The role of fire on Earth

Juli G. Pausas
CIDE, CSIC, Valencia, Spain
www.uv.es/jgpausas | jgpausas.blogs.uv.es | @jgpausas

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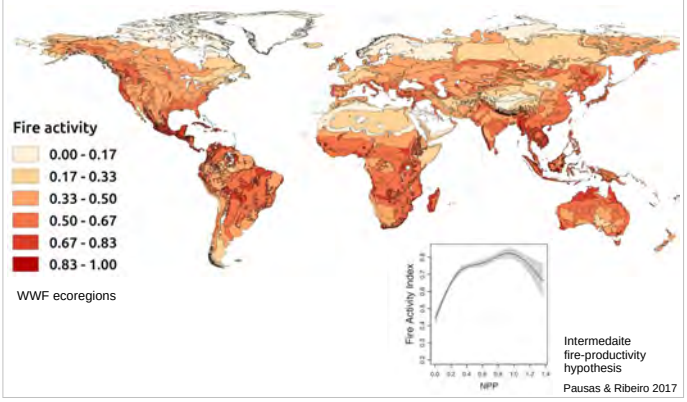
Fires occur everywhere ...



Intermedaite fire-productivity hypothesis

Pausas & Ribeiro 2017

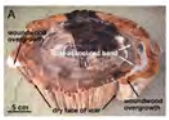
... and at any time in history

- Ignitions: Lightning, volcanoes
- Oxygen: Plants
- Fuel: terrestrial plants

Silurian (444 - 416 Ma)

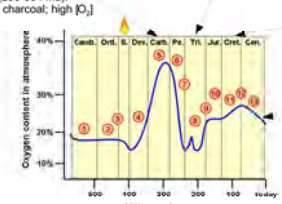
Fossil charcoal (low intensity fires) Glasspool, 2004

Charcoalified plants



Carboniferous (290-354 Ma): very freq fossil charcoal; high $[O_2]$

Cretaceous (65-145 Ma): gymnosperms replaced by angiosperms (+flammable); high $[O_2]$



Quaternary: homicids, megafauna extinction (mammoths)

Scott 2018

The role of fire on Earth

Hypothesis:

Fire have *coevolved* with the biosphere and thus it plays a key role in many Earth processes

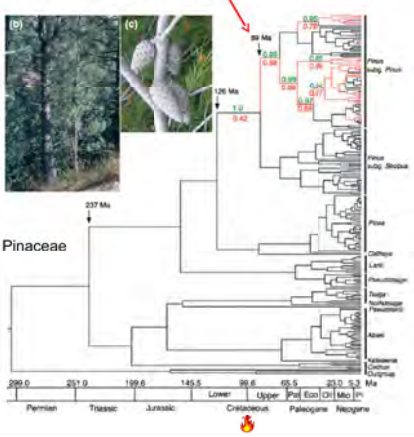
Contents:

1. Evolutionary force
2. Shapes biodiversity across space
3. Structures communities and biomes
4. Promotes biogeochemical cycles
5. Is fire a land degradaction agent?

1. Evolutionary force: a diversity of fire traits

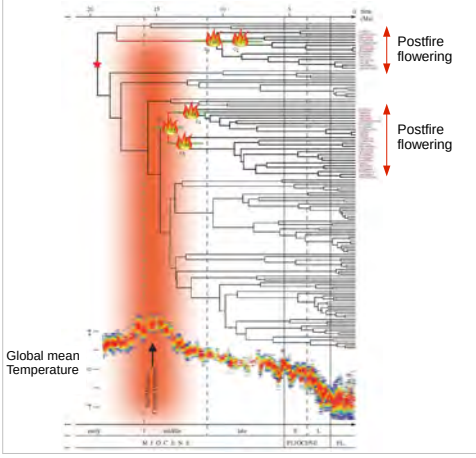
Serotiny (canopy seed bank) in pines

Ancestral reconstruction: Serotiny



He, Pausas, et al. 2012 New Phytol.

