

Global mapping of human fire use and management from new databases and models

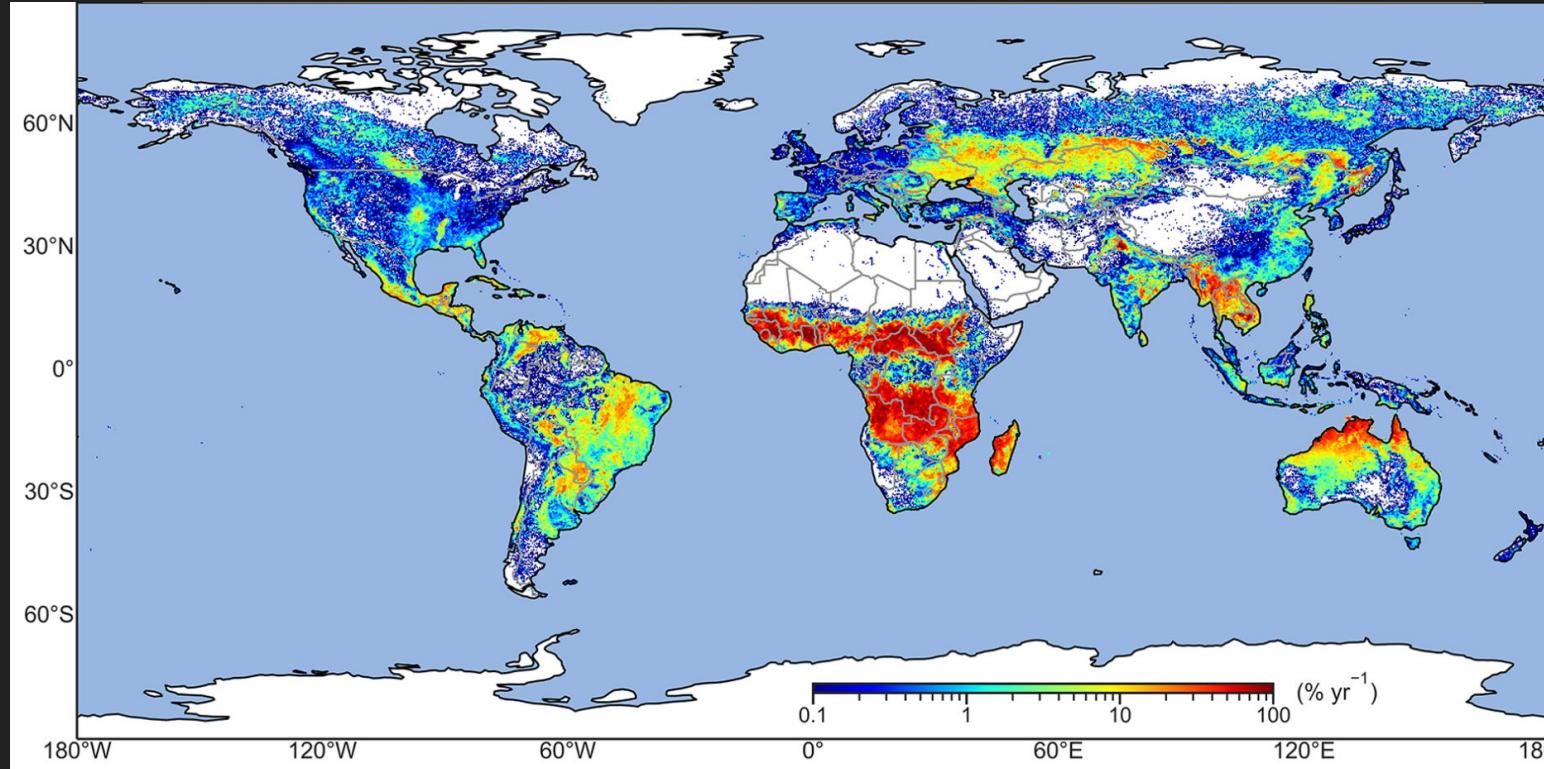
O. Perkins, J.D.A. Millington, C. Smith, J. Mistry

28 Aug 2024, Royal Geographical Society Annual Conference



LEVERHULME
Centre for Wildfires,
Environment and Society

Global Burned Area (from space)



GFED 0.25° (~25 km at equator)

Annual mean %/yr

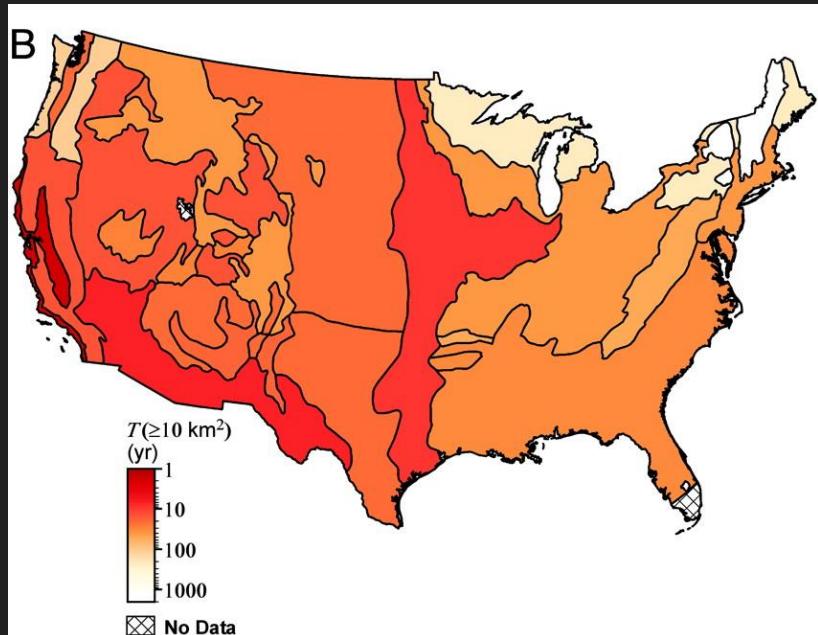
Paper: Chen et al. 2024 | Data: via Zenodo

Burned Area (from government data)

USFS and US DOI recorded
657,949 wildland fires (1970-2000)

Malamud *et al.* (2005) used
88,916 USFS fires >1 acre to
map fire regimes by ecoregion

- 64% were classified as
human caused: ‘campfire’,
‘arson’, ‘miscellaneous’ and
‘smoking’



Recurrence intervals for fires >10 km² per 1,000 km²

Diverse Empirical Research

Burning the Seasonal Mosaic: Preventative Burning Strategies in the Wooded Savanna of Southern Mali

Paul Laris¹

Human Ecology, Vol. 30, No. 2, June 2002 (© 2002)

Data are presented indicating a seasonal mosaic pattern of burning in the savanna of southern Mali. A seasonal mosaic is a landscape that is annually



Journal of Environmental Management 82 (2007) 481–494

Cattle-rangeland management practices and perceptions of pastoralists towards rangeland degradation in the Borana zone of southern Ethiopia

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Received 7 March 2004; received in revised form 12 January 2006; accepted 13 January 2006
Available online 17 April 2006

Abstract

A survey was conducted in the Borana pastoral areas of southern Ethiopia to assess current rangeland management practices and the perceptions of the pastoralists about future pastoral development.



