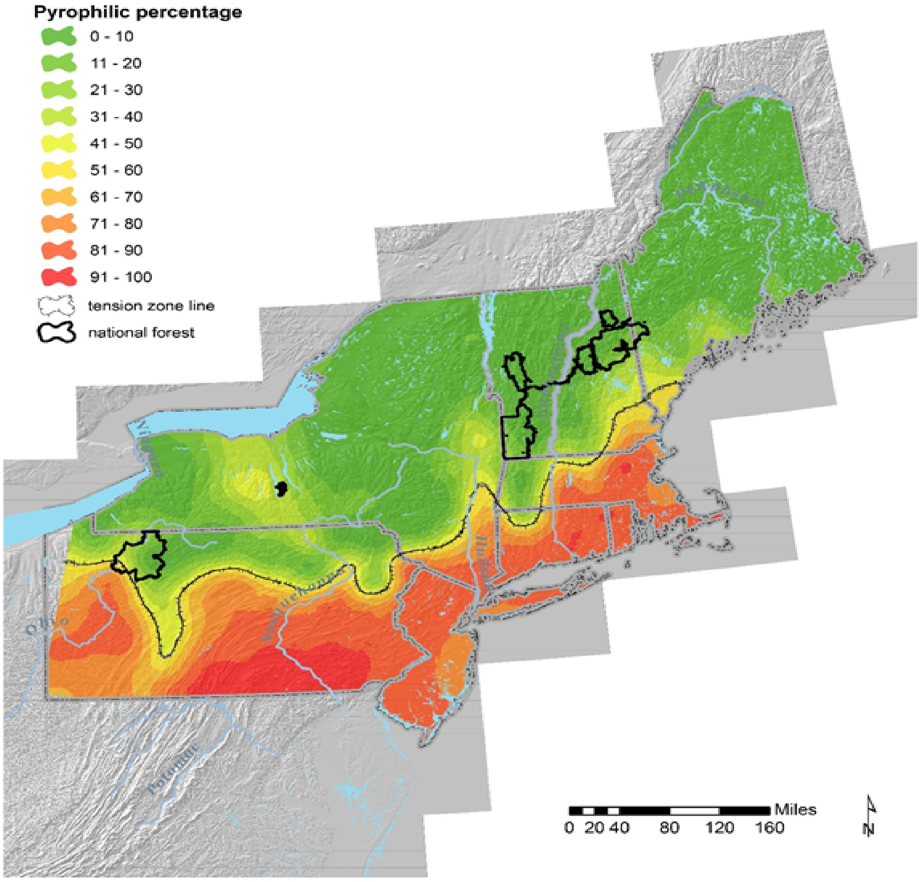

Figure 1. Pyrophilic (fire adapted) percentage map, depicting the importance of historic fire, and the tension zone line spanning the northeastern United States (from Thomas-Van Gundy et al. 2015).

infrequent and transient members in relatively undisturbed, closed-canopy, old-growth forests as described by Oswald et al. (2020). These expressed old-growth forest conditions are more indicative of shade-tolerant, late-successional, wind-dominated conifer-northern hardwood dominated by hemlock (*Tsuga*), maple, and beech north of the Tension Zone. Seemingly, the imposition of northern hardwood dynamics onto oak-pine systems of the south is commonplace in ecology and does not allow the true dynamics of the latter to be recognized and appreciated (Nowacki and Abrams 2015).

