Global fire models:
How they work,
and how they could work better

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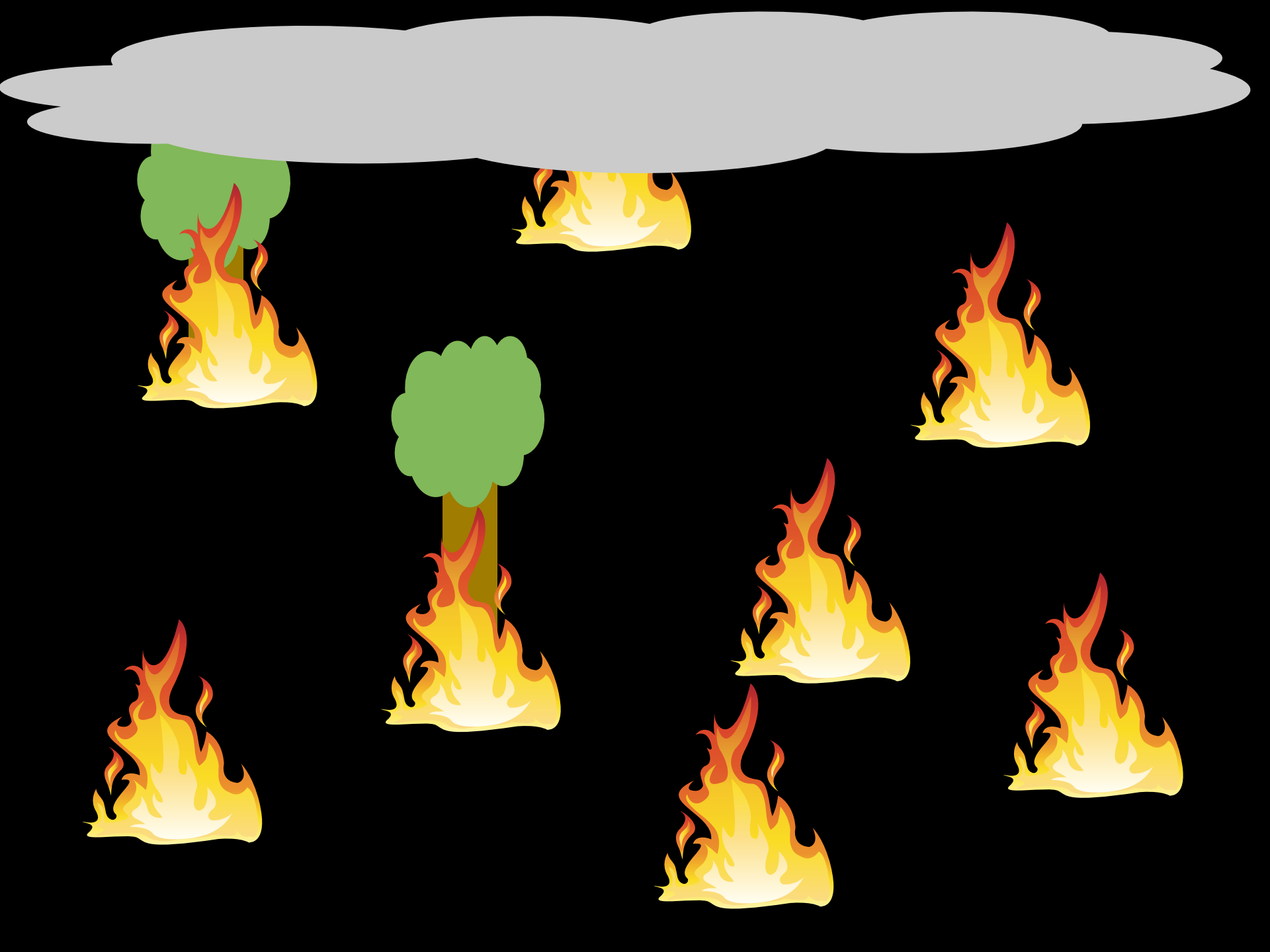
Empirical relationships