Fire-stimulated flowering in *Disa* (orchid)

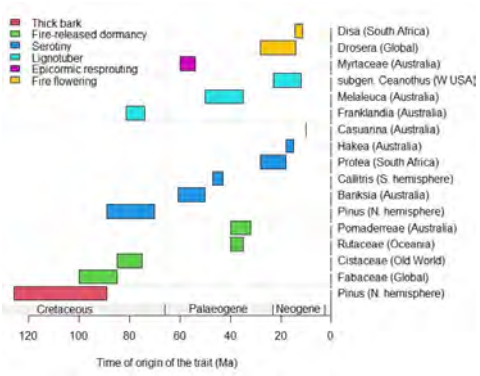



Disa pygmea

Bytebier et al. 2010 *Proc R Soc*

1. Evolutionary force

Ancestral reconstructions



Fire has shaped plants for at least for more than 100 Ma (but probably more)
Independent of fossil charcoal

Keeley & Pausas 2022 *AREES*

2. Fire shapes extant biodiversity: plants

log(#species/area)

WWF ecoregions

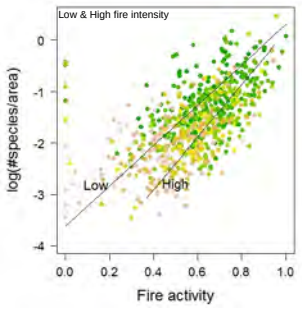
Pausas & Ribeiro 2017

2. Fire shapes extant biodiversity: plants

Plant species richness

	AIC	LR	p		Trend	R^2
Multivariate model: environment + fire						
Null	1,480.39					
Mean NDVI (productivity)	1,303.13	179.26	< .0001	+		.30
+ Biome[14]	1,176.61	152.52	< .0001			.45
+ Temperature seasonality	1,145.62	33.00	< .0001	−		.50
+ Fire activity	939.26	208.36	< .0001	+		.61
+ Fire intensity	840.83	100.42	< .0001	−		.65
+ FA x FI	680.52	162.31	< .0001	+		.71

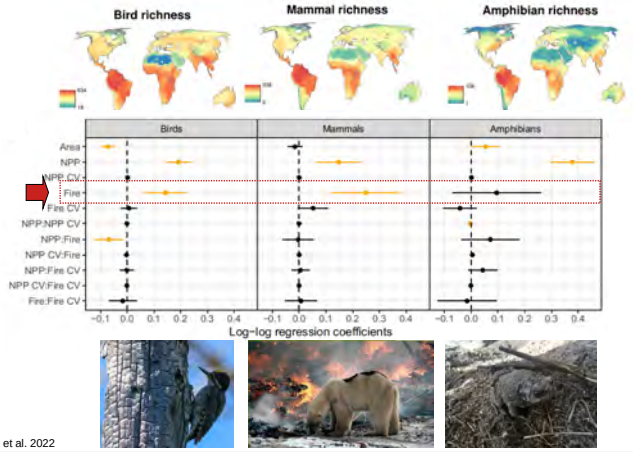
Plant species richness



Fire explains a significant proportion of the variability of global plant diversity

Pausas & Ribeiro 2017

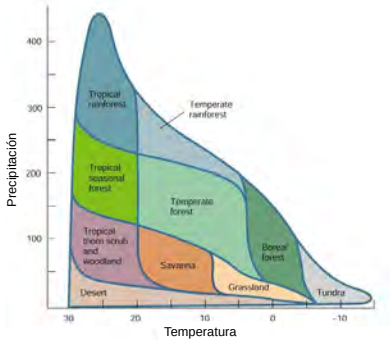
2. Fire shapes extant biodiversity: animals



Moritz et al. 2022

3. Fire shape communities & biomes

Environments / Biomes

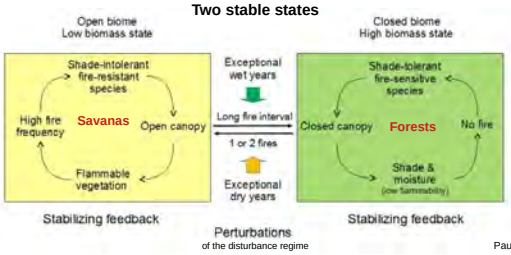


Correlative science

3. Fire shape communities & biomes

Alternative Biomes States:
Different biomes in the same environment
With markedly different traits, sharp boundaries
Fire maintain open ecosystems

