

A Rule of Thumb for Estimating a Wildfire's Forward Spread Rate from Wind Speed Alone

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November 18-21, 2019 – Ottawa, Ontario

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What is a “Rule of Thumb”?

- A principle with broad application that is not intended to be strictly accurate or reliable for every situation.
- It refers to an easily learned and easily applied procedure or standard, based on practical experience rather than theory.





Rules of Thumb in Wildland Fire Management and Science

RULE OF THUMB FOR DETERMINING RATE OF SPREAD

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Lake States Experiment Station

To determine the approximate rate of spread of a fire in terms of perimeter increase, multiply the rate at which the head of the fire is advancing by *three*.

Example: If the head of a fire is advancing at the rate of 5 chains per hour (5.5 feet per min.), the rate of spread is approximately 3 times 5 or 15 chains per hour.

1937. Fire Control Notes 1, 395-396.

General Need

There will be situations where there is little or no time available to undertake a detailed prediction of fire spread.

Yet, fire operations personnel still need to be able to issue warnings to the general public and wildland firefighters based on fire spread potential.

Photo: Alberta Agriculture & Forestry



2011 Slave Lake Fire, AB



2016 Fort McMurray wildfires, AB

Photo: Alberta Agriculture & Forestry

Objective of Present Study

To investigate the existence and validity of a simple and scientifically credible rule of thumb for the effect of the 10-m open wind speed on the spread rate of wildfires in fire-prone forest and shrubland environments.

Based on the premise that under certain conditions wind speed is the dominant factor in determining a wildfire's forward rate of advance.



References for Data Sources

Conifer forests

Alexander ME, Cruz MG (2006) Evaluating a model for predicting active crown fire rate of spread using wildfire observations. *Canadian Journal of Forest Research* **36**: 3015-3028.

Dry eucalypt forests

Cheney NP, Gould JS, McCaw WL, Anderson WR (2012) Predicting fire behaviour in dry eucalypt forest in southern Australia. *Forest Ecology and Management* **280**, 120-131.

Temperate shrublands

Anderson WR et al. (2015) A generic, empirical-based model for predicting rate of fire spread in shrublands. *International Journal of Wildland Fire* **24**, 443-460.

Characteristics of Wildfire Datasets

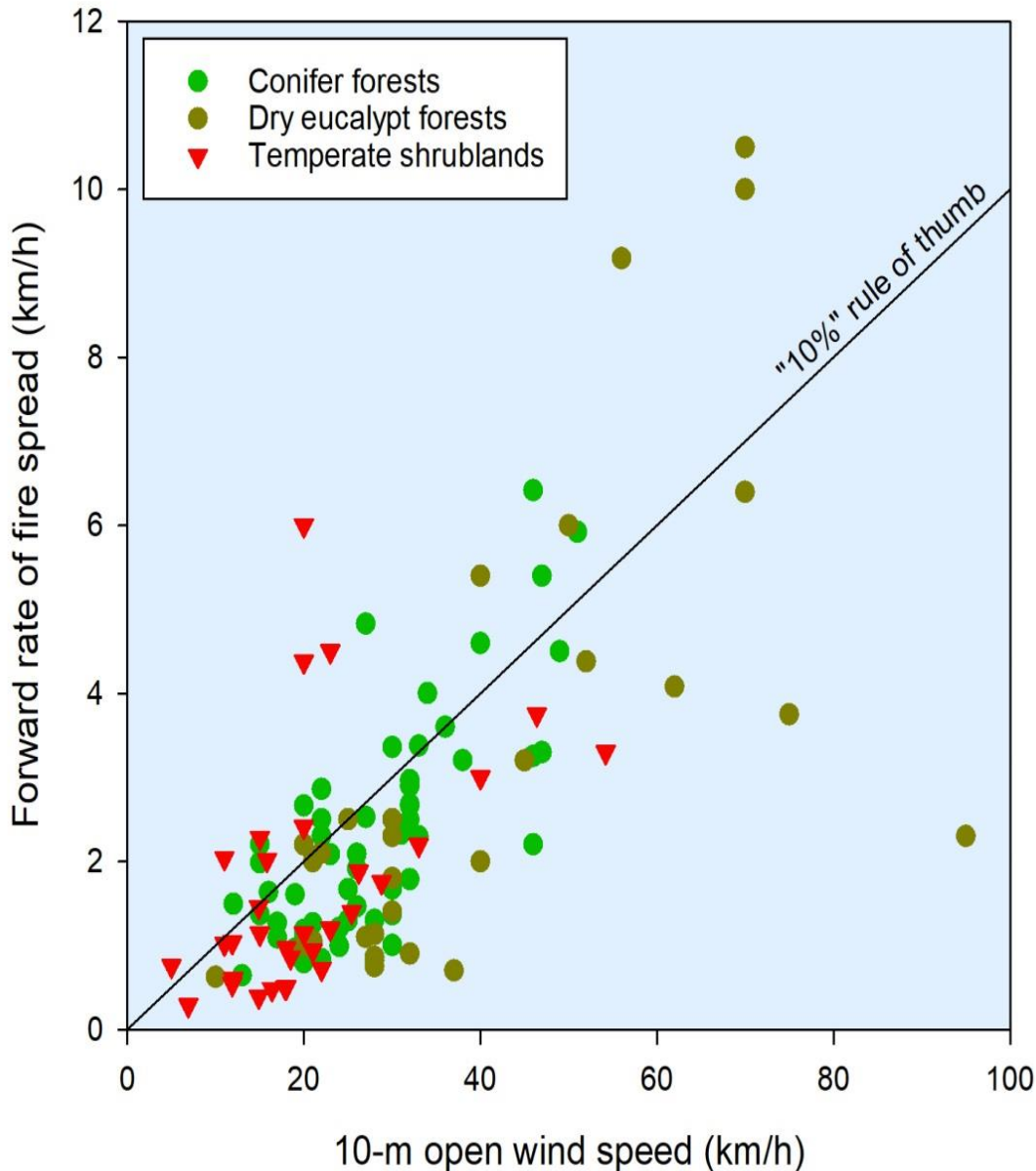
Variable	Conifer forests	Dry eucalypt forests	Temperate shrublands	All fuel types
Number of observations	57	29	32	118
10-m open wind (km/h)	12-51	10-95	5-54	5-95
Fine dead fuel moisture content (%)	5-11	3-10	3-18	3-18
Rate of fire spread(km/h)	0.64-6.4	0.63-10.5	0.29-6.0	0.29-10.5

Duration of fire runs was typically 1 to 3 hours



Includes some of