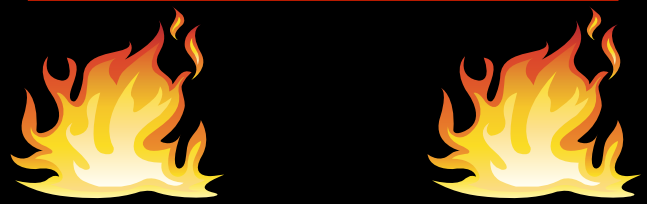
Quasi-MECHANISTIC models

MECHANISM

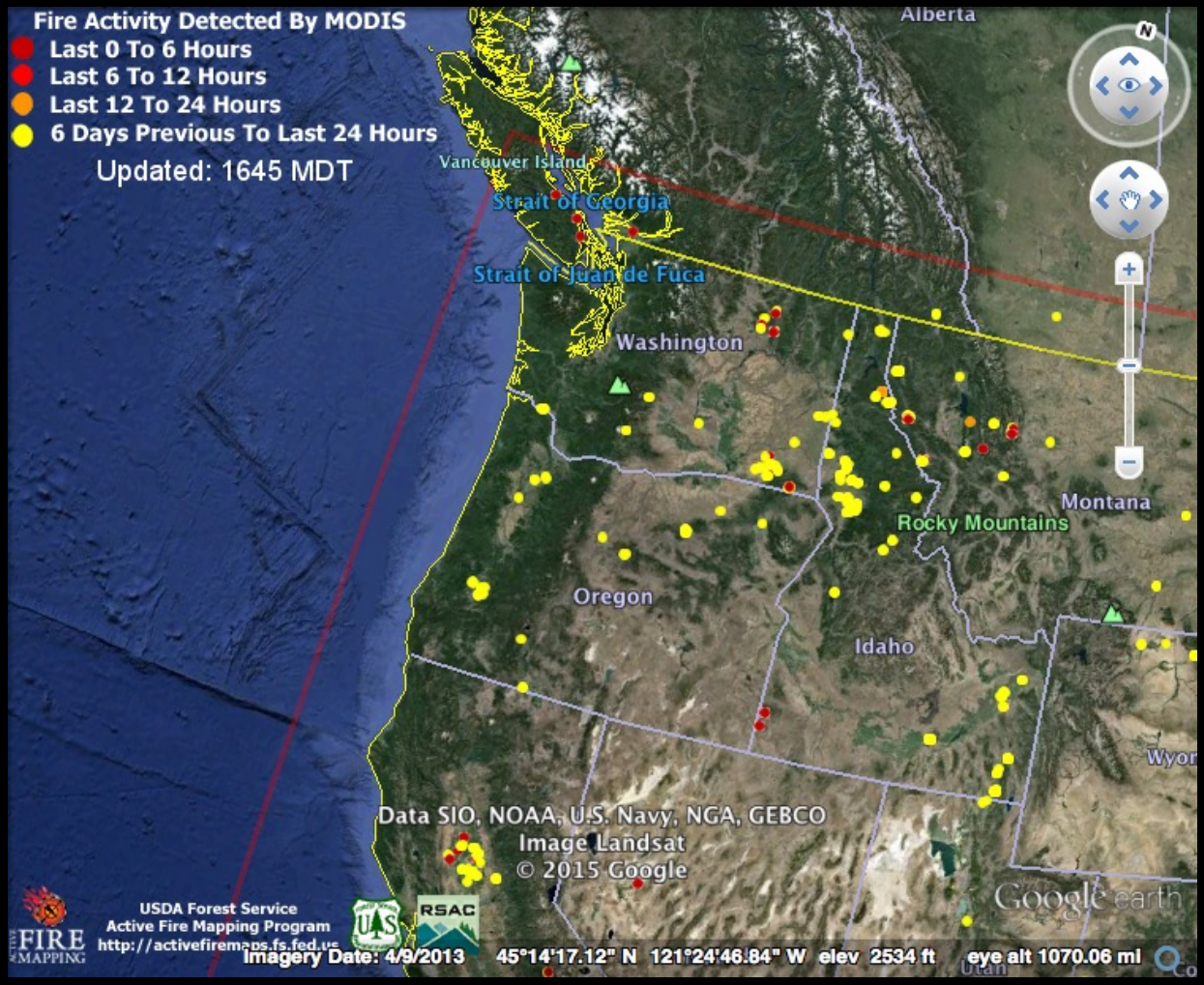


Ignitions

Fires

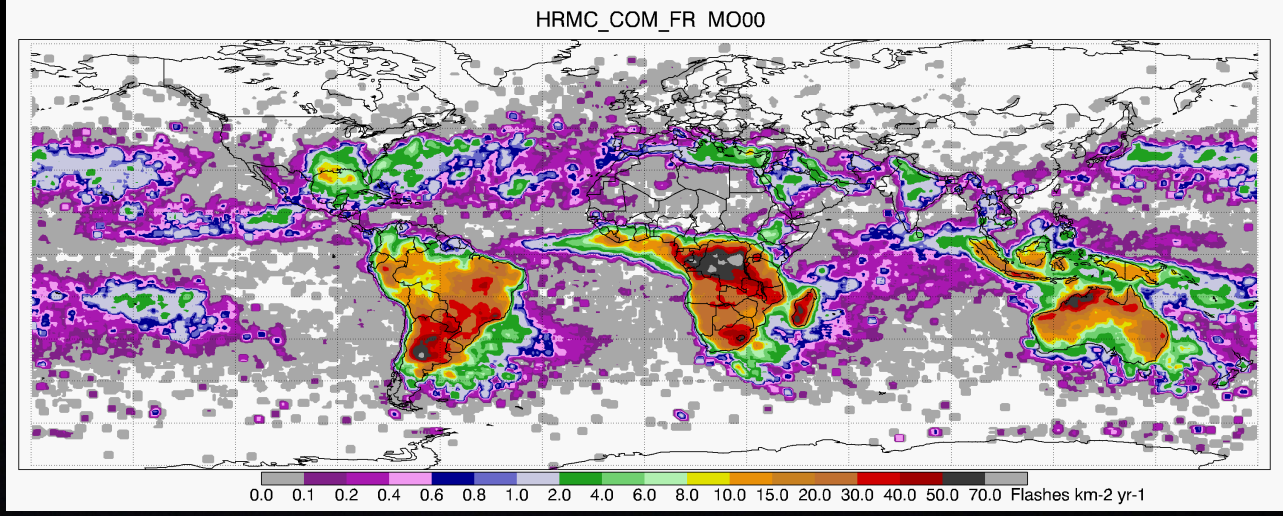


Number of fires



Climatology

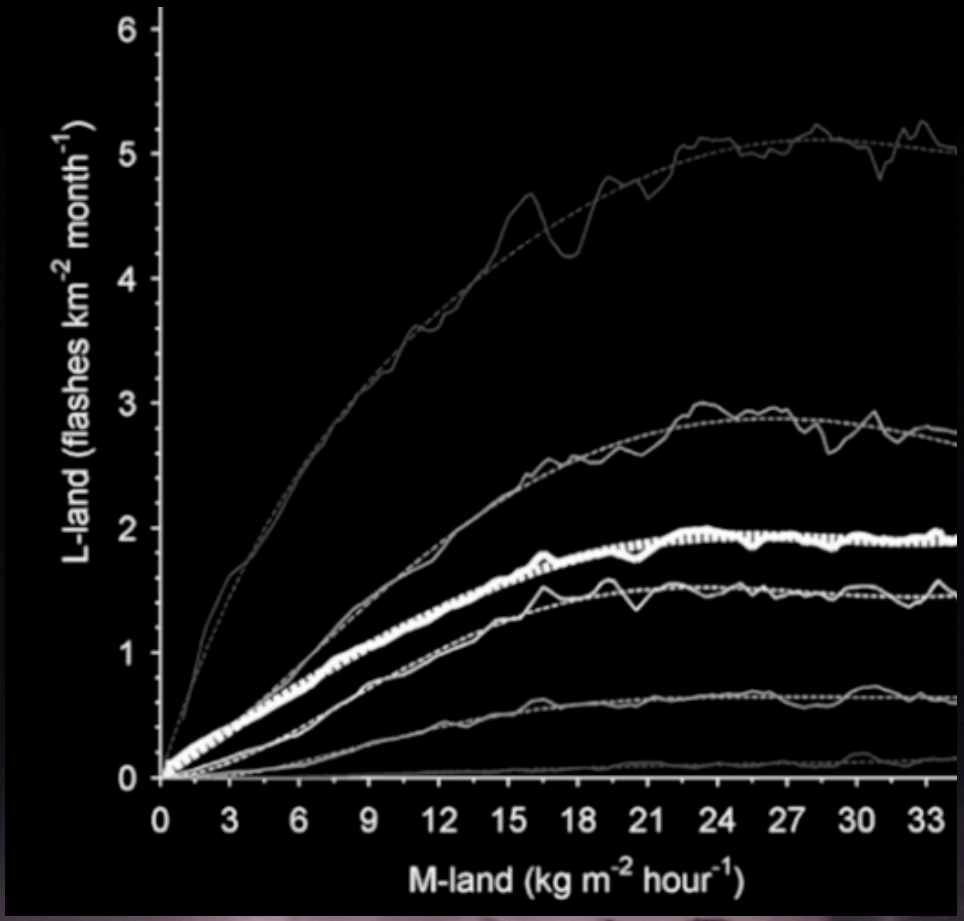
+ Within-month distribution
+ Interannual variability