Land Use Policy 47 (2015) 448–458
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Why do farmers burn rice residue? Examining farmers' choices in Punjab, Pakistan

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ABSTRACT

Burning agriculture residues has been a common practice in developing countries to reduce carbon and control pests. This study examined the reasons behind burning rice residue by farmers in Punjab, Pakistan. The study used a cross-sectional survey design and collected data from 100 farmers through a structured questionnaire. The results showed that the main reason for burning rice residue was to increase soil肥力 (fertilizer). The study also found that the majority of farmers were not aware of the negative effects of burning rice residue on the environment. The study recommended that the government should provide incentives to farmers to encourage them to adopt alternative methods of managing rice residue.

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Managing grassland for wildlife: the effects of rotational burning on tick presence and abundance in African savannah habitat

Anne E. Goodenough, Alison N. Harrell, Rachel L. Keating, Richard N. Rolfe, Hannah Stubbs, Lynne MacTavish and Adam G. Hart

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New Databases and Models

DAFI

Database of Anthropogenic Fire

Millington *et al.* (2022)

LIFE

Livelihood Fire Database

Smith *et al.* (2022)

GFUS

Global Fire Use Survey

Smith *et al.* (in review) [data online]

WHAM!

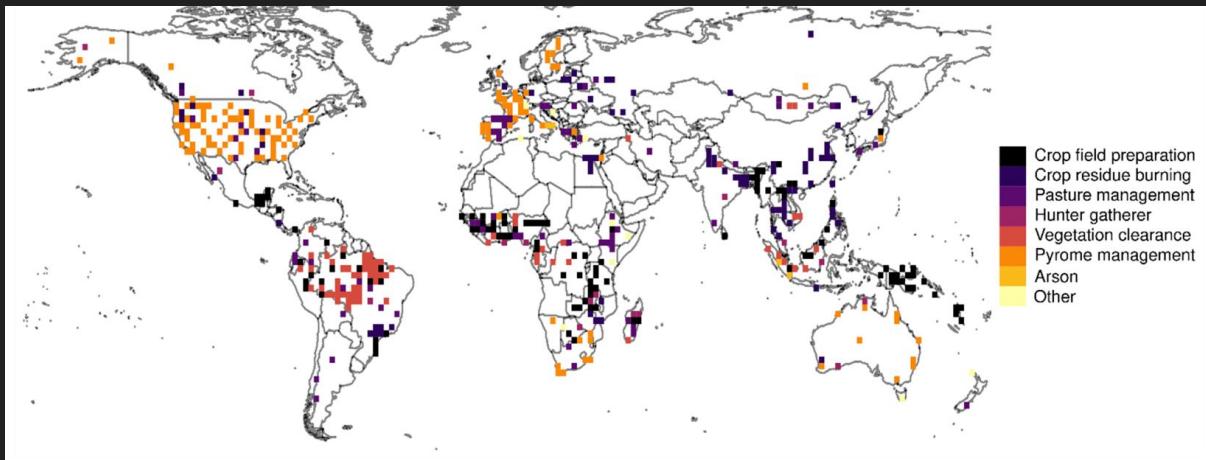
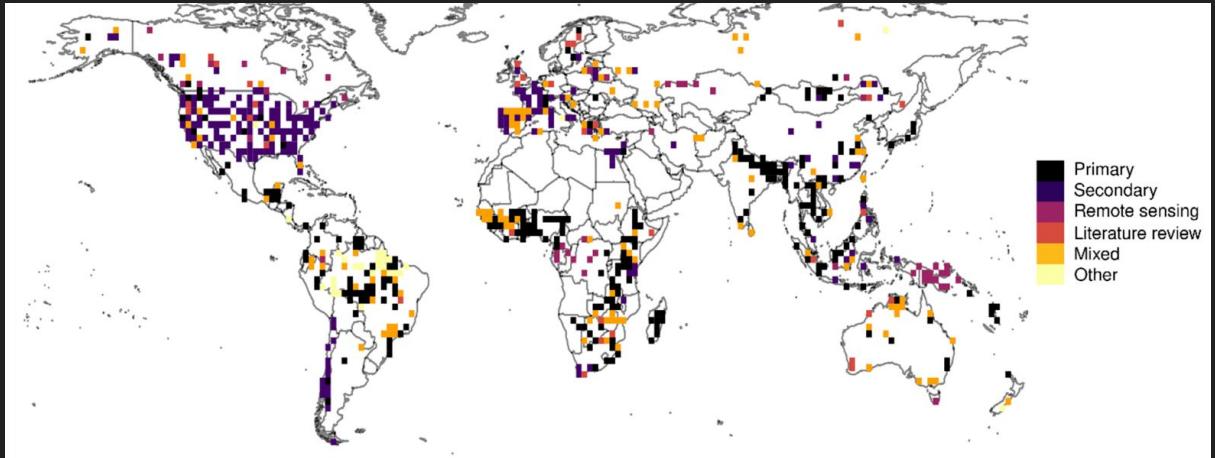
Wildfire Human Agency Model

Perkins *et al.* (2024)

