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Forum

Conserving landscape dynamics, not just landscapes

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Abstract

Protected areas form the backbone of modern conservation. However, the current policies and practices in protected areas reinforce a static view of nature. This view is further enabled by cultural resistance to change, including efforts to mitigate or exclude keystone ecosystem processes (e.g., characteristic wildfire) that that create and maintain desired conditions. This protectionist model of conservation undervalues the human role in generating landscape dynamics and will be ineffective over the long term and increasingly in the short term. Under climatic change, resisting natural landscape dynamics will backfire and heighten vulnerability to ecosystem transformation through large-scale disturbance (e.g., megafires and megadroughts). Within protected areas, there is an urgent need to rethink what we are protecting: the current landscape conditions or the landscape dynamics that generate those conditions. Cast in a different light, protected areas could be the cornerstones for a new era of conserving landscape dynamics across broader geographies.

Keywords: climate change, disturbance ecology, forest restoration, protected areas, stewardship

In *The Invention of Nature*, historian Andrea Wulf describes a popular eighteenth century view of the New World primeval forest as a "howling wilderness that had to be conquered." However, following his 3-year expedition to the Americas, the book's protagonist, Alexander von Humboldt, presciently recognized that humans "had the power to destroy the environment and the consequences could be catastrophic." Rapid colonization of western North America by European-Americans over the next century—and their unbridled notion of manifest destiny to conquer wild nature—led to broader environmental concerns regarding the decline of forests and other natural features. Left unchecked, von Humboldt's vision of the destruction of nature might have been realized. It was clear that nature needed protection.

A little more than a decade after von Humboldt's death, the US federal government apparently agreed with the need for protecting nature. Yellowstone National Park was created in 1872 as a first of its kind 8900-square-kilometer protected landscape "dedicated and set apart as a public park or pleasuring-ground for the benefit and enjoyment of the people"; anyone settling on that land "shall be considered trespassers and removed therefrom" (US Congress 1872). Just 150 years later, protected areas have become a pillar of Western conservation and for good reason: They have worked for a long time.

Within their boundaries, protected areas have largely minimized the effects of rampant agricultural and urban development, unsustainable resource extraction, and other threats to culturally, biologically, and ecologically important landscapes and the cultural aesthetic of "natural" spaces. According to the United Nations Environment Programme's data platform Protected Planet, the United States now boasts over 51,000 protected areas covering just under 13% of the nation's land area and 19% of the nation's marine environments. The numbers change depending on the definition of *protected area*. For our purposes in the present article, we define a protected area as any legally defined administrative unit that exists to safeguard biological resources, generally restrictive of human activities, including active management. No matter how we define them though, protected areas continue to be effective in preventing habitat loss caused by anthropogenic land uses change in the United States and globally.

Because of their successes and the ever-expanding threats to the natural world, there are growing calls in conservation communities to significantly expand the global protected area network. The 2010 Convention on Biological Diversity's Aichi target 11 called for protection of at least 17% of terrestrial and inland water areas (at the time, approximately 13% of that area was protected). Globally, governments appear to have been successful, with the current tally sitting at 17.6% as of January 2025 (www.protectedplanet.net/en). In 2022, the United Nation's COP 15 goal (Dinerstein et al. 2019) called for increasing global protected land area to 30% by 2030 (30×30), an initiative that was mirrored in US President Biden's executive order 14008 with a stated goal of "conserving at least 30 percent of our lands and waters by 2030." Conservation-minded scientists, advocates, policymakers, and the environment-conscious public appear to universally accept such objectives as noble and good.

The problem of protected areas

At the same time, the protected area model contains troubling foundations. Protected areas embody a way of thinking about nature as separate from humans, a worldview that is Western and colonial. This view stems partly from early European ideas of

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forests as private hunting preserves for royalty. Indeed, the Latin verb *forestare* means "to keep out, to place off limits, to exclude." Even in the non-Western world, many existing models of nature protection are the result of imported imperialist ideas from the European colonial era (Fletcher et al. 2021) and more modern environmental anxieties originating in the Western world (Ross 2015).