LIS/OTD; ghrc.nsstc.nasa.gov

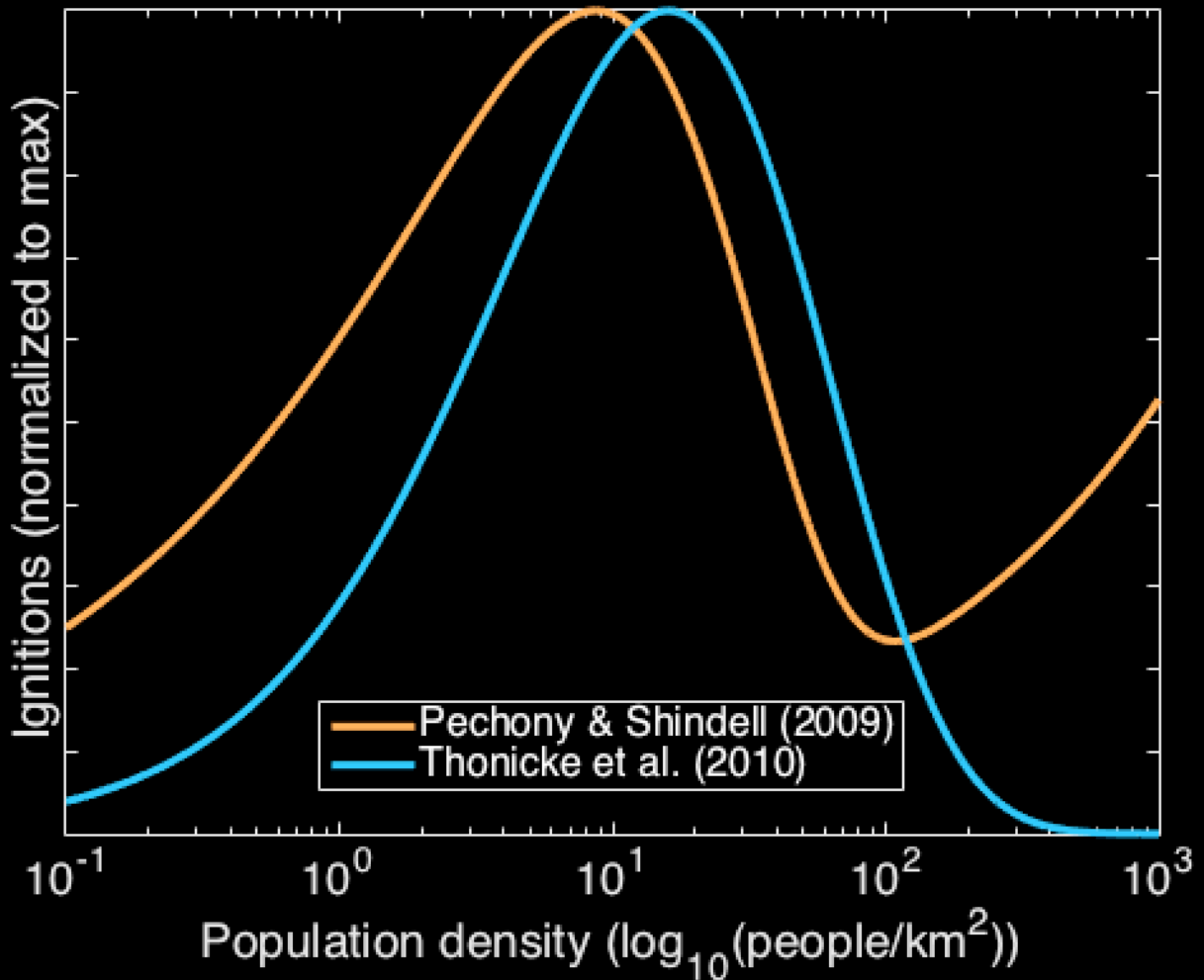
Dynamic

Magi (2015)



Anthropogenic ignitions

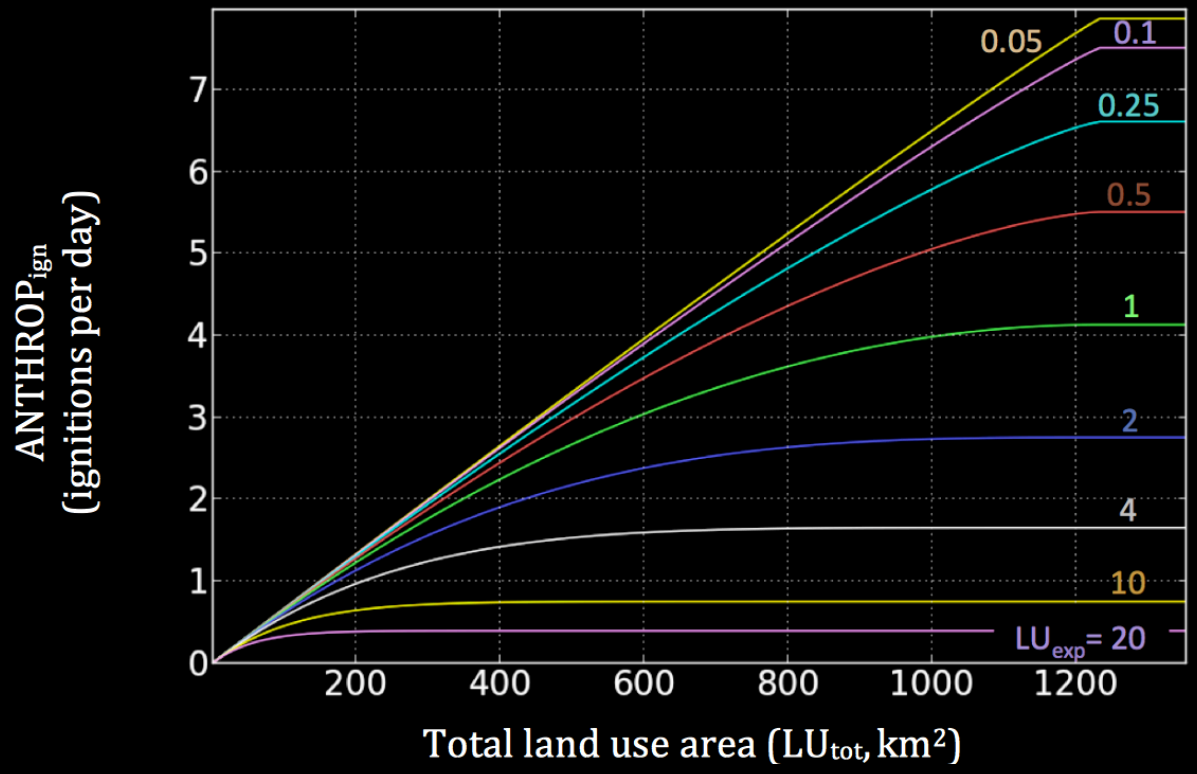
- Population density



Anthropogenic ignitions

- Population density
- Land use, GDP

Le Page et al. (2015)



People light fires for *reasons*

Often not like “natural” fire!