	DAFI	LIFE	GFUS
Data Points	1809 cases 504 sources	1708 practices 592 sources	174 regions 311 responses
Data Source	Literature: Primary, Secondary, Remote Sensing, Reviews	Literature: Primary	Primary: Expert elicitation
Time Span	1990-2020	1990-2020	2018-2022
Fire Uses	<i>7 primary</i> [>20 total] Crop prep., Crop resid., Pasture, Hunt-Gather, Veg. clearing, Fuel mgmt, Arson	<i>8 primary</i> [29 total] Crops, Pasture, Hunt-Fish, Gather, Charcoal, Movement, Health, Social Signals	<i>25 total</i> Main type by user: Livelihood - agri/pasture State/NGO - fuel mgmt. Commercial - agri/pasture
Policy and Governance	<i>Intervention:</i> Incentivise, Restrict, Ban <i>Rationale:</i> Environ., Econ., Health	<i>Intervention:</i> Regulations, Incentives, Voluntary <i>Intention:</i> Reduce, Retain, Grow, Introduce <i>Actor:</i> state, NGO, community	<i>Intervention:</i> Reg., Incentives, Voluntary <i>Effectiveness:</i> Very, Somewhat, Not <i>Level:</i> High, Med, Low

DAFI

Spatial Distribution of Sources



DAFI

Spatial Distribution of Fire Uses

We constructed a freely available **Database of Anthropogenic Fire Impacts (DAFI)** from a meta-analysis of 1,800 worldwide case studies. We find seven main fire-use types, linked to land user intention.

Poster: [Perkins et al. 2021](#)
 Paper: [Millington et al. \(2022\)](#)
 Data: via [FigShare](#)

Human-Fire Interactions: A Global Database

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Presented at the American Association of Geographers Annual Meeting, April 2021



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Environment and Society



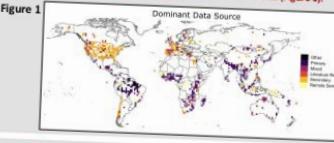
Studies of landscape fire vary in approach around the world. DAFI synthesises these studies.

Empirical studies of human use and management of fire in landscapes around the world have been conducted in many different academic fields, including geosciences, anthropology, land economics and ecology. Studies have varied in approach, from quantitative and broad-scale (e.g., remote sensing) to qualitative and local-scale case studies (e.g., anthropological). No global synthesis of human-fire interactions has yet been attempted that covers the breadth of human fire use and suppression approaches. We present the most comprehensive analysis of global fire use to date, spanning all key land systems and policy regimes from over 105 countries on all continents (except Antarctica) between 1990–2019. This study has produced a database comprising data (Table 1) from 523 papers containing 1808 case studies that we call the Database of Anthropogenic Fire Impacts (DAFI) (Perkins and Millington 2021). Because existing studies vary across disciplines, approaches, DAFI was developed in an iterative manner but based on a framework that accounts for fire stages (after Pyne 2019) and land system. Fire stages are pre-across space, with a prevalence of secondary studies in Europe and North America versus a dominance of primary studies in Asia and Africa (Figure 1).

Information	Data Format (case study)	DAFI	Example Variables (DAFI)
Fire Use	Quantitative	Continuous	Intended or actual fire size
Suppression	Mixed	Ordinal	Activity type & effort level
Policies	Qualitative	Boolean	Existence of laws or incentives
Land Use & Cover	Mixed	Continuous & Nominal	Land use intensity & type

Table 1

Figure 1



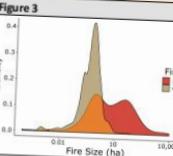
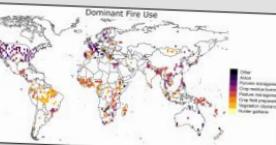
Quantitatively distinct fire regimes arise from local interactions between fire use, suppression and policy.

Analysis of DAFI reveals that seven fire-use types (listed in Table 2) account for >90% of case studies. The seven fire-use types have distinctive quantitative signatures (Table 2) and spatial distributions (Figure 2). Shifting cultivation field preparation has a similar mean fire size to non-shifting crop residue burning. However, the relatively low fire-return period and high density of fields when compared to shifting cultivation combine to produce a much greater proportional mean burned area. Pyrome management activities dominate in North America and Europe, while vegetation clearance is a primary use across much of Brazil, and crop residue burning is dominant across parts of Asia.

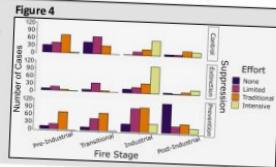
Fire-use Type	DAFI Records (%)	Mean Size (ha)	Mean Burned Area (% LS)	Mean Return Period (yrs.)	Expt. Burn (%)
Field Prep.	19.8	0.8	14.2	10.2	0.05
Crop Residue Burning	16.7	3.9	36.3	2.0	0.01
Pasture Prep.	12.9	33.9	32.1	3.4	4.97
Hunt/Gather	6.4	2.1	14.3	5.0	2.90
Veg. Clearing	14.2	9.2	2.5	N/A	3.23
Pyrome Mgmt.	17.7	357.2	14.0	5.9	0.30
Arisen	3.3	N/A	N/A	N/A	N/A

Table 2

Figure 2



DAFI enables examination of fire regime characteristics as a function of broader fire-use approaches and how fire uses vary between fire regimes. For example, cropland fires tend to be smaller than fire broadcast across pasture and forest landscapes (Figure 3). We find distinct differences in fire suppression between fire stages (Figure 4). Code for analysis of DAFI and plots is available (Perkins 2021).



Representation of anthropogenic fire in global models demands consideration of land use context.