Many early colonists of southern New England describe open, parklike forests because of Native American burning and vegetation management (Bromley 1935). Keep in mind that this and other early observations occurred during a pandemic and forced westward relocation that profoundly and negatively disrupted Native American populations and societies (Richter 2001). In his thoroughly researched book, Whitney (1994) reviewed the credible eyewitness accounts of Native American burning in northeast forests and concluded that their cumulative impact is substantial. In areas of the eastern US where General Land Office (GLO) historical tree surveys or land cover maps are available, it is possible to calculate tree density of pre-European settlement forests based on point-center quarter sampling. These studies report the low density, open nature, of most pre-settlement forests and significant increase in tree density in modern-day forests, which is attributed to the suppression of fire after 1940 (Nowacki and Abrams 2008, Hanberry and Abrams 2018). We believe that Oswald et al. (2020) show a significant disregard for the ecological and physiological requirements of the oak and pine species by stating that they do not require fire and can grow in closed-canopy, old-growth forests (Myers and Peroni 1983). The fact that they extend that falsehood into management implications is unfortunate and regressive.

LIMITATIONS OF PALEOECOLOGICAL STUDIES

Paleoecologists often do not differentiate charcoal input between low to moderate intensity surface fires versus crown fires in the sedimentary record. In a study of biomass consumption and behavior of wildland fire, Stocks and Kaufmann (1997) conclude that high intensity wildfires are responsible for the majority of lake sediment charcoal in temperate and boreal ecosystems and that surface fires resulted in lower fuel consumption and input to the sedimentary record (also see Patterson and Sassaman 1988). Abrams and Seischab (1997), in response to Clark and Royal (1996), argued that surface fires in northern oak forests would not produce sufficient charcoal in the sediment record. More recently, Feurdean et al. (2017) used charcoal morphotype analysis in sediment records to distinguish between crown and surface fires in the forests of northeast Europe. This is based on charcoal morphotype work from Enache and Cumming (2006), Jensen et al. (2007), Crawford and Belcher (2014) and others, but was not included in the study by Oswald et al. 2020. There was no mention in that paper that deciduous broadleaf forests in the northeast US, including oak, only sustain surface fires. In contrast, northern pine forests may burn with either crown fires, as in the case of jack pine (*Pinus banksiana*) and dwarf (or barrens) pitch pine (*P. rigida*) or surface fires, as in the case of white pine (*P. strobus*), red pine (*P. resinosa*) and tree-size pitch pine (Wright and Bailey1982). Surface fires in the study catchment may have been recorded in the paleo record, but not those outside the catchment. In contrast, crown fires from both inside and outside the study catchment probably were recorded. We believe the fire record reported by paleoecologists underestimates regional surface (forest understory) fires, including those set by Native Americans. Moreover, very low values on the ZChar axis, represents a regional background level of fire, including low intensity surface fires in pine and oak, rather than no fire at all. Increases in ZChar values represent more local fires. Lastly, misinterpretations of charcoal sediment records led to misconceptions of past fire regimes - misconceptions that can be long lasting and hard to overcome (Oberndorfer 2020).

HISTORICAL EVIDENCE OF FOREST COMPOSITION AND FIRES IN THE NORTHEAST

Many studies of early witness tree versus modern tree surveys that have assessed changes in the oak-pine forests of southern New England. One of the most striking changes is the increase in shade tolerant, maple (mainly red maple, *Acer rubrum*; Abrams 1998, Fei and Steiner 2007, Nowacki and Abrams 2008, 2015, Thompson et al. 2013). The increase in red maple is multifactored, but much of it can be attributed the suppression of forest fires in the early to mid-1900s. Oak and pine are light-demanding, disturbance-oriented genera. Even pitch pine in coastal southern New England and Long Island may be successional in the absence of fire, although this highly flammable system rarely goes too long without burning (Gucker 2007). Exceptions to this are pitch pine (both dwarf and tree size) dominated communities growing on rock outcrops, which appear to be an edaphic climax (Abrams and Orwig 1995, Motzkin et al. 2002). Some coastal dwarf pitch pine communities may be an edaphic (sandy) climax but burn too frequently to express this ability (Gucker 2007). We believe that if the oak and pine systems in southern New England burned as infrequently as suggested by some palaeontologists they would have densified and changed to later successional types, including red maple and beech (Abrams and Hayes 2007). Indeed, Guyette et al. (2012) estimates the pre-European fire return interval at 12-20 years for southern New England and Long Island. Oak and pine trees were vitally important to the northeastern coastal tribes as a food source (e.g., mast in the case of oak) and for wood to build canoes and seal them with resin (in the case of pine). Native people would have managed these forests (mostly using fire) to sustain them and to prevent forest succession to less important tree species, such as red maple. If one posits that fire was unimportant in pre-European eastern oak and pine forests, one must explain why red maple had such low importance in the uplands.