People light fires for *reasons*

Li et al. (2013)

Pfeiffer et al. (2013)

Rabin et al. (in prep.)

Pfeiffer et al. (2013)

Rabin et al. (in prep.)

Kloster et al. (2010)

Li et al. (2013)

But how useful for paleo?

Anthropogenic ignitions: The LPJ-LMfire approach (Pfeiffer et al., 2013)

Foragers

Maximize diversity: intermediate disturbance

Pastoralists

Maintain rangelands: 5-year burn cycle

Farmers

Protect croplands: 20-year burn cycle

Light fewer fires in dangerous conditions

Effects on vegetation

Combustion & mortality:

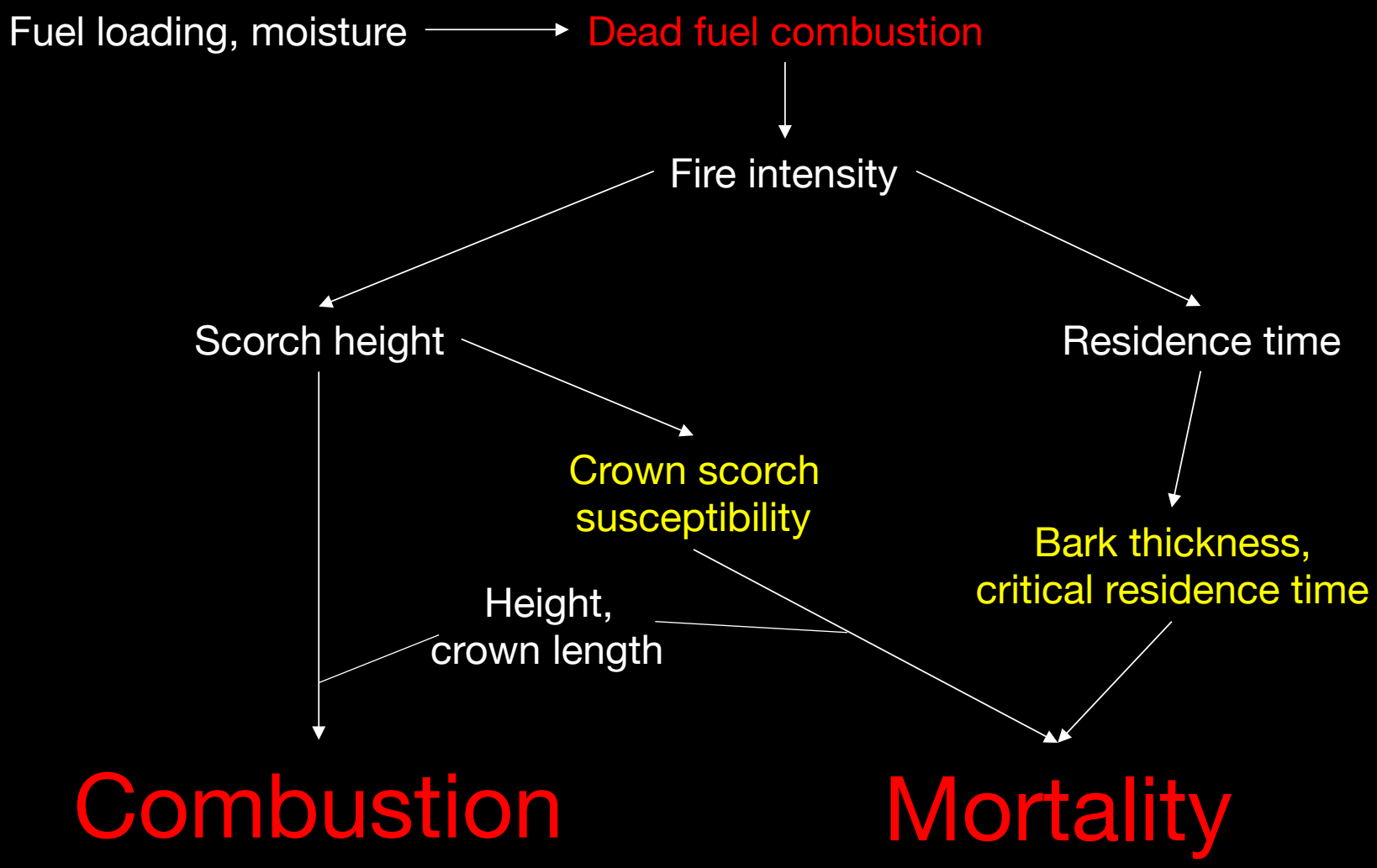
Empirical

Table 1. Combustion and Mortality Factors for Leaf, Stem, Root, and Litter Pools for CTEM PFTs

	Combustion Factors				Mortality Factors		
	ϕ_L	ϕ_S	ϕ_R	ϕ_D	ψ_L	ψ_S	ψ_R
PFTs	Leaf	Stem	Root	Litter	Leaf	Stem	Root
Needleleaf evergreen	0.70	0.20	0.00	0.50	0.20	0.60	0.10
Needleleaf deciduous	0.70	0.20	0.00	0.50	0.20	0.60	0.10
Broadleaf evergreen	0.70	0.20	0.00	0.60	0.20	0.60	0.10
Broadleaf cold deciduous	0.70	0.20	0.00	0.60	0.20	0.40	0.10
Broadleaf drought deciduous	0.70	0.10	0.00	0.60	0.20	0.40	0.10
C_3 crop	...	...	...	...	...	...	...
C_4 crop	...	...	...	...	...	...	...
C_3 grass	0.80	0.00	0.00	0.70	0.10	0.00	0.25
C_4 grass	0.80	0.00	0.00	0.70	0.10	0.00	0.25

Arora & Boer (2005)

Combustion & mortality:
Quasi–MECHANISTIC



Ecology matters!