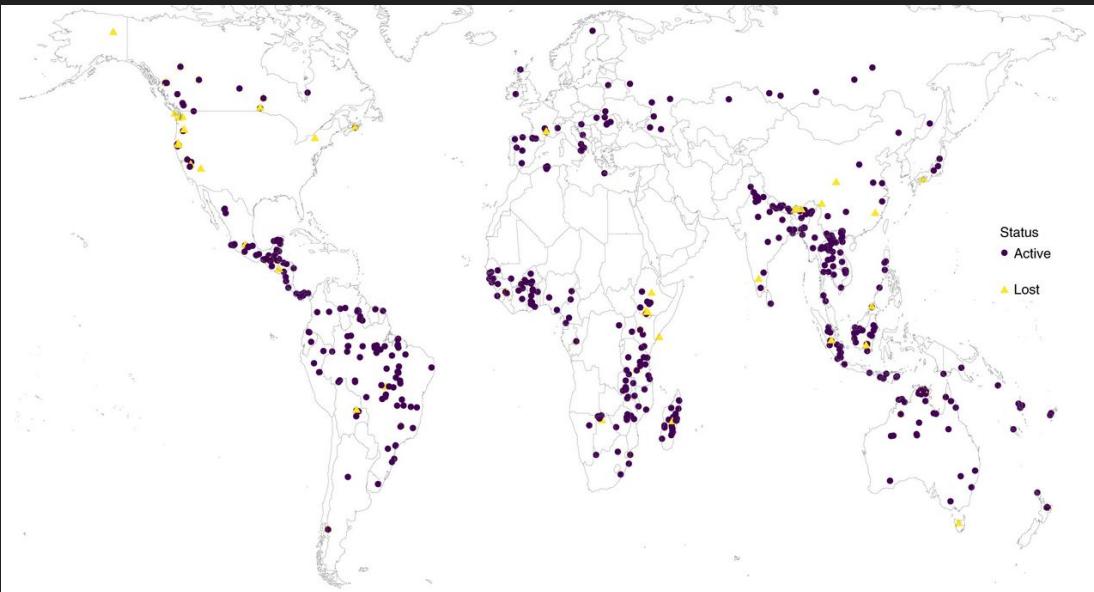
Attempts to systematically study human-fire interactions have sought to configure human impacts as deviations from underlying "natural" axes of vegetation and fire regimes (e.g., McWethy et al. 2013). Such approaches have not yet developed a coherent framework to capture human impacts on wildfire. A key finding of the Global Land Use and Intercomparison Project was that the lack of a systematic empirical basis for understanding human impacts on wildfire regimes here contributes to improving this situation. DAFI is freely available (Perkins and Millington 2021) and continues to grow. We plan to use DAFI to support the development of agent-based modelling approaches to better represent human fire in GCMs. The poor performance of anthropogenic fire in GCMs still relies on fire spread rate and fuel load metrics of human activity, such as population density and GDP. The poor performance of land systems. To provide this context, we will use DAFI to develop agent functional types that characterise anthropogenic fire use and suppression as a function of underlying land use objectives. Examples may include shifting cultivation farmer, large-scale industrial logger, and conservationist. We expect that by mapping these types globally using ancillary data, we will be able to improve simulation model representation of human fire, including feedbacks with vegetation and climate.

References: [McWethy et al. \(2013\)](#); [Global Land Use and Intercomparison Project](#); [Perkins et al. \(2021\)](#); [Pyne \(2019\)](#); [Perkins and Millington \(2021\)](#); [Figure 1](#); [Figure 2](#); [Figure 3](#); [Figure 4](#); [Table 1](#); [Table 2](#); [Poster](#); [Data](#)

LIFE

Spatial Distribution of Case Studies

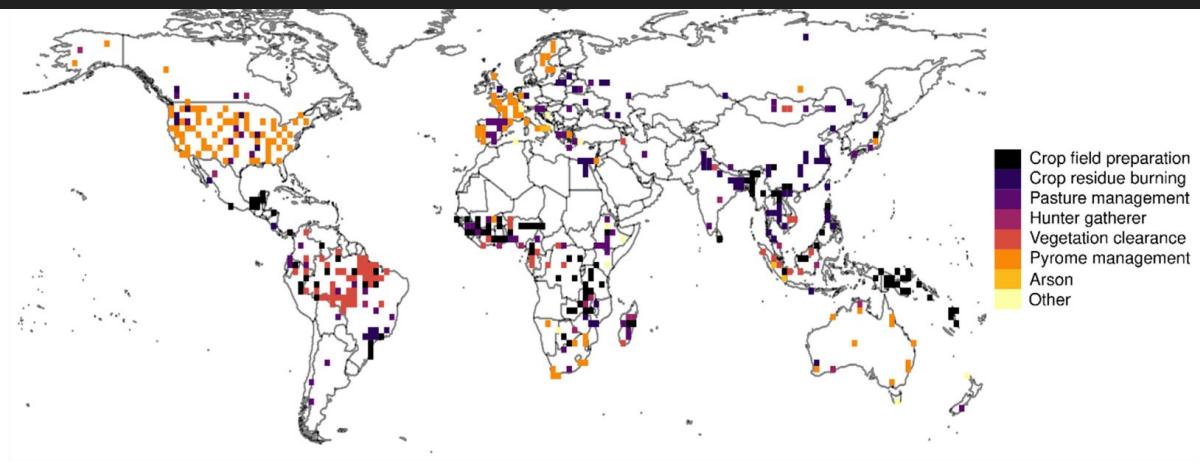
(point location)



DAFI

Spatial Distribution of Fire Uses

(gridded mode)

