(Wild)fire is not an ecosystem service

In their paper entitled "Wildfires as an ecosystem service", Pausas and Keeley (2019) summarize the benefits generated by – as well as the evolutionary and socioecological importance of – wildfires for humankind. Although we recognize the importance of wildfires in such a context, we argue that presenting wildfire per se as an ecosystem service is conceptually incorrect and can be misleading for policy makers and resource managers. Throughout their paper, the authors repeatedly refer to (wild)fire as a potential provider of multiple ecosystem services (and not as an ecosystem service itself, as indicated in their article's title). We believe that this is more than a dispute over semantics, for such a contradiction could lead to misperceptions about the definition of the term "ecosystem services", which is especially concerning in light of its real-world applications to fire management.

Incorporating (wild)fire into the broader conceptual framework of ecosystem services is problematic for a number of reasons, starting with the negative assumption of "wildfire" as an unplanned event with undesired societal or environmental impacts, and given that wildfire includes both services and disservices (Vaz *et al.* 2017). We argue that using the term "fire" (as often done by Pausas and Keeley) instead of "wildfire" emphasizes the process itself (Bowman *et al.* 2009) and thereby enables a more balanced perspective of its positive and negative contributions to human well-being (Costanza *et al.* 2017; Vaz *et al.* 2017). The ecosystem services cascade model (Potschin and Haines-Young 2016) helped to distinguish between ecosystem structures, processes, functions, services, benefits, and values. Here, ecosystem services refer to the positive – not the negative – contributions of ecosystems to human well-being, connecting the ecological and the social dimensions of socioecological systems. The capacity of each ecosystem (that is, its function) to provide services and benefits to society is influenced by interactions between processes (such as fire) and biophysical structures (such as vegetation) (Potschin and Haines-Young 2016; Costanza *et al.* 2017; Pettorelli *et al.* 2018). Conversely, losses in the regulating services of an ecosystem may jeopardize that system's ability to deliver provisioning services in the future (Sil *et al.* 2019).

As an ecological process, fire not only is part of a complex network of interactions that shape ecosystem functioning (Bowman *et al.* 2009) but also is shaped by management actions and people's perceptions that affect an ecosystem's (in)ability to regulate fire (Silva *et al.* 2010), which in turn shapes the positive or negative impacts of fire on human well-being and how society views fire (Sil *et al.* 2019). The Common International Classification of Ecosystem Services (Haines-Young and Potschin 2018) recognizes "fire protection" as an ecosystem service. In the above-mentioned cascade model, an ecosystem's fire regulation capacity allows maintaining fire-regime attributes (eg fire frequency and severity) within "safe" boundaries (Sil *et al.* 2019), alongside other ecosystem services. Pausas and Keeley (2019) provide many valuable examples of such services, but largely overlook the negative outcomes of fire to humans (ie disservices; see below) (Figure 1 and WebTable 1), which contributes to an unbalanced perspective of fire within an ecosystem services framework. In addition, fire-regime attributes such as fire frequency (Keeley *et al.* 2005) or fire intensity (Adams 2013) play important roles in certain ecosystems and should not be disregarded. In this sense, ecosystem disservices, as the direct negative effects of ecosystems to human well-being (Vaz *et al.* 2017), are also useful in characterizing the impacts of fire on the economy (including livelihoods) and human well-being (eg health and safety). The disservices associated with fire add to the negative effects that it may have on ecosystem services (eg climate regulation, soil erosion control). These dual effects of fire on human well-being call for a more integrated view, embedded in an ecosystem services–disservices perspective (Vaz *et al.* 2017) (WebFigure 1).

Research on ecosystem services (Costanza *et al.* 2017), as well as its use as a catchy buzzword (Abson *et al.* 2014), has been steadily growing. While this signals a broad adoption by the scientific community, there is an increased chance that the term could be unintentionally used in an ambiguous way. In the case of fire, the distinction between ecosystem processes and services goes beyond semantics. Notwithstanding the notable effort made by Pausas and Keeley (2019) to describe how fire can provide ecosys-

Figure 1. Fire negatively affects ecosystem services such as (a) wood production (provisioning service) and (b) erosion control (regulating service) and acts as a source of ecosystem disservices including (c) destruction of infrastructure (material disservice) and (d) air pollution (health disservice).

tem services, their use of the term in their paper's title is potentially misleading. Failing to integrate fire as an ecological process within an ecosystem services–disservices framework can promote a biased perspective of wildfire. An example of the risks of such a perspective is the historical fire-suppression policy that largely ignored the various socioecological roles of fire, indirectly fostering catastrophic fires over the past decades (the so-called "Fire Paradox"; Silva *et al.* 2010). Improved communication of ecosystem services and disservices can help to guide decision making in fire management policy and land-use planning.

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Supporting Information

Additional, web-only material may be found in the online version of this article at http://onlinelibrary.wiley.com/doi/10.1002/fee.2106/suppinfo

Wildfires misunderstood

Rain is a natural process that provides a range of services to humans but certainly not all rainfall events (eg those generating floods) are beneficial to human societies. Biodiversity can also deliver a variety of services, even though there are species capable of harming humans. Likewise, the vast majority of life depends (directly or indirectly) on sunlight, yet we can get sunburn and develop skin cancer after overexposure. In the same way, wildfires can offer a range of ecosystem services (Pausas and Keeley 2019) but obviously not all fires, and not all fire regimes, provide services to humankind; indeed, wildfires can have negative (even catastrophic) impacts on society. For instance, if we build houses in a fire-prone (or flood-prone) area, then the inhabitants of those houses are likely to suffer negative impacts when a wildfire (or a major rainfall event) occurs. Similarly, when we substantially increase fuel loads and landscape homogeneity (eg due to a fire exclusion policy, or with a massive and poorly managed tree plantation), the impact of wildfires – especially under novel climatic conditions – can be catastrophic (eg the case of the 2017 fires in Portugal and Chile; Bowman *et al.* 2019).

In more general terms, negative impacts to humans (disservices) often occur when we perturb the historical fire regime: that is, when one or some of the fire regime parameters (ie frequency, seasonality, spread pattern, or intensity) are altered