Fortress conservation describes the model of enforced and often violent colonial protection of cultural and natural resources to the detriment and exclusion of local communities (Binnema and Niemi 2006, Siurua 2006). Historically, protected areas following the fortress conservation model have been mechanisms of exclusion, forced relocation, cultural erasure, and violence against local and Indigenous peoples across the globe (Grant 1991, Colchester 2004, West et al. 2006). Today, areas where new protected lands might be established are often inhabited and used by Indigenous peoples, risking further violence and exclusion under initiatives such as 30×30 (Aiken 2022, Oxfam International 2022). Violent exclusion and cultural erasure are undeniably part of the dark history of protected areas, but they also were employed nearly everywhere, not just in protected areas. In the Global South, fortress conservation continues to present significant social and political challenges (Rai et al. 2021, Mahalwal and Kabra 2023).

From a societal perspective, protected areas reinforce a narrow view of human behavior that is linked to Garret Hardin's (1968) tragedy of the commons. This allegory assumes that individuals are unable to collectively act to manage their shared resource systems. The offered cure for such tragedies is centralized management by a government entity. This view of human behavior runs counter to global Indigenous cultural stewardship of lands (Ostrom, 1990, 2009). Similarly, the focus on government-managed protected areas limits our potential to consider and better understand how a much broader scope of governance arrangements, including bottom-up and collaborative ones, might favorably influence environmental conservation amid changing ecological and societal conditions (Nagendra and Ostrom 2012, Cumming and Epstein 2020).

From an ecological perspective, protected areas reinforce an ecologically inauthentic, static view of nature where desirable conditions are seen as stationary landscape elements, rather than emergent properties of ecosystem processes (Hessburg et al. 2019). Although they appear stable, landscapes continuously shift in large and small ways, sometimes nearing tipping points; at other times, they are deep in the cup, using the ball and cup analogy (Walker et al. 2004). In western US forests, this dynamic was common historically under the influence of natural and human-caused disturbances (e.g., wildfire and cultural burning, drought, beetle outbreaks). Across broader landscapes, spatial and temporal variability in disturbance intensity and the resulting succession produced landscapes with patches of varied successional conditions, including nonforest, often referred to as a *shifting mosaic stead state* (Hessburg et al., 2016, 2019, Prichard et al. 2017). But now, uncharacteristic large and severe disturbances in forests can literally overrun stabilizing features occurring at smaller scales, and extensive forested areas can be converted to nonforests for long periods (Coop et al. 2020, Prichard et al. 2021).

By virtue of the changing frequency, size, and severity of disturbances to ecosystems, protected areas increasingly will *not* contain the environmental conditions or habitat components that they were originally designated to protect. For example, because the boundaries of protected areas are static, climate-driven shifts of plant and animal species ranges will increasingly push the ideal climate conditions of high-value or sensitive biological communities into nearby unprotected or degraded surroundings (Elsen et al. 2020). Such a problem has been long anticipated (Peters and Darling 1985) and will diminish the value of many existing protected areas from the standpoint of biological conservation (Lawler et al. 2015). Climate change is moving the goalposts, forcing the conservation community to revise its ideas surrounding the purpose and future utility of protected areas.

Protected areas and the backfire effect

Although protected areas have successfully minimized direct human development influences, our intense focus on this foundational conservation solution has allowed other threats to creep in unnoticed. In particular, the restriction of certain human activities that promote dynamism (e.g., cultural fire use) while permitting others that actively limit it (e.g., fire suppression) has created a backfire effect in many protected areas. This effect occurs when the prohibition of natural dynamics leads to even more undesirable, unnatural dynamics. Such an effect may be especially likely to occur in disturbance-prone ecosystems where Indigenous fire stewardship and cultural burning played dominant roles (Boerigter et al. 2024, Eisenberg et al. 2024). For this reason, we illustrate many of our examples using fire and its historical exclusion in western US forest ecosystems throughout the rest of the article.

The backfire effect can be seen playing out right now surrounding the conservation of mature and old-growth forests in the United States. A recent assessment revealed a 10% per decade decline in mature forests within nationally reserved areas (including designated wilderness, roadless areas, and national monuments) between 2000 and 2020 (USDA Forest Service 2024). At the same time, mature forest area outside of protected areas remained stable, and old growth forests outside of reserved areas *increased* by 7.8% over the same period. The report concluded that "strictly reserving mature and old-growth forests may not always ensure that they are protected from future losses" (USDA Forest Service 2024). These observed differences in mature and old growth forest conservation success were attributed to the more severe disturbances, mostly fire, occurring in reserved areas—where lower intensity disturbances have been suppressed to maintain "desirable" conditions. At the same time, proactive management to increase forest resilience was limited in reserved areas.