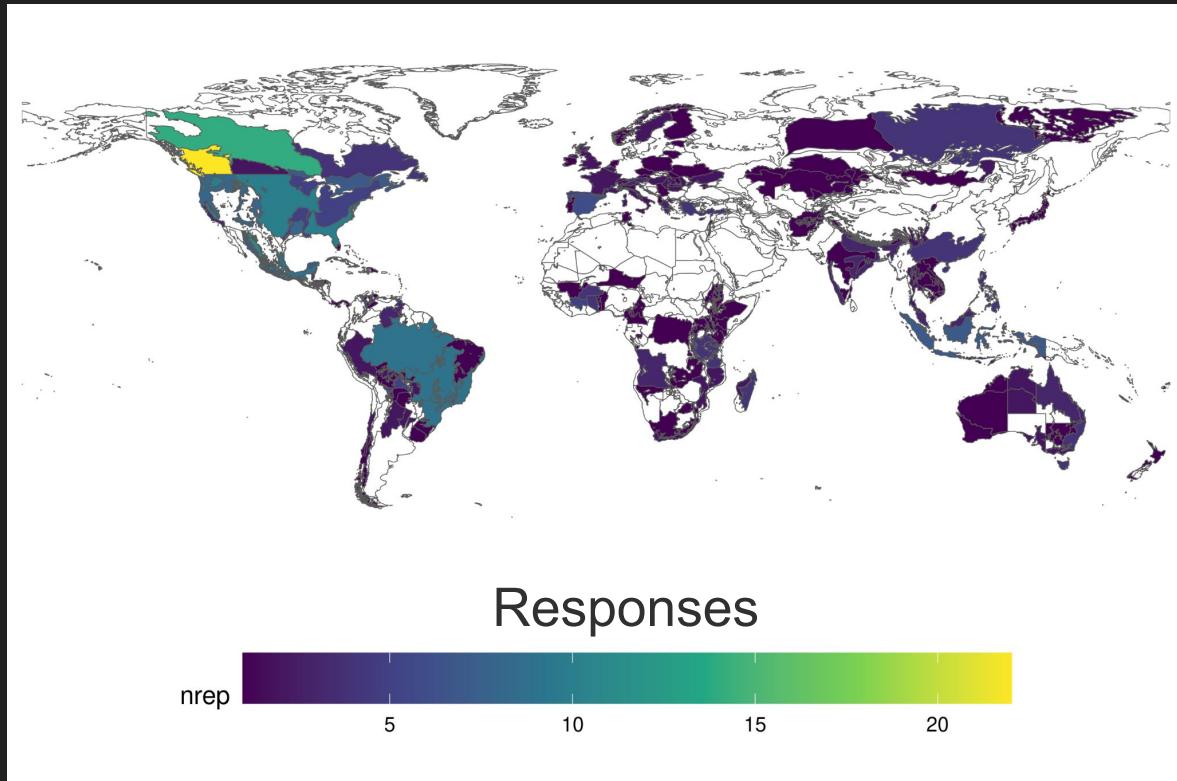


GFUS

Spatial Distribution of Responses

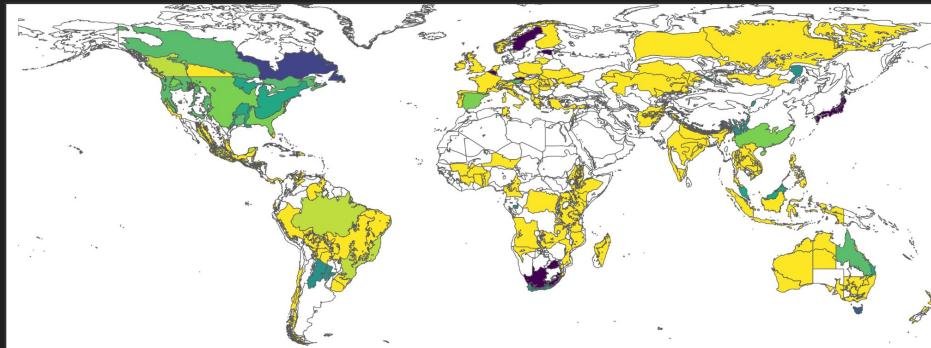
Data for Russia and
Kazakhstan

Over-representation in
Americas?

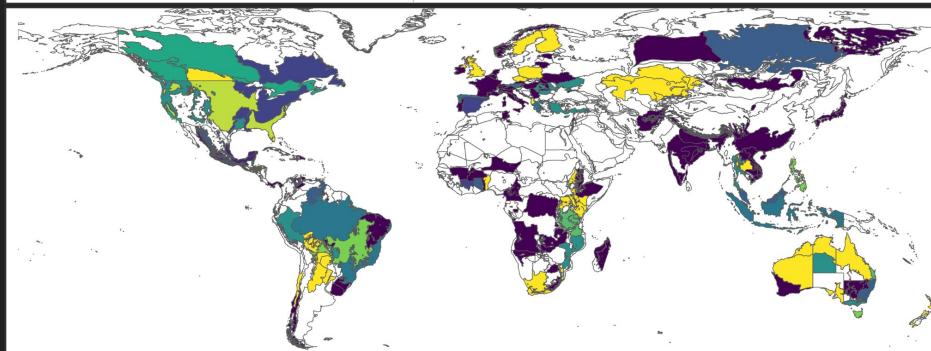


GFUS

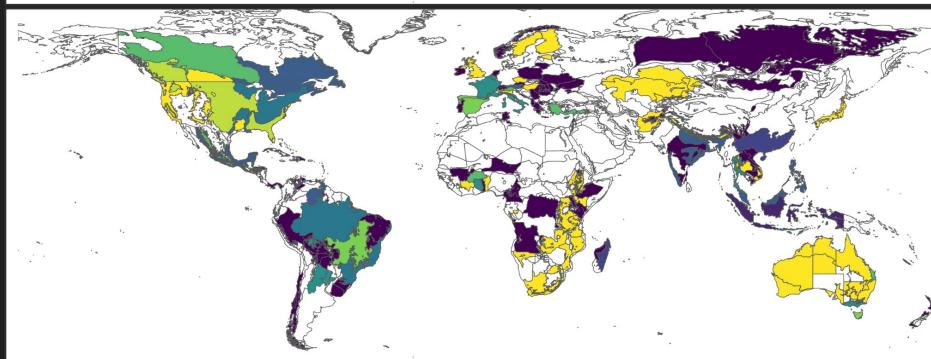
Prop. of responses
indicating actor is
present in a region



Livelihood



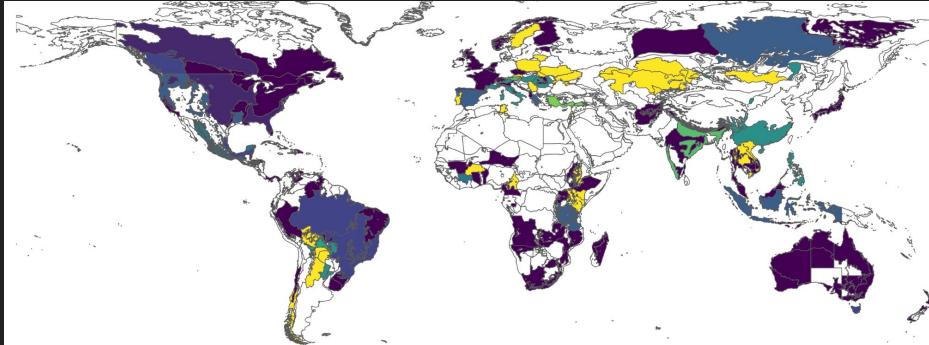
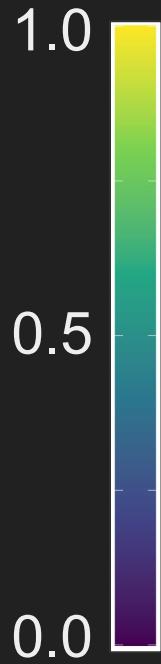
Commercial