Two stable states

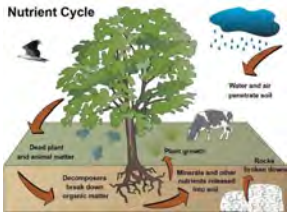


Non linear
≠ sucession
≠ autosucesion

Pausas & Bond 2020. *Trends Pl. Sci.*

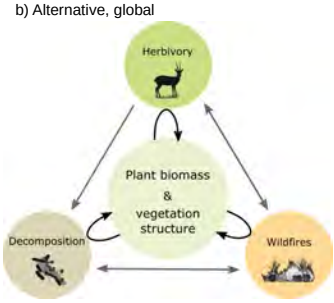
4. Promotes biogeochemical cycles

a) Classic
Recycling of matter and nutrients



Soil decomposition (OM→ IM)

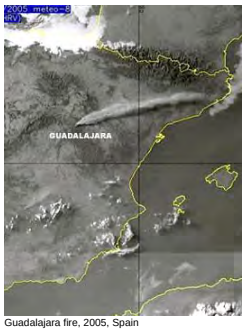
b) Alternative, global



Small → Scale → Large

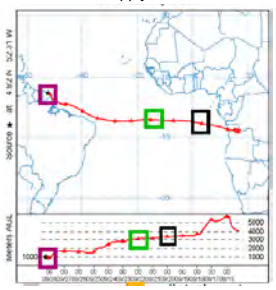
Pausas & Bond 2020. *Trends Ecol. Evol.*

4. Promotes biogeochemical cycles



Guadalajara fire, 2005, Spain

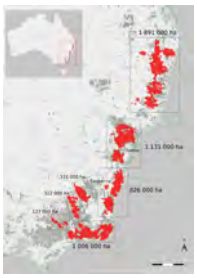
African fires supply P to the Amazon



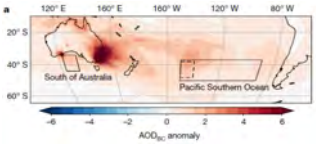
African fires can supply up to 50% of the P depositely annually in the Amazon basin (aerosol)

Barkley et al. 2019 PNAS

4. Promotes biogeochemical cycles: C



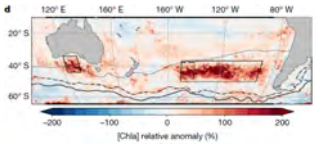
Aerosol (BC, Fe, … ; anomaly)



Tang et al. 2021, *Nature*

Ecological surprise!

Phytoplakton productivity (Chorophyll a; anomaly)



Unprecedented phytoplakton boom! (fertilization)

Unprecedented, extreme fire weather
Area, pyrocumulonimbus & firestorms,
CO_2 & aerosols relased (millions of tones), etc.

"**a balance** between carbon loss over land and gain over the ocean" (Wang et al. 2022 *STOTEN*)

"using geochemical paleo-reconstructions, a century-long relationship between wildfire magnitude and marine phytoplankton production" (Li et al. 2022 *Nature Comm*)

5. Fire and land degradation

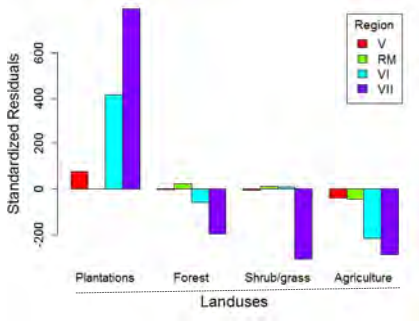
- **Q**: If fire plays a key role on Earth, why we have the perception of fire as a land degradation agent or even a catastrophic?
- **R**: We are blaming to fire our mismanagement! - *Compound disturbances*

Prometheus

5. Fire and land degradation

Chile massive fires 2016/17: 600,000 ha

Landuses burnt x landuses available in the landscape



Fire-prone forest plantations
(*Pinus radiata, Eucalyptus*)
A hotspot of fires!