We do not believe that blowdown in the absence of periodic fire would have sustained oak-pine communities - alone it would have only accelerated the transition to later successional stages through understory release (Abrams and Nowacki 1992, Holzmueller et al. 2012). Indeed, in a study of the historical development of old-growth white pine forests at the Pisgah tract in southwestern New Hampshire, Foster (1988) concluded that white pine needs a combination of both extensive wind-throw and fire for successful establishment; wind-throw by itself may not be adequate. Fire and blowdown are two common disturbing agents associated with white pine in eastern forests and operate in concert with one another (Abrams 2001).

When discussing fire, one must ask "What is the ignition source?" Modern-day lightning-strike density is low in southern New England and Long Island (Abrams and Nowacki 2008, Holle and Brooks 2019) and does not adequately explain the predominance and persistence of fire-adapted oak-pine forests, especially in the humid East where lightning is normally associated with rain events. Furthermore, lightning storms are largely restricted to the summer growing season when humidity is high and vegetation flammability is low. Based on pre-Euro-American fire-scar research, most oak systems burned during the dormant season, fully consistent with Native rather than lightning ignitions (Guyette et al. 2006). Even though fire occurrence is associated with drought, as often reported (including Oswald et al. (2020)), the fire-scar record indicates that drought-induced fires are not fully realized without broad-scale human ignitions (Guyette et al. 2006; Stambaugh et al. 2018). Pyne (1984) concluded that lightning produced a small proportion of the ignitions in the Northeast. The low occurrence of lightning in the study area is inconsistent with the large fire-based vegetation formations of southern New England and suggests that Native American ignitions were highly important (Abrams and Nowacki 2008, 2015).

EVIDENCE OF FIRE IN THE PALEOECOLOGICAL RECORD

In paleo-chronologies of 2500 to 3500 years for oak, chestnut (*Castanea*) and pine forests in north-central Massachusetts, Foster et al. (2002) concluded that "fire was an important but varying force shaping vegetation patterns at the regional, landscape and stand scale in central New England. Given that fire ignitions are inferred to be largely anthropogenic in origins this also implies that the New England landscape must be considered controlled, at least in part, by cultural, as well as natural and environmental factors over past millennia." These statements support the findings of other paleoecology studies. On Deep Pond located in Suffolk County, Long island NY, oak and pine forests were sustained for 2,180 years with moderately high fire activity (Patterson 2006). Stevens (1996) suggested that frequent Native American burning on the island of Martha's Vineyard, Massachusetts, may have been responsible for the coincidence of high charcoal values and high oak and grass pollen percentages. She also found abundant charcoal with abundant oak and grass pollen in post-settlement sediments. Parshall and Foster (2002) reported that pre-settlement fires were clearly most common in the pitch pine-oak forests along the warmer New England coastal region, especially on the outwash plains of Cape Cod, Martha's Vineyard, and Long Island. Pitch pine is shade-intolerant and does not regenerate well in thick leaf litter, so fires of moderate to severe intensity can encourage stand establishment. However, they conclude that while Native American populations were higher along the coast of New England, the high occurrence of fires in pitch pine and oak forests in these locations can be explained by the climatic and fuel conditions without attributing a higher incidence of burning by people. They do not explain the ignition source for these coastal fires.