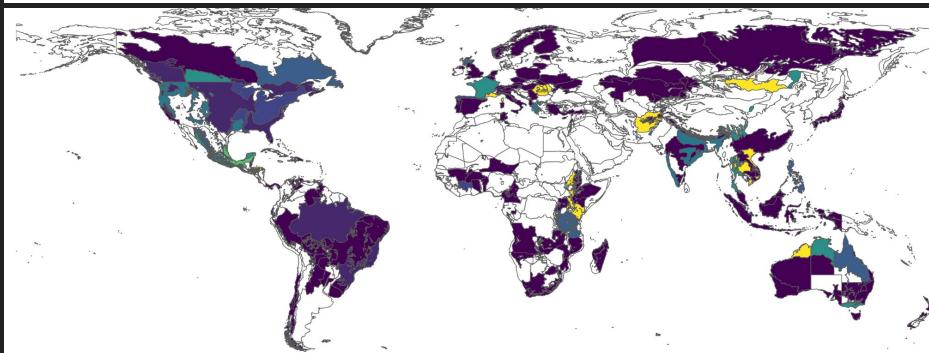
State/NGO

GFUS

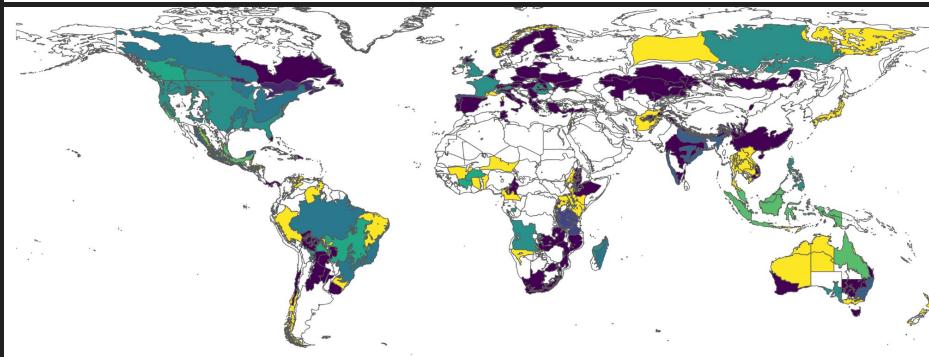
Prop. of responses
indicating action is
present in a region



Banned



Economic
Incentive

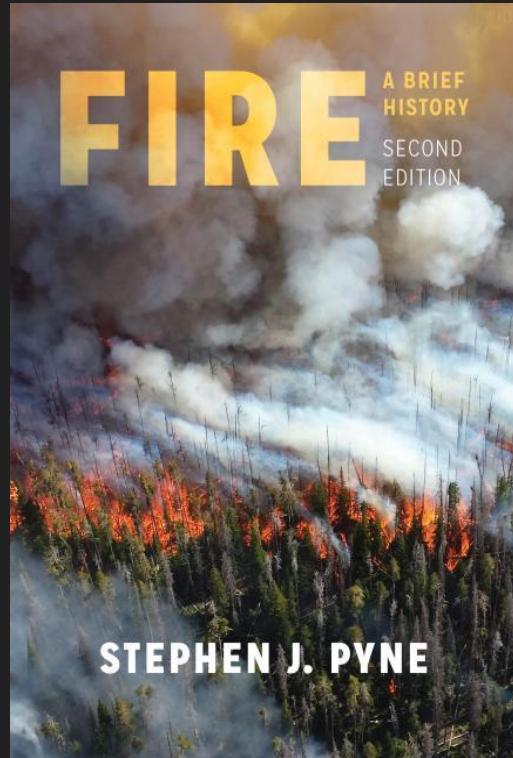


Community
Governance

1. Anthropogenic Fire Regimes

- First Fire pre-human
- Second Fire pre-industrial
- 2.5th Fire transition
- Third Fire industrial
- Pyrocene post-industrial

After Pyne's Fire 'stages', AFRs reflect available resources and management perspectives



[\[TED 15 min summary\]](#)

2. Land Use Systems



Non-Extractive



Pasture



Forest



Cropland

Combine land use intensity and land management practices

See Václavík *et al.* 2013 [[GEC](#)], Dou *et al.* 2021 [[Lsp Ecol](#)]

Land-Fire Systems [‘AGENT TYPES’]

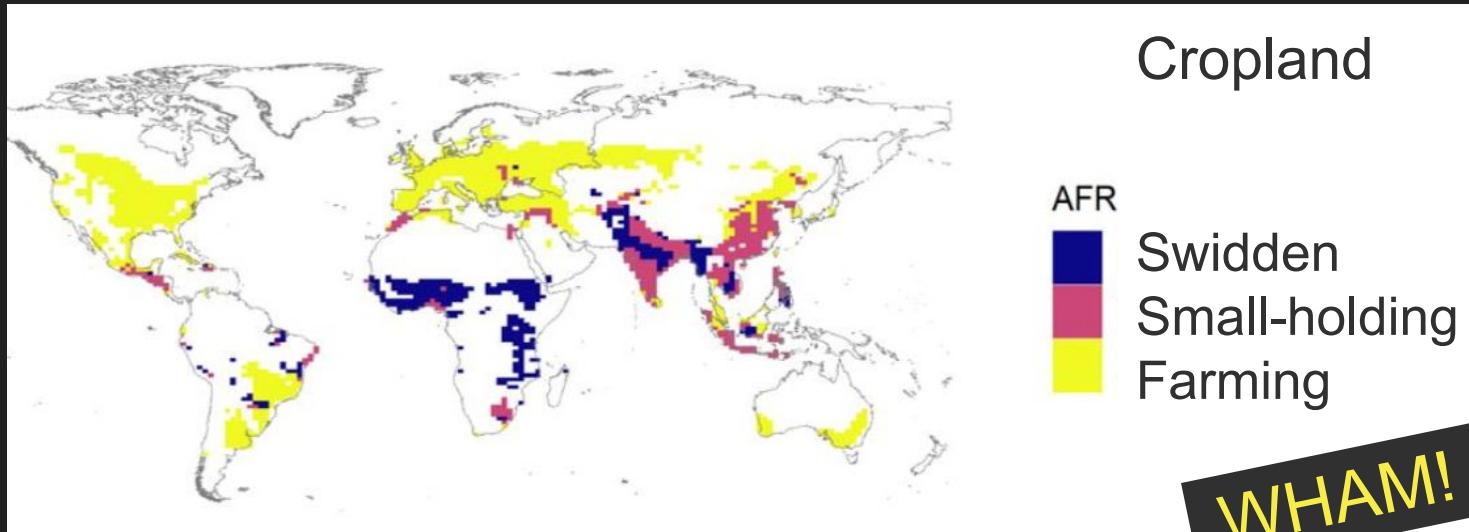
More here: Perkins *et al.* (2024)