Within western US national forests, the backfire effect appears to be playing out to the detriment of sensitive wildlife species. For example, thousands of 1- to 2-square-kilometer protected activity centers were set aside in the early 1990s to safeguard the best available nesting habitat for the federally threatened spotted owl (*Strix occidentalis*). To this day, most forest management activities are restricted in protected activity centers, and restorative activities (e.g., prescribed burning) are given such narrow and unpredictable implementation windows that they usually do not occur (Clark et al. 2024). In the absence of natural disturbances and restoration, many protected activity centers have become overly dense with shade-tolerant trees, increasing tree competition for water and ladder fuels that increase the risk of canopy fire. As a result, in California, in the United States, mature forest habitat losses to drought and wildfires from 2011 to 2020 were greater inside than outside of spotted owl protected activity centers because of this degradation of drought- and fire-resilient forest conditions (Jones et al. 2022, Steel et al. 2023). Similarly, after a quarter century of slow but steady recruitment of old-forest conditions in late-successional reserves designed to protect habitat for spotted owl and marbled murrelets (*Brachyramphus marmoratus*) under the Northwest Forest Plan, a single year (2020) of large wildfires

erased all earlier gains (Davis et al. 2022). These examples surrounding mature and old forest conditions are emblematic of the unintended consequences of policies that attempt to hold the line on current conditions or characteristics, instead of promoting the processes that dynamically generate those conditions.

Our world is different now from what it was during the rise of the protected area model, and new problems require new solutions. Although reestablishing historical dynamics is itself a worthwhile conservation goal, those dynamics also represent the best insurance that ecosystems and landscapes will adapt to oncoming environmental challenges. The rise of the protected area model in North America corresponded with an era of rapacious greed manifest in extensive colonial land conversion, road, rail, agricultural, and urban development, and timber harvest (Hessburg and Agee 2003, Hagmann et al. 2021). Against this threat, protected areas served their purpose, and they still do in areas where development or land use is the primary threat (Le Saout et al. 2013). However, in many geographies, new threats are emerging—some of which are the result of fortress conservation—where culturally and ecologically important resources, species, and biological communities are becoming increasingly vulnerable to large-scale wildfires, droughts, nonnative species invasions, and worsening climatic influences. Just as medical treatments are adapted to confront the emergence of new diseases, conservation approaches must adapt to meet emerging threats.

The rise of dynamic views of nature

Although Indigenous peoples and some Western naturalists have long recognized aspects of dynamic nature, the appreciation of nature as often perturbed and changing has been slow to enter Western science consciousness. Reticence to accept ecosystems as dynamic is partly explained by historical Judeo-Christian views of creation and nature as fixed and unchanging and the dominance of such views in Western thought for many centuries (Cohen 1985). Charles Darwin, with much trouble, challenged this view by proposing that species were not fixed entities and that natural selection could result in adaptations over time and even the rise of new forms of life (Darwin 1859). Von Humboldt's discoveries in global biogeography and his observations of human influence on nature pointed to a dynamic and ever-changing world. John Muir shared von Humboldt's concern over deforestation and the shrinking of "wild nature." Muir's advocacy led to the creation of Yosemite National Park in 1890, as well as the mass expulsion of affiliated tribes that were living for millennia and culturally burning in the valley (Spence 1996).

But although Muir's experiences led him to favor nature's preservation and its protection from human influence, Muir's friend and the first chief of the US Forest Service, Gifford Pinchot, embraced the role of humans as natural resource users. Pinchot's conservation advocated for sustainable resource use, including timber harvesting and domestic livestock grazing, and viewed forest resources as having market value (Pinchot et al. 1919). Although it is an oversimplification to say that Pinchot's view of forests meant he embraced the idea of dynamic systems—after all, Pinchot's policies reinforced fire exclusion—his view of nature accommodated a human role. Pinchot's new system of forest reserves and their management for people mostly excluded Indigenous cultural practices of stewarding sustainable ecosystems and their dynamics (Raish 2000), and Pinchot's opponents criticized his commercialization of nature and still do to this day. But Pinchot popularized ideas about nature not as an untrammeled and howling wilderness but a system that could be understood and managed in a renewable way for the benefit of all people.