At times paleoecologists have equivocated that "During times when Native populations were relatively high, we found no evidence for forest clearance, elevated use of fire, or widespread agriculture (Oswald et al. 2020)." In contrast, Patterson and Sassaman (1988) conclude that there was a significant burning and agricultural fields near protohistoric Native American settlements and that a high density of Native populations existed in the coastal area of southern New England and Long Island. While the Native America populations of northern New England were mostly nonagricultural, hunters and gathers (including fishing) due to the poor climate and soils, populations to the south practiced extensive agriculture (Cronon 1983). A study of regional forest dynamics in north-central Massachusetts, Foster et al. (1998), reported that "prehistorical Indian activity in the region had adopted maize agriculture by approximately 1200 BP and were utilizing a mixture of hunting, food gathering, and small-scale agriculture at the time of European contact (Mulholland 1988). One potential broad-scale Indian impact was the use of fire to clear settlements, to maintain fields, and to improve wildlife habitat." Paleoecological data from the study area indicated that Native American populations were greater and fire more frequent and/or intense at lower elevations, maintaining high abundances of oak (Fuller et al. 1988). A study of many sites in the northeastern US by Munoz et al. (2010), reported that prior to European settlement human population level increased in response to the widespread adoption of maize agriculture during the late Woodland period. Their study demonstrates the long-term interconnectedness of prehistoric human cultures and the ecosystems they inhabited in the northeast US, including southern New England and Long Island.

Given the vast complexity, uncertainty and controversary concerning the historical role of Native Americans in southern New England, we are surprised that paleoecologists posited such an extreme view. Previous historical ecology studies (paleo or otherwise) have been much more conservative in their conclusions. Paleoecology is important in that it provides information on vegetation dynamics and fire for much longer times scales than is possible with other fields, such as tree ring science. However, paleoecology is not a perfect science due to vast variation in pollen production and dispersal among species and genera and problems associated with interpreting sedimentary charcoal records (Patterson and Sassaman 1988). We caution certain climate-fire scientists that their rather extreme conclusions are disrespectful and very hurtful to Native Americans, past or present, who view themselves and their ancestors as very proficient vegetation managers, for all the benefits that ensued, dietary and otherwise, which often involved the use of prescribed fire (Bromley 1935, Curtis 1959, Abrams and Nowacki 2008, Sands and Abrams 2011, Whitehair et al. 2019).

The results from oak-pine forests in the south do not apply to the conifer-northern hardwood of central and northern New England (Nowacki and Abrams 2015). However, the main results of the Oswald et al. 2020 study, reporting a scarcity of Native American burning and agriculture, seem more applicable to conifer-northern hardwoods where fire was isolated to areas adjacent to Native American villages (Thomas-Van Gundy et al. 2015) or on dry exposures (Mann et al. 1994). The study by Oswald et al. (2020) expands on previous paleoecology research by including information on long-term changes in climate (temperature and precipitation) and Native American population density. They believe that these sites were mostly under climate control prior to European settlement, but thereafter that link broke down because of extreme changes in land-use. We strongly agree that catastrophic disturbance regimes impacted these forests after European settlement and altered them in ways that had little to do with climate change (Nowacki and Abrams 2015). Indeed, there was at first a large increase in burning following European settlement despite a cooling climate associated with the Little Ice Age (Stambaugh et al. 2018), followed by a dramatic decline in burning associated with the Smokey Bear fire suppression era that occurred during a period of abrupt warming (cf. Abrams and Nowacki 2015).

The role of historic fires in shaping world vegetation is front and center in long-running climate-disturbance debate. While both climate and humans are major drivers of fire, the incidence of fire increased with rise of humans in many locations and the world would be a very different place, in terms of both climate and vegetation, without fire (Bond et al. 2005, Bowman et al. 2011). Nonetheless, the view of paleoecologists that Native American land-use (fire, clearing, agriculture, etc.) played a minor role in the forest/vegetation dynamics is not uncommon among ecologists (Power et al. 2008, Marlon et al. 2013). We find extreme views on this issue as untenable. Fires are not overwhelmingly human or climate, but a combination of both, except in some very rare cases. In the case of oak and pine forests in southern New England and Long Island NY, where Native American populations were high enough, lightning-caused fires rare enough, the vegetation flammable enough, and the benefits of burning great enough, we believe human burning and other forms of land-use during the Holocene were important factors.