From combination of Anthro. Fire Regimes and Land Use Systems

WHAM!		Land Use System			
Anthro. Fire Regime	Non-Extractive	Livestock	Crops	Forestry	
	Pre-Industrial	Unoccupied	Pastoralism (S)	Swidden (S)	Hunt & Gather (S)
	Transition	Unmanaged	Ranching (Extensive, S M)	Small-holding (S M)	Logging (Primary Forest)
	Industrial	Pyro-exclusion (State Manager)	Ranching (Intensive, M)	Farming (Intensive, M)	Managed (Plantation or Second Forest)
	Post-Industrial	Pyro-diverse (Fuel Load Management)	Grazing (Subsidised, Fuel Mgmt)	Abandoned	Abandoned

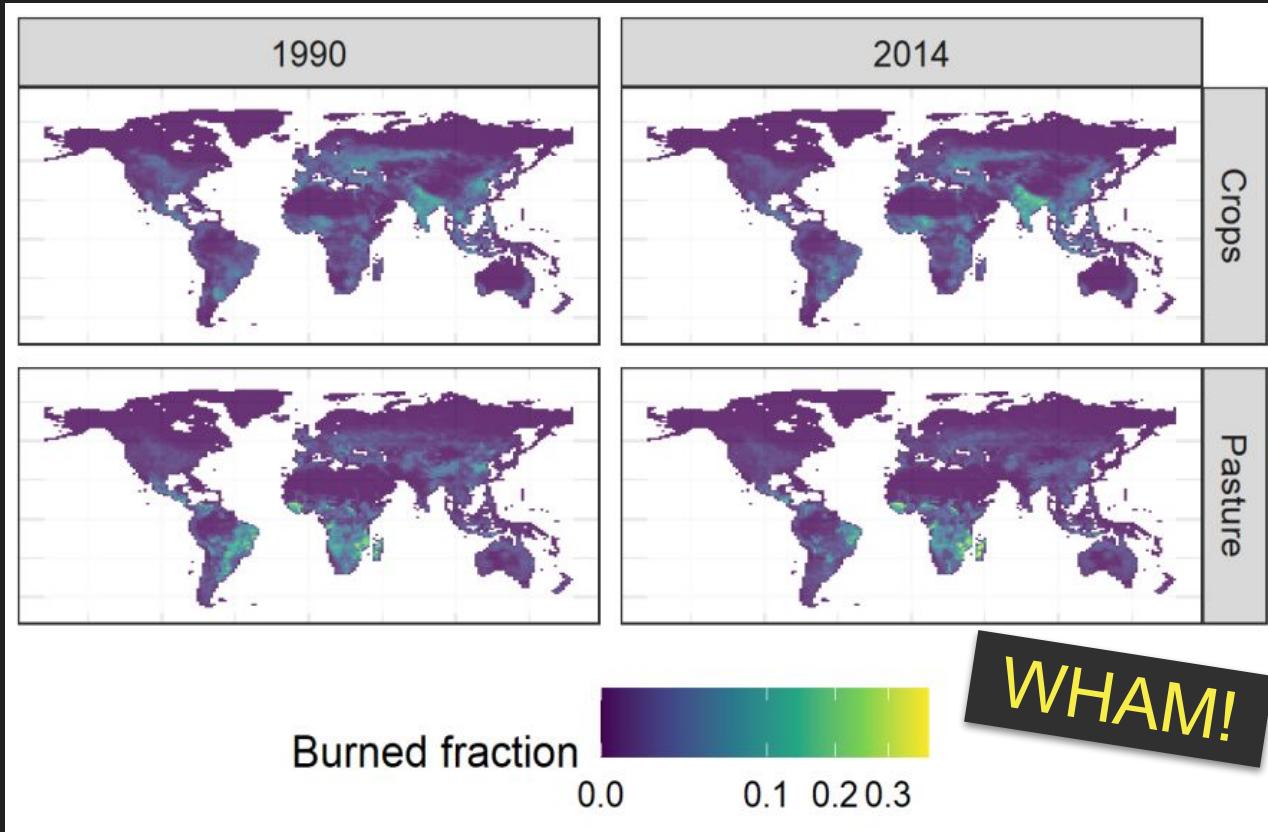
Non-Extractive = e.g. parks S = subsistence M = market