Boreal tree strategies re: fire

Embrace

Die from fire, but resprout quickly

Resist

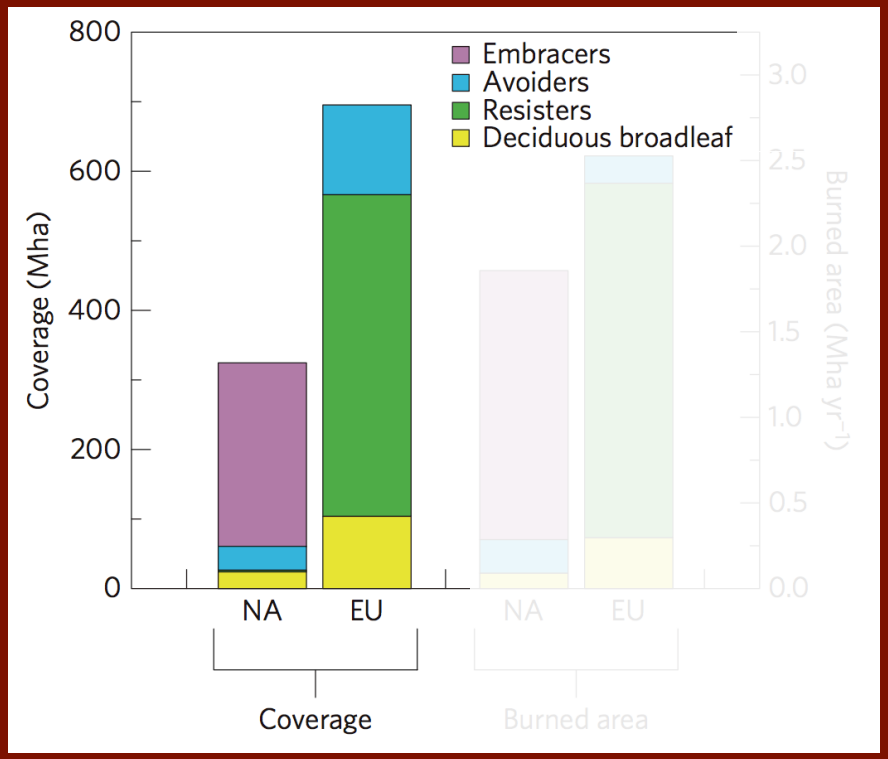
Invest in mechanisms to survive burns

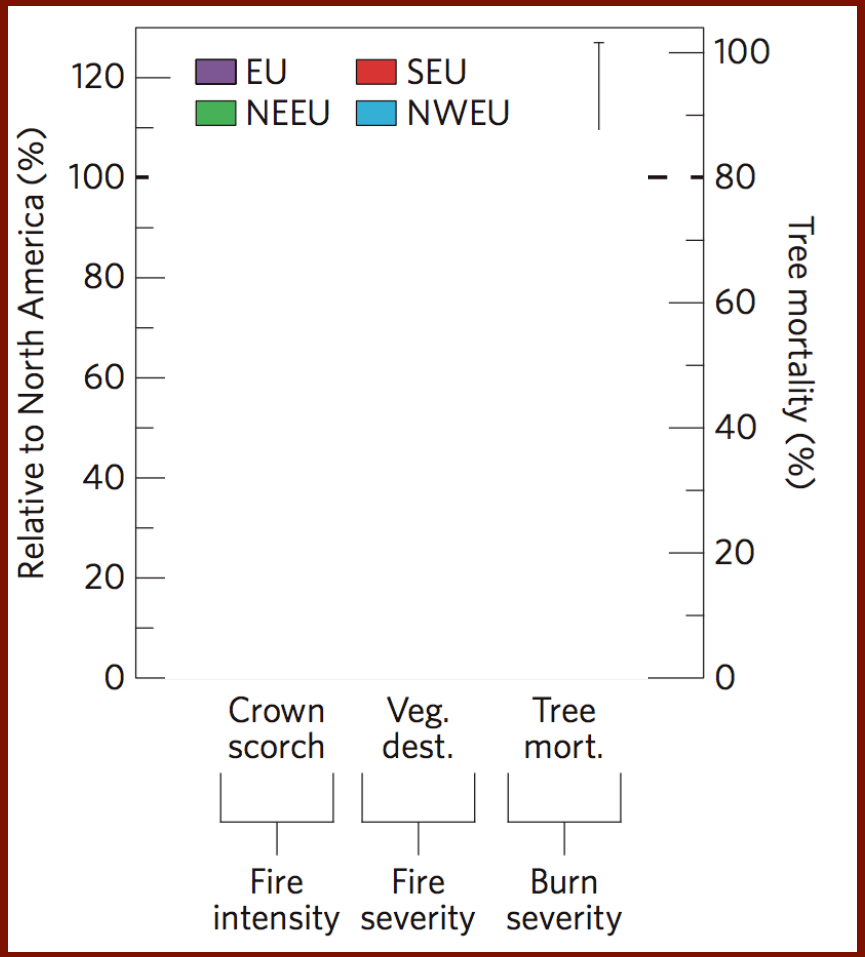
Avoid

Don't live where burns are likely

Rogers et al. (2015)

Ecology matters!