CONCLUSIONS

The US has recently taken some important steps to rectify past injustices to Native Americans. These include the Supreme Court upholding an 1833 treaty guaranteeing tribal sovereignty in eastern Oklahoma and several professional sports teams ridding derogatory expressions for Native Americans from their names. However, in our profession, global change ecology, we believe there is a trend to downplay the importance of Indigenous People.

In the US, Native people have long been regarded as ecosystem architects, taming nature and molding it in ways to sustain their needs for food and shelter. The anthropological evidence suggests this is true in most places worldwide. An example in the central U.S. is the existence of vast areas of tallgrass prairie that existed for millennia before the arrival of European settlers. Most ecologists attribute this to frequent fires set by Native American Indians because lightning fires are not very common in that region. These people used fire to prevent the conversion of grasslands (a great food source for humans and the animals they hunted) to forests. Similarly, Native people burned the vast expanses of oak, hickory and pine forests in the eastern US to prevent their conversion to less desirable trees. Oak and hickory are great nut producers and pine was important to build canoes and seal it with resin.

Yet, a subset of scientists, in their quest to attribute ecological patterns exclusively to climate change, are ignoring the extensive evidence pointing to the role of Native people in shaping the landscape. For example, using a network of sites in southern New England and Long Island, one group of scientists contends that Native American burning was rare, the few fires that occurred were mostly climate driven and that their use of agriculture was also very limited (Oswald et al. 2020). These conclusions contradict the fact that oak and pine forests require periodic understory burning, have dominated in this region for thousands of years and most anthropological evidence that points to the extensive use of fire and agriculture by Native People.

Having studied forest change in the eastern US over the last 40 years we do not deny the importance of climate in vegetation and fire dynamics or its role in enhancing the extent of human fires, but this team's study was limited by the fact that low intensity understory fires produce insufficient charcoal to discern in the lake sediments they studied. Indeed, many of the changes that occurred after the cessation of Native burning are not consistent with climate being the primary ecological driver. A warming world over the last century, should have promoted warm adapted grasslands and oak and pine, but instead, according to our research, promoted the invasion by cool-adapted trees due to the absence of burning, much to the detriment of these major vegetation biomes.

In their zeal to promote the importance of climate change as an ecological driver, these scientists and many others are neglecting the profound ecological role that Indigenous People played in the eastern US. Their conclusions contradict the proud legacy and heritage of land use and stewardship by Indigenous Peoples, not only in the US but worldwide. There has been an exponential increase in scientific journal articles dealing with climate change over the last few decades. It is the dominant focus of environmental scientists and for good reason. However, it is unfortunate that science, as a human endeavor, can be prone to bandwagons that trample over other ideas to promote the centric view. This is not fair and often not intentional but is a fact of life. In this case, however, it is not just different scientific ideas that are being ignored but a huge body of evidence pointing to the importance of Indigenous People. This trend is not limited to New England but can be found in many locations in the US and around the world. Examples include attributing catastrophic fires in the western US and Australia solely to climate change, when, in fact, the absence of Indigenous or Aboriginal burning over the last century or more, and the resulting buildup of highly flammable fuels, is another primary contributor.

Ignoring the important role that Indigenous People played, and in some areas still play, further marginalizes these people. It also hampers our ability to understand how to best manage vegetation against the invasion of unwanted species and future catastrophic fires, such as reducing fuels by forest thinning and restoring natural fire cycles with controlled burning. Scientists need to consider the vast array of causes for ecological change, not only climate, to better serve the stewardship of the world's precious biomes and resources.

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