More recently, modern ecological science has revealed just how inherently dynamic nature is, even when it is not visible to the casual observer. In the 1970s and 1980s, ideas about the role of natural disturbances, patch dynamics, and shifting mosaics emerged (Holling 1973, Pickett and White 1985), and ideas about the balance of nature came into question (Wu and Loucks 1995). The nascent field of landscape ecology recognized powerful links between the visible patterns in an environment, like the arrangement of trees in a forest, and the processes that give rise to and are generated by those patterns, such as forest fires (Turner 1989). Subsequently, it became clear that landscape patterns, processes, and their dynamic feedbacks were scale dependent (Wiens 1989, Levin 1992), and dynamic and interacting links across scales were pervasive (Allen and Hoekstra 2015, Allen and Starr 2017). Long-term monitoring of ecological systems has revealed remarkable decadal cyclical dynamics generated by the existence of predator–prey interactions, including the apparent reshaping of entire ecosystems when such interactions vanish (e.g., keystone species; Estes et al. 2011). At much larger time scales, apparently stable climatic periods can exist within centuries to millennia–scale cycles that drive the expansion and recession of continent and mountain glaciers and broadscale shifts in biogeography (Lin and Qian 2022). At nearly any spatial and temporal scale of ecological organization you can fathom, highly dynamic systems are at play.

Problems of perception

This begs the question: If we understand the role of dynamics in nature so well, what is keeping our methods of conservation from better reflecting the importance of disturbances and dynamics of the ecosystems we manage? A central problem facing the development of more dynamic conservation models is that the temporal scales at which nature changes are hard to perceive, because they extend beyond the lifespan of most humans. As individuals, we cannot perceive long-term climatic cycles or the succession of a forest stand as it initiates, ages, and is renewed by disturbance. At the scale of a human life, the undisturbed landscape in front of us appears to be unchanging, even constant.

This mismatch between our perception and reality when considering long-term landscape dynamics can generate a phenomenon known as *shifting baseline syndrome*, where each new generation of people accept the current conditions they observe as normal, ever present (Pauly 1995, Soga and Gaston 2018). Picture, for a moment, a "pristine" forest. What do you see in your mind's eye? Do you imagine a forest of green trees, continuous for tens or hundreds of kilometers? You would not be alone. However, in most mixed conifer forests of the western United States, continuous forests are the result of over 150 years of fire suppression and exclusion of Indigenous cultural burning (Hagmann et al. 2021). Therefore, such a conjured image is hardly emblematic of "pristine" conditions, and has no basis in fact.

Modern science offers tools to help us see past the shifting baseline syndrome. Early landscape photographs, when compared with recent ones, can help us recognize these longer timescales of change (Hessburg et al., 2015, 2019). Large historical land surveys can be revisited to understand changes in forest structure and composition over many decades (Stephens et al. 2015, Levine et al. 2017). Dendrochronology methods can aid us to reconstruct centuries-long climatic records, fire histories, and cohort

development of disturbed forests (Margolis et al. 2022), so we can better place current conditions into context.

However, teaching ourselves to understand these many changes, their drivers and links, the dynamics they produce, and the effects of those dynamics over long time scales is difficult outside of focused scholarship. Lacking an intimate connection to place through ongoing interaction and repeated observations, it is nearly impossible to detect even large changes over time. However, Indigenous knowledge, which extends across many generations, can aid in counteracting this problem of shifting baselines (Alleway et al. 2023). Intergenerational planning that merges Indigenous and Western knowledge systems and practices can provide frameworks to confront these modern environmental problems and their drivers (Hankins 2024).

