



## Research Brief for Resource Managers

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## Fire and Herbivory Shape Non-forested Ecosystems

*Pausas, J.G., and W.J. Bond. 2018. Humboldt and the reinvention of nature. Journal of Ecology 107:1031-1037. [10.1111/1365-2745.13109](https://doi.org/10.1111/1365-2745.13109).*

More than two hundred years ago, the naturalist Alexander von Humboldt laid the groundwork for the present-day fields of ecology and biogeography by describing how environmental factors shape plant distributions. Humboldt's ideas were revolutionary and they remain important today. However, Humboldt's experiences led him to center forests and view open, non-forested ecosystems such as savannas, grasslands, and shrublands as degraded, an idea that has perpetuated a devaluation and disregard for non-forested systems. To correct this forest-centric bias, as well as to update Humboldt's strictly climate and soil shaped world view, Pausas and Bond (2018) recommend "embracing" trophic ecology as a major ecological and evolutionary process. In other words, they argue that, just as influential as climate and soils, plant consumers (i.e., fire and vertebrate herbivory) are key evolutionary drivers for shaping global vegetation patterns.

To support this point, Pausas and Bond (2018) present several lines of evidence. Specifically, the **fossil evidence** shows wildfire has a long ecological history. It first occurred in the Silurian (420 Ma), increased in importance as plant density and height increased through the Devonian (420-360 Ma), then became common with higher atmospheric O<sub>2</sub> during the Carboniferous (360-300 Ma; Fig.1). Mid-Miocene

### Management Implications

- Interfering with natural consumer processes (i.e., altering fire regimes or removing megafauna) can impact nature as much as climate change does. Therefore, conserving or restoring consumer processes may help to conserve ecosystems.
- Today, the megafaunal role in shaping and conserving open, non-forested ecosystems has been somewhat replaced by livestock.
- However, human-altered fire regimes have been degrading both closed (forested) and open (non-forested) ecosystems for at least 200 years. Managers should be aware that the fire management tools for both kinds of ecosystems differ dramatically and are locally specific.

fossil evidence shows that some of the first African savanna plants evolved the first structural defense traits against bovid (cow-like) browsers: spines! **Phylogenetic evidence** also reveals evolutionary effects of fire. For example, fire was frequent enough for fire adaptive traits, such as serotinous cones and epicormic resprouting, to evolve in pines, eucalyptus and the Proteaceae during the Carboniferous. Frequent fire also

caused C<sub>4</sub> grasses to spread with the rise of savannas during the late Miocene.

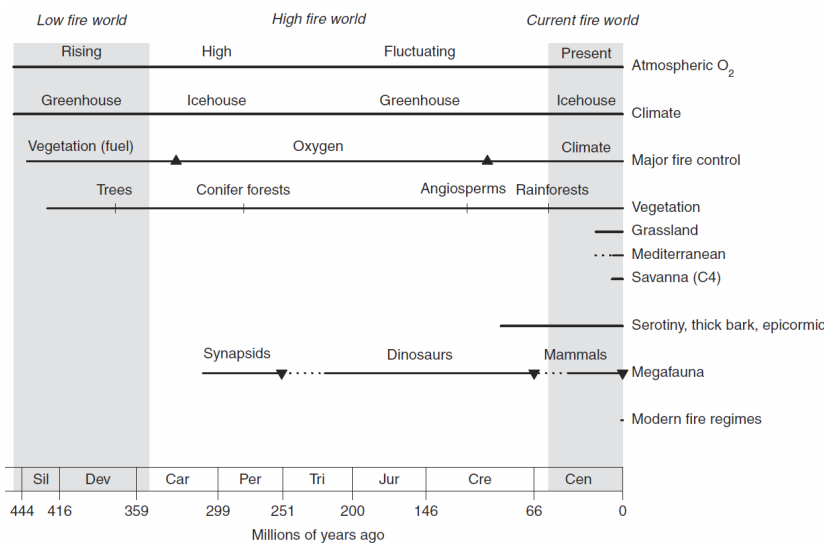
Finally, the existence of **alternative stable vegetation states** makes the important role of consumers at a community scale evident. While a Humboldtian framework suggests that climate is the main driver of ecosystem distributions, the prevalence of forest/open ecosystem mosaics around the world suggest more than one vegetation type can exist in a given climate region (i.e. alternative stable vegetation states). Many such alternative stable states are driven by fire and/or herbivory, underscoring the importance of these drivers (e.g., Fig.1). Regardless of the ecosystem, it has been shown that **when the natural consumer processes (i.e. fire and**

**herbivory) are perturbed**, vegetation type conversion may ensue. This may take the form of transitioning to an alternative stable state (e.g., from savannah to forest), or to a more permanent, environmentally degraded, novel ecosystem. All of these lines of evidence help to demonstrate that consumers are just as important as climate in shaping and maintaining ecosystems.

**Recommended Reading Suggestions:**

*Bond, W. J. 2019. Open Ecosystems: ecology and evolution beyond the forest edge. Oxford University Press, United Kingdom.*

*Wulf, A. 2015. The invention of nature: Alexander von Humboldt's new world. New York, NY: Knopf Doubleday Publishing Group.*



**Figure 1.** Changes in the drivers related to fire and herbivory, together with the evolution of different vegetation types, and some plant traits (serotiny and thick bark of pines, epicormic resprouting in eucalyptus), during the evolutionary history of plants (see main text for details). Upper pointing triangles are peaks of O<sub>2</sub> atmospheric concentration and fire activity; lower-pointing triangles are megafauna extinction events, also associated with fire activity peaks. Note that modern fire regimes are very recent and at this scale they are almost a point. Modified from Scott, Bowman, Bond, Pyne, and Alexander (2014)



**Figure 2.** Forest-savanna mosaic under the same geology in the Serengeti, home to one of the world's richest remaining open habitat megafaunas. Savanna fires have killed some of the trees at the edge of the forests, and elephants have killed some of the trees in the savanna. The Serengeti is mapped as “deforested” and “degraded” in the Atlas of Forest Landscape Restoration Opportunities of the World Resources Institute. The Atlas is used as a basis for global forest landscape “restoration” projects. This suggests persistent misunderstanding of ecosystem dynamics and the long-lasting legacy of Humboldt.