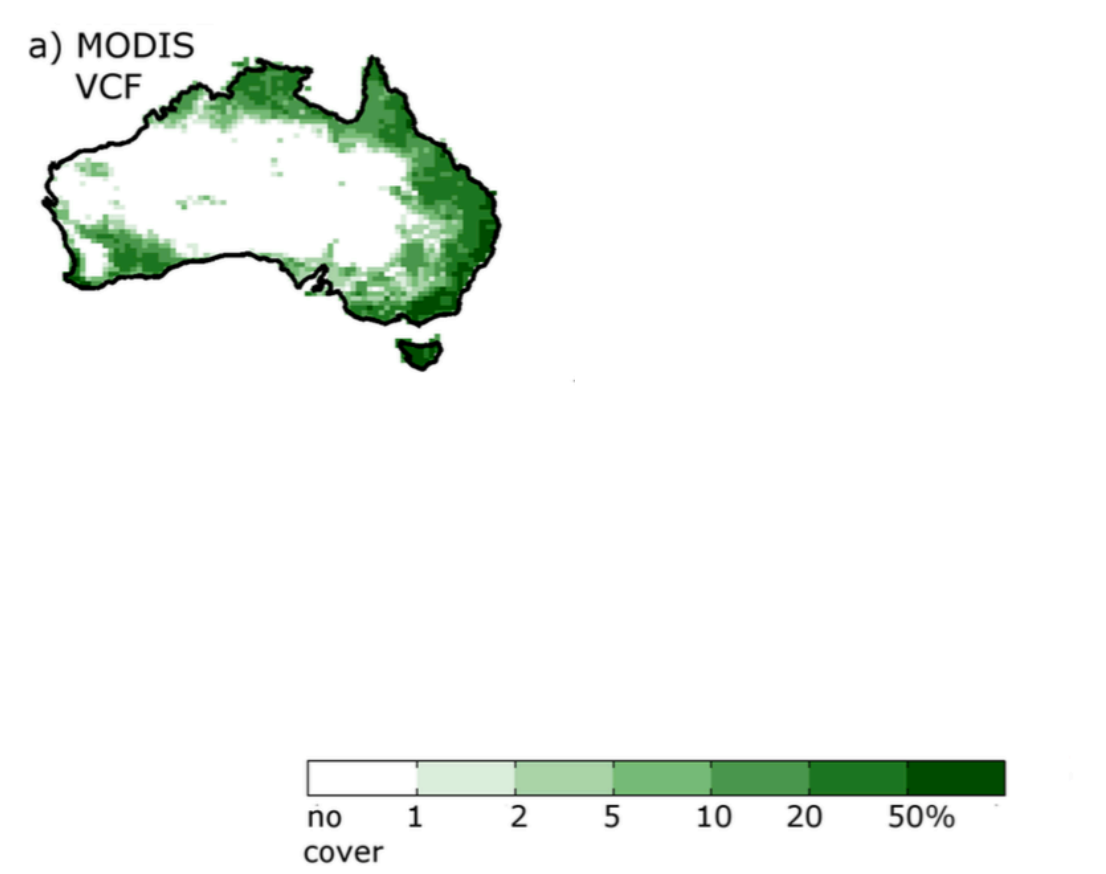




Rogers et al. (2015)

Ecology is difficult!

LPX
(Prentice et al., 2011)



LPX-Mv1
(Kelley et al., 2014)

…plus re-sprouting

"Emissions factors"

g emitted per kg of dry matter combusted

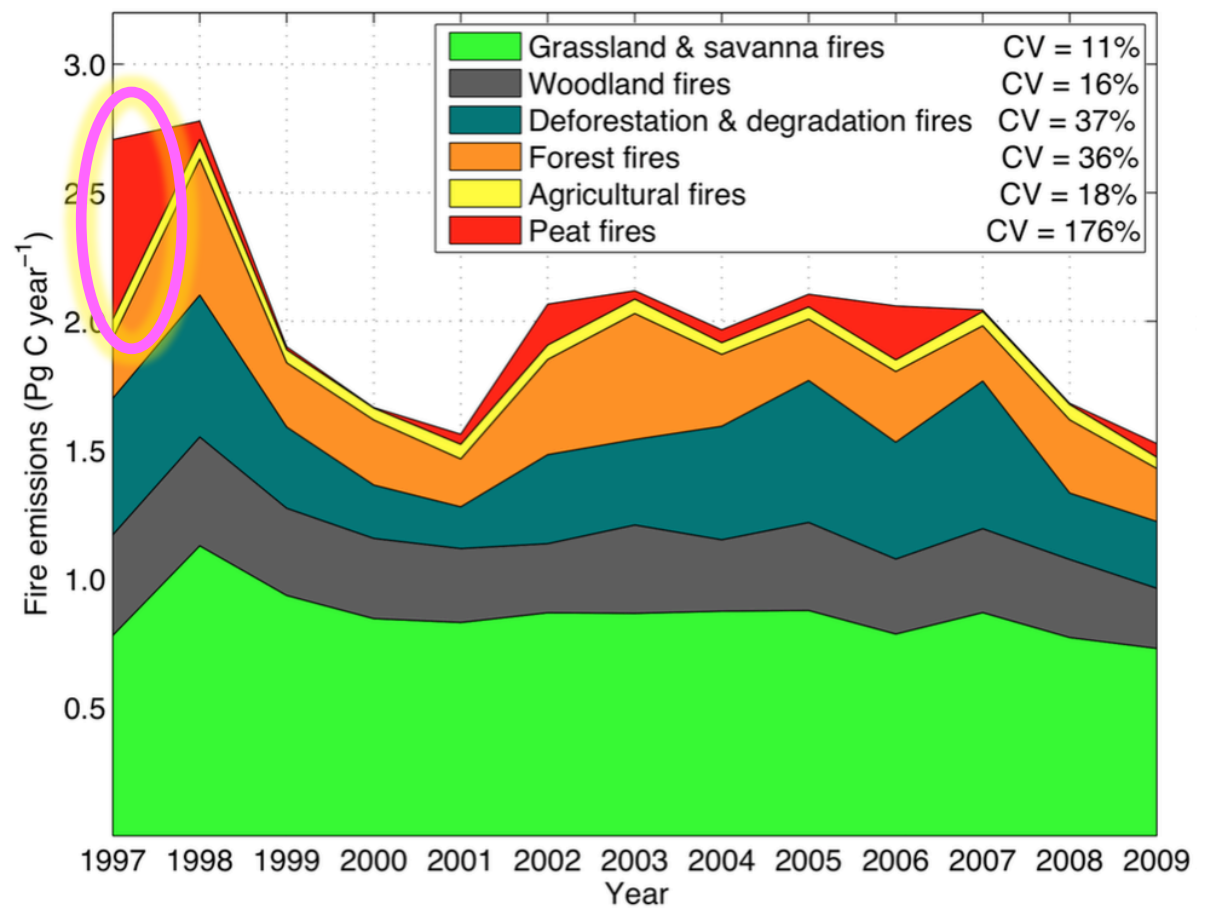
PFT	CO_2	CO	CH_4	NMHC	H_2	NO_x	N_2O
BET Tropical	1631	100	6.8	7.1	3.28	2.55	0.20
BDT Tropical	1654	64	2.4	3.7	0.98	2.49	0.20
BET Temperate	1576	106	4.8	5.7	1.80	3.24	0.26
NET Temperate	1576	106	4.8	5.7	1.80	3.24	0.26
BDT Temperate	1576	106	4.8	5.7	1.80	3.24	0.26
NET Boreal	1576	106	4.8	5.7	1.80	3.24	0.26
BDT Boreal	1576	106	4.8	5.7	1.80	3.24	0.26
C4	1654	64	2.4	3.7	0.98	2.49	0.20
C3 Non-arctic	1576	106	4.8	5.7	1.80	3.24	0.26
C3 Arctic	1576	106	4.8	5.7	1.80	3.24	0.26
BDS Temperate	1576	106	4.8	5.7	1.80	3.24	0.26
BDS Boreal	1576	106	4.8	5.7	1.80	3.24	0.26

Flaming vs. smoldering

Peat?