Protecting a thing that always changes

In championing conservation approaches that embrace ecosystem and landscape dynamics, must we abandon the protected area model? No. In fact, the vast and growing network of protected areas across the globe can provide the foundation for promoting conservation of ecological processes, patterns that reinforce them, and dynamics that ensure their existence over space and time. Protected areas may be the best places to support dynamic landscapes through time. There is an urgent need to rethink what we are protecting within those areas, and how humans can play a role. Rather than focusing on protecting features that exist today within protected areas, the emphasis must shift to managing patterns, processes, and links that facilitate ongoing emergence of similar but spatially and temporally shifting conditions. In this way, protected areas can become reference areas for managing characteristic landscape dynamics while still safeguarding important social, ecological, and cultural places from urbanization, development, and unsustainable resource extraction (Eisenberg et al. 2024).

After all, humans and nature are not separate but are intertwined. Some intermediate degree of human activity and stewardship in protected areas can serve as an alternative to the fortress conservation model and promote desirable landscape dynamics (Elleason et al. 2021). For example, working lands that occur on public, tribal, or private lands often lack explicit conservation easements but maintain high conservation value through stewardship activities that cooperate with natural ecosystem processes (Burger et al. 2019, Hobart et al. 2019, Chapman et al. 2023). Indigenous concepts of landscape stewardship offer a powerful alternative to a fortress conservation model.

In the Indigenous context, landscape protections have been applied in various ways in recognition of time honored stories that are passed down through the generations, which outline how one can best act in certain places. Indigenous protected areas can be associated with a protected knowledge of places or customs, restricted access due to restricted knowledge within their culture, gendered landscapes, sacred sites, and other distinctive norms and practices (Hankins 2024). But those that could access restricted or sacred sites were still responsible for their ongoing and active stewardship. Working lands, nondurably protected areas, and Indigenous conservation practices all offer means for humans and nature to interact sustainably, not as opposing forces but in mutually reinforcing ways. Where humans and landscapes have long been intertwined, such relationships must endure to promote the conservation of landscape dynamics.

Promising examples of conservation strategies embracing dynamic nature do exist. For example, the resist–accept–direct framework (Lynch et al. 2021), which is applied in some US national parks, explicitly recognizes that, in some cases, managers must prepare the way for change rather than try to maintain current conditions. Although still rare, some wilderness protected areas in the United States use prescribed fire to restore ecological structure and process in order to preserve the wilderness character (Center for Public Lands 2023). Within some existing protected areas, policies facilitate a more dynamic and natural relationship between humans and landscapes. For example, protected wilderness areas in Alaska allow for Indigenous people to harvest food (e.g., salmon and ungulates) under the Alaska National Interest Lands Conservation Act. In cases in which species cannot track rapid climatic and landscape changes, strategies such as assisted migration help to facilitate species survival and adaptation to ecological novelty (McLachlan et al. 2007).

In addition to rethinking what it is we are protecting within protected areas, we must also consider how a broader array of institutional arrangements might facilitate the conservation of landscape dynamics (Evans et al. 2008, Cumming and Epstein 2020), including those that share decision-making rights in management (e.g., adaptive comanagement; Armitage et al. 2009). Alternative forms of governance supporting dynamic conservation include community-based, bottom-up conservation initiatives that can empower local communities to organize and design adaptive and resilient social and ecological systems in the face of change (Ruiz-Mallén and Corbera 2013, Manley et al. 2020). Indigenous land stewardship, which relies on deep cultural knowledge of landscape history and tradition, as well as ecosystem dynamics, often involves cultural burning and other ceremonial activities that produce resilient and ever-changing landscapes that conserve their dynamism and features (Hankins 2024). *Indigenous protected and conserved areas* are areas that offer a means for communities to steward lands under their own governance structures (Moola and Roth 2019, Tran et al. 2020). Dynamic ecosystems must be better linked to social systems when considering governance structures, because landscape change does not occur in isolation. The social–ecological systems framework (Ostrom 2009) and related work (Folke et al. 2010) offer new approaches for considering how social and ecological systems can best interact and the various institutional designs that might best govern them. These alternative models of environmental governance do not inherently ensure conservation of landscape dynamics, but they may allow for more nimble responses to environmental change that align with a dynamic paradigm.