5. Fire and land degradation

Sierra de la Culebra, 60,000 ha, Zamora, Spain, 2022

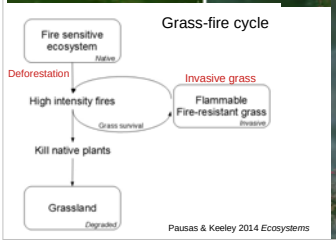
Large and high intensity fires driven by homogeneous poorly managed tree plantations

Similar patterns Spain, Portugal, Central Europe, Chile, ...

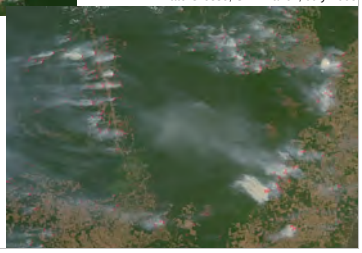
5. Fire and land degradation

Non-fire-prone (fire sensitive) ecosystems experiencing fire: deforestation of the Amazon

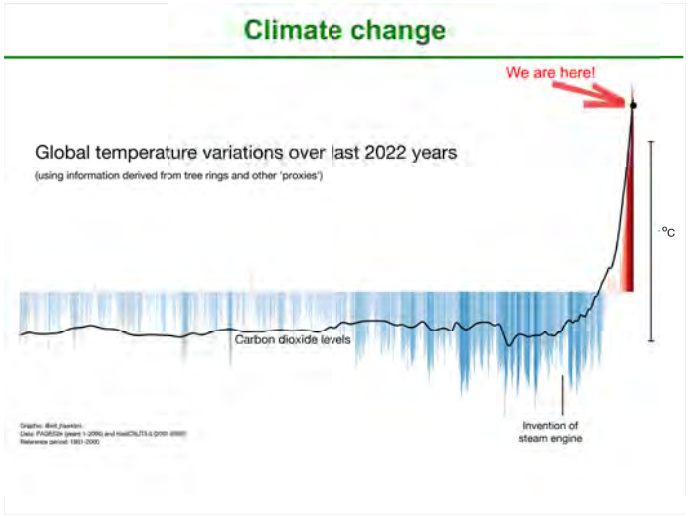
Mato Grosso, SE Amazon, July 2005



Pausas & Keeley 2014 *Ecosystems*



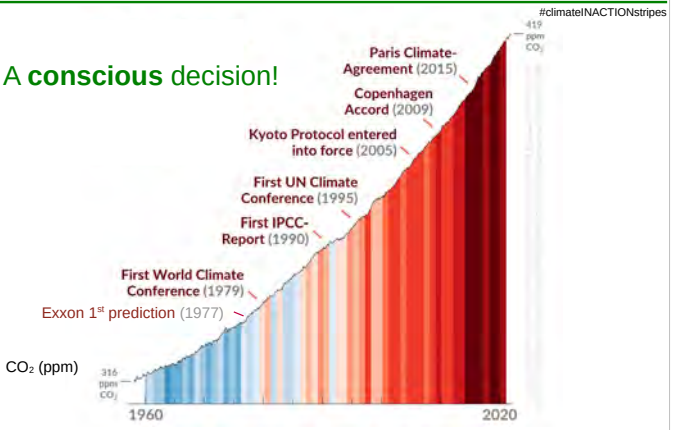
Climate change



Climate change

#climateINACTIONstripes

A **conscious** decision!



and the implications for fire … See next talk by S. Doerr

Concluding remarks

- Fire is an evolutionary force and explain a % of the variance in biodiversity across time (geological scale) and space. There are fire adaptations
- Fire is a mechanism assembling communities and biomes
- Fire decompose OM and move C & nutrients at broad-spatial scales
- The Earth system is complex and interconnected, we cannot understand it by looking only at small spatial and temporal scales
- The effect of fire as a degradation agent is often due to interaction with other disturbances (deforestation, poor afforestation, climate change, ...).
- Fire as opportunity to rethink land managment. E.g., from afforestation to restoring nautral ecosystems & fire regimes
- We cannot expect vegetation & management of the 20thC climate to be sustainable under the 21st C climate – wildfires will help the shift! 😱

"A world without fires is like a sphere without roundness, i.e., we cannot imagine it"
-- Pausas & Keeley 2009

¡Gracias!

Projects & funding:

fireEUrisk

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Web: www.uv.es/jgpausas
Blog: jgpausas.blogs.uv.es
Twitter/Mastodon: @jgpausas