Li et al. (2012)

Peat matters!



GFED3 (van Der Werf et al., 2010)

Li et al. (2013):
Peat fire as function of:

Precipitation over last 60 days

Top 17 cm of soil:
Temperature
Moisture

Peatland area

Smoldering combustion…

Fire size

Cheney & Sullivan (2008)

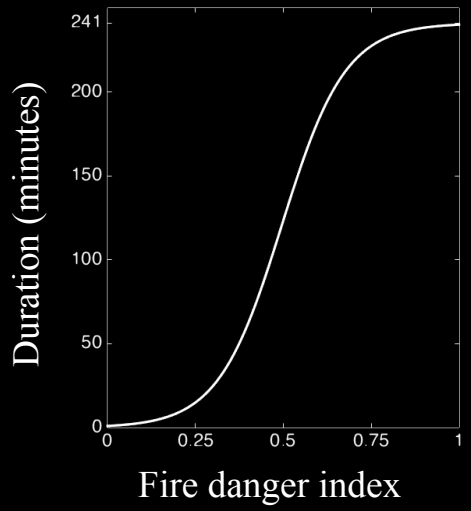
Fire duration

Empirical

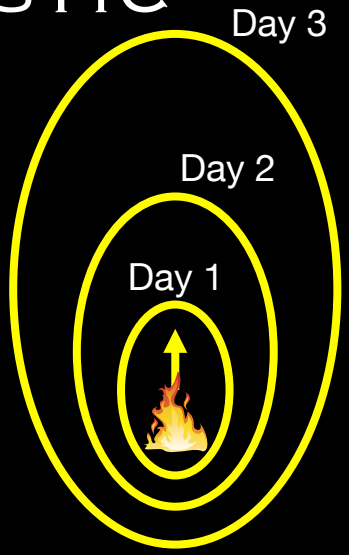
Just assign it!

E.g., Li et al. (2012)

*Quasi–*MECHANISTIC

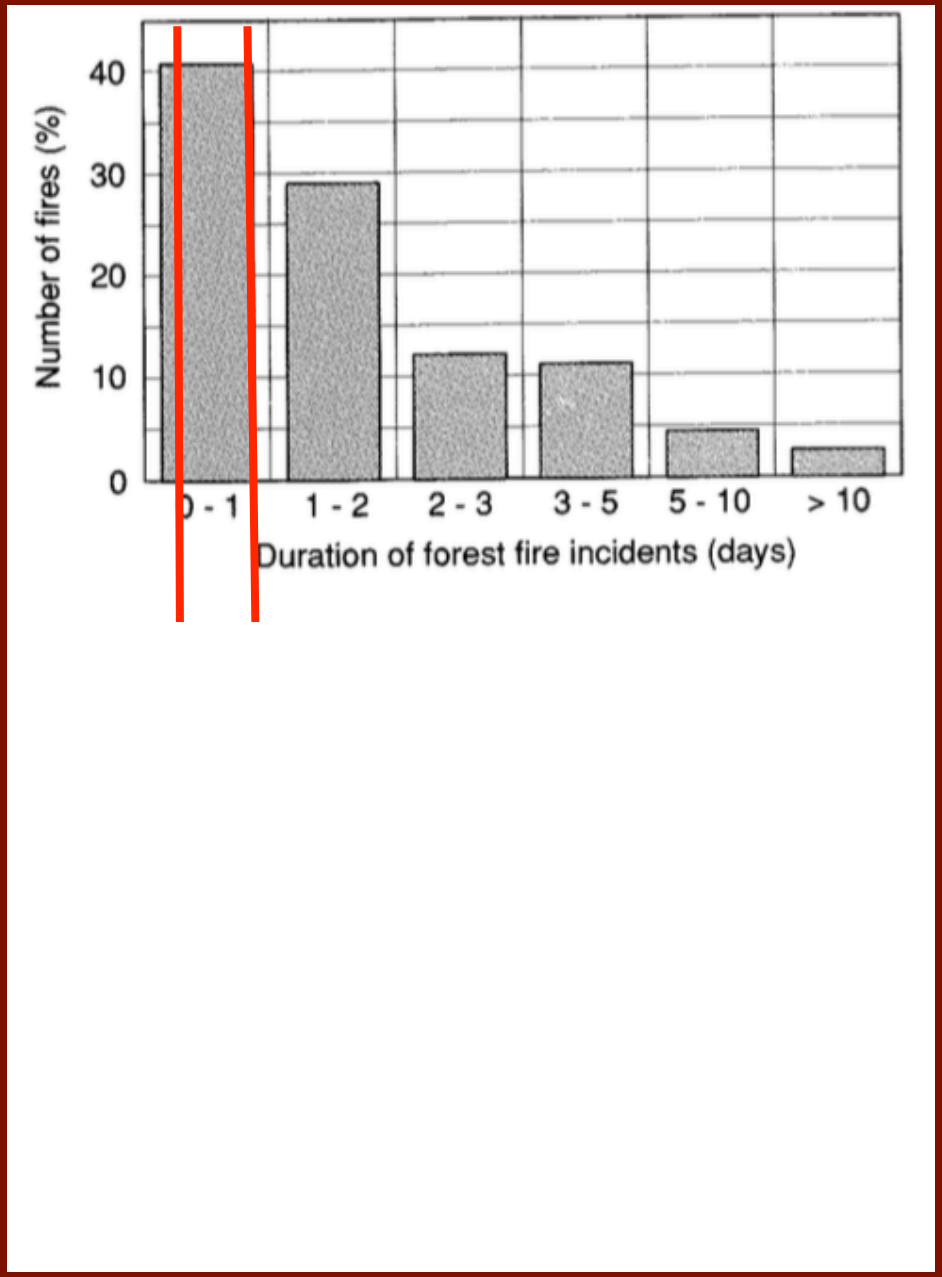


After Thonicke et al. (2010)



Multi-day burning!
(Pfeiffer et al., 2013;
Le Page et al., 2015)

Long-lasting fires can be important



Russia,

~70s to ~90s

(Korovin, 1996)