Successful models of dynamic conservation sometimes come in surprising forms. In the United States, Department of Defense lands (i.e., military installations) contain the highest density of federally threatened and endangered species compared with any other US agency's land estate (Stein et al. 2008). A number of these lands include extensive bombing and artillery ranges, which can cause great concern about the potential for widespread habitat destruction. However, although artillery testing certainly has no ecological precedent, it has, in some cases, approximated natural fire frequencies and promoted dynamic conservation of state and federally listed species. For example, the St. Francis' satyr (*Neonympha mitchellii francisci*), a small and extremely rare butterfly occurring only on the Fort Bragg Army Installation in southern North Carolina, was considered extinct in 1990. But when surveyors were permitted in artillery ranges around 2010, they discovered thriving populations in areas that had experienced near-constant disturbance from military activities that generated a highly dynamic system of burning (Haddad 2018). As Haddad wrote, "My visits to the artillery ranges coupled with near

extinction outside finally broke me from my hands-off approach to restoration… This caused me to propose disturbances that replicate range-like conditions in new areas." The shifting mosaic of habitat driven by human-caused disturbances, in lieu of intact natural disturbance regimes can in fact support resilient populations of native species and communities.

Toward dynamic conservation

Our conservation philosophies must more fully embrace and support a vision of dynamic nature and our human role in that dynamism than they do presently. For example, rather than attempting to maintain a forest reserve in a static state, we must better understand historical disturbance regimes, fire return intervals, historical ranges of variability, and influences of climate and seek to approximate this variation through conservation action—all of which can contribute to a forest landscape that is, in reality, more "natural" (Boerigter et al. 2024). In many cases, this will include intentional human actions that are historically novel but can increase ecosystem and human community resilience to future changes.

For example, mechanical tree removal in managed forests that have become overly dense because of fire exclusion can restore ecosystem resilience to wildfire and drought (Young et al. 2017, Koontz et al. 2020). In some instances, this type of activity might have to generate relatively novel conditions, such as significantly lower stand densities than may have existed in recent times, to promote ecological integrity in the face of future climate pressures (North et al. 2022). *Facilitated change* or *managed dynamics* (Gaines et al. 2022, Steel et al. 2023) describes this human-driven process of mindful stewardship that can create heterogeneity, stability, and resistance to severe disturbance-driven transformation (Holling 1973, Stephens et al. 2020, North et al. 2021).

The idea of moving away from the existing model of protected area management will give some readers pause. But let us be clear: We are not suggesting a return to the days of exploitation in areas that currently have protected status. Many supporters of the protected area model in the United States and critics of active vegetation management in protected areas or anywhere else on public lands are those who lived through post–World War II wood demands for housing and the dramatic market driven abuses of public lands that followed (Burk 1970). They remind us of the environmental and habitat damage that can happen when institutions responsible for the stewardship of public lands shift their philosophies from custodians to commodity production and deemphasize sustainability practices (Bolle 1989). The mere existence of protected areas is not the problem, per se; the main concern is our failure to recognize that our working definition of *protection* overemphasizes static desired conditions and excludes critically important ecological processes and the resulting dynamics they catalyze. Continuing to adhere to a strict model of protectionist conservation will be ineffective in protecting nature for the long term and increasingly in the short term.

Especially when faced with new and seemingly overwhelming threats, we may be tempted to fall back on established models of conservation: Draw bigger boxes on the map and reserve more land. Or create larger buffers around sensitive areas. Or further restrict human activities in wilderness areas. What harm could come of these practices? Tragically, much. Consider again the UN's COP 15 30×30 goal to protect 30% of global land area by 2030. Greatly expanding global protected lands following historical protection methods including eviction of Indigenous peoples and resisting natural disturbance dynamics would only act to further compound the problems we have described in this article. However, if 30×30 was recast as an effort to restore natural disturbance dynamics to 30% of global land area, it would be among the greatest conservation achievements of the last century, and would prepare ecosystems to better absorb future climate impacts.

Against the backdrop of our expanding understanding of dynamic nature, and given the global context of a warming climate, an overreliance on stationarity of conditions and features will indeed result in harm to the very things we are attempting to protect. The precautionary principle—which commonly leads to decision conservatism and paralysis (Sunstein 2003, Hessburg et al. 2021)—would lead us to move toward a new, dynamic model of conservation that embraces and influences change. We must recognize that protecting a place and embracing change are not mutually exclusive. We must consider reducing our focus on conserving landscapes, and move toward the conservation of landscape dynamics.

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Author contributions

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