Modelled Spatial Distribution of LFS



Combine density of *LFS* with
data from DAFI to
estimate *human Burned Area*

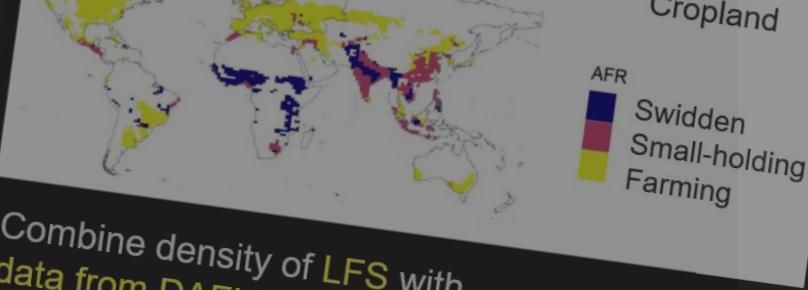
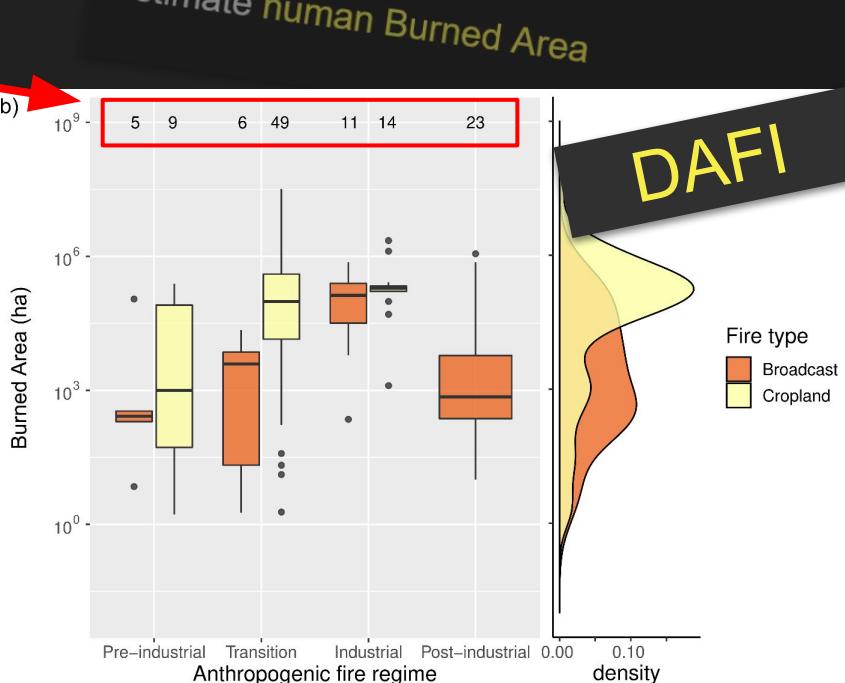
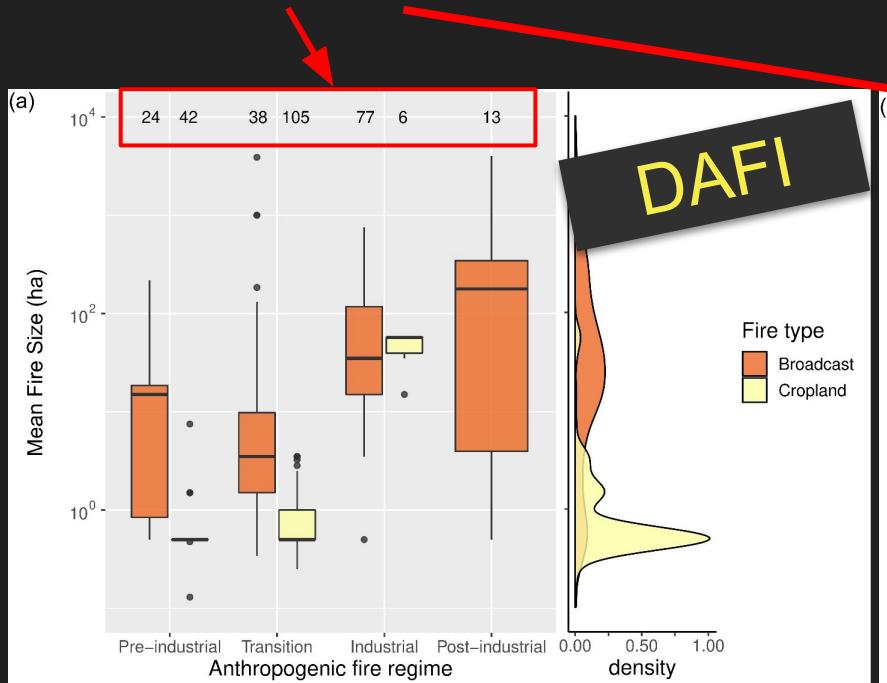
Modelled Agriculture Burned Area



Paper:
Perkins *et al.* (2024)

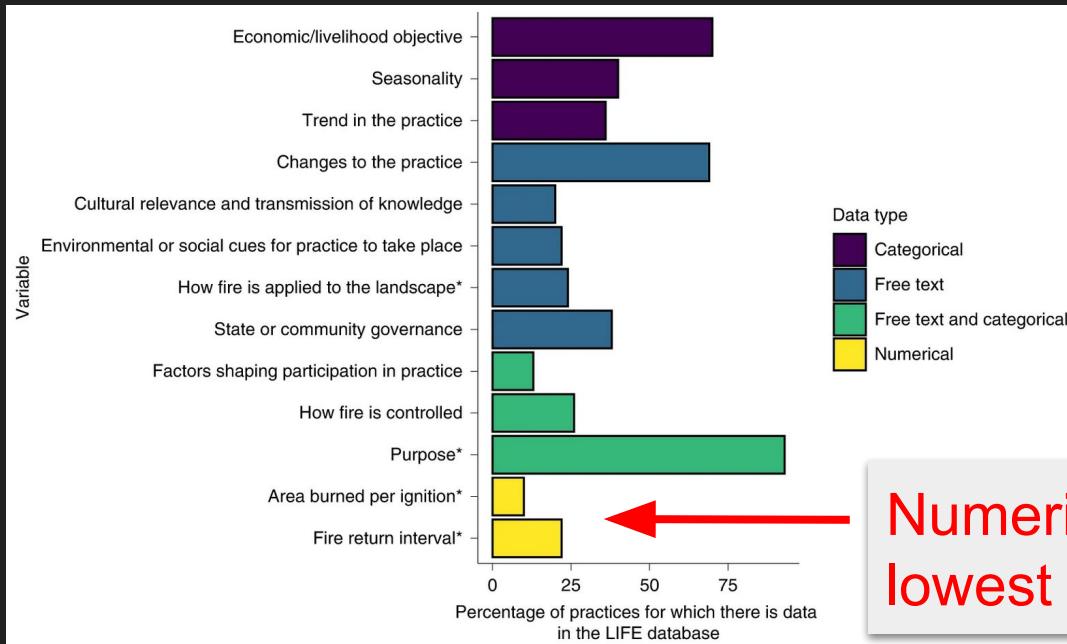
Quantitative Estimates

Global BA by agent type based on relatively *low sample sizes*



Combine density of LFS with
data from DAFI to
estimate human Burned Area

LIFE Variable data completeness



DAFI

Only half of studies
on Hunt-Gathering
provided quantitative
metrics

Numerical variables have
lowest representation in LIFE

*Not all fire users use formal quantification ...
but statistical and many simulation models do*

Other Challenges

Clandestine Activity

- Difficult to study and therefore an area of uncertainty
- No studies (3.5% of all) had quantitative metrics for arson
- Several GFUS responses highlight importance of illegal activities

Studies of Fire Absence

- LIFE highlights the loss of traditional fire practices
- Studies of (wild)fire mitigation and suppression are limited
- More studies needed on where fire is not used where it could be
- Longer-term understanding of absence (e.g. land abandonment)

Summary

Good progress collating/analysing data globally, but challenges and gaps in data and understanding remain

- **Spatial Coverage:** language, areas of change
- **Fire Use in DGVMs:** model fires, not ignitions - but better data needed!
[see **Kasoar et al. (2024)**]
- **Clandestine Activity:** need more studies on effects of state bans, arson
- **Mitigation and Suppression:** far fewer studies than of fire use
- **Long-term change:** understanding pre-1990s fire use
- **Qualitative Emphasis:** mixed methods studies? e.g. with RS