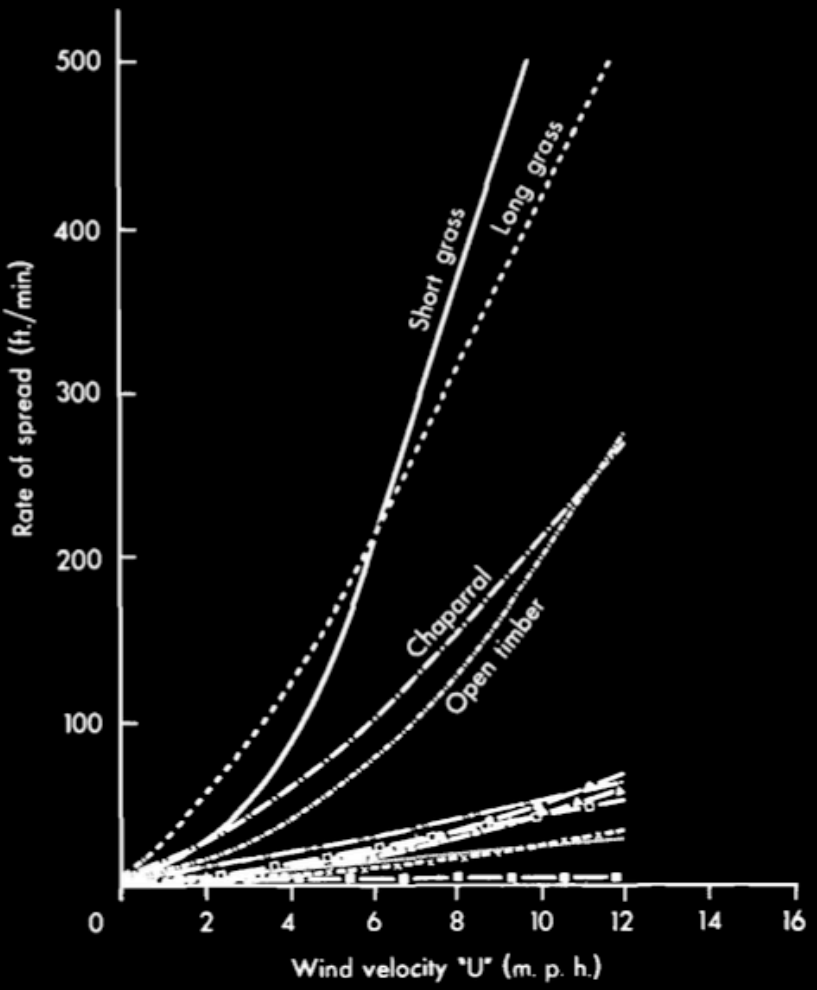
Limits to fire size

Coalescence of multiple fires

"Passive suppression"

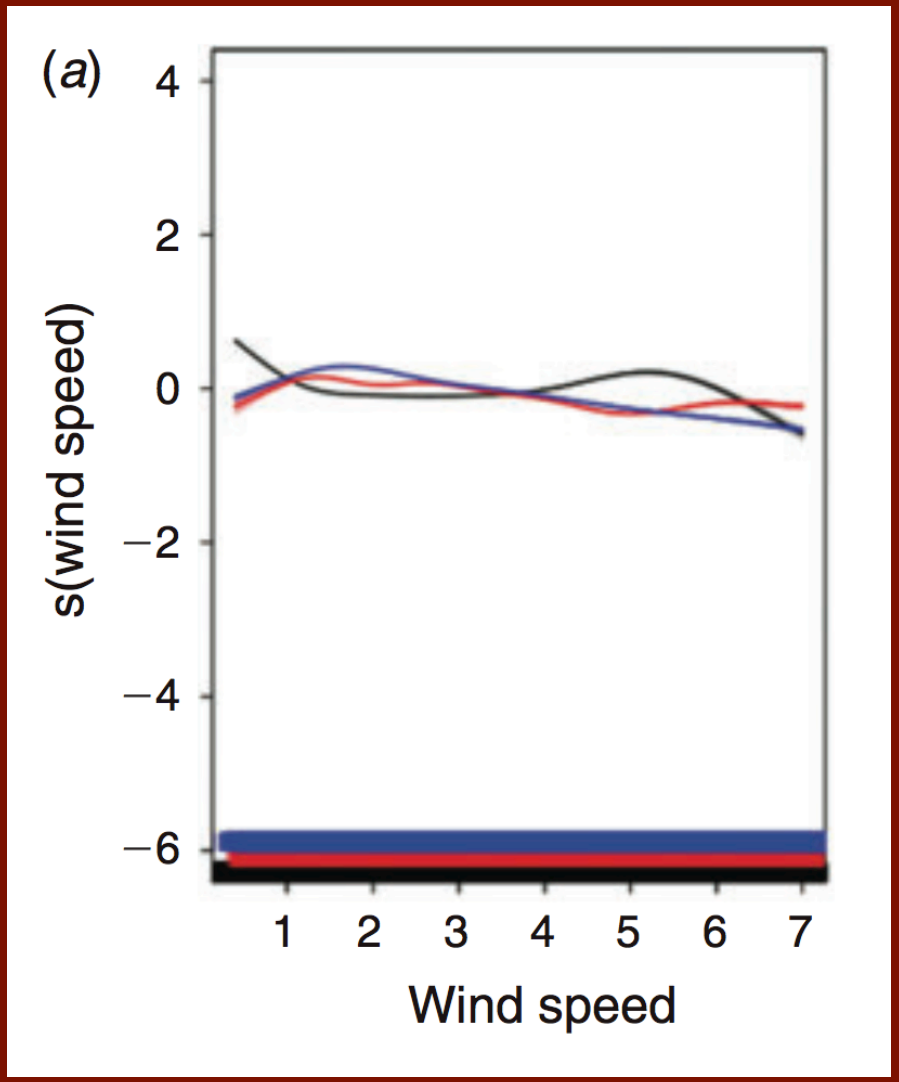
Terrain

Wind speed



Rothermel (1972)

Wind speed … might not be so great



Lasslop et al. (2015)

Thank you!

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Image sources

- Campfire: https://pixabay.com/get/5ae1c74256e5590f9ae4/1442428128/campfire-310430.svg
- Cigarette: https://pixabay.com/static/uploads/photo/2013/07/12/15/36/cigarette-150153_640.png
- Torch: http://icons.iconarchive.com/icons/artua/pirates/256/
- Lightning photo: https://upload.wikimedia.org/wikipedia/commons/0/09/West_Texas_Lightning_Storm.jpg
- "Effects on vegetation" left: https://upload.wikimedia.org/wikipedia/commons/2/2e/Forest_fire_mae_hong_son_province_01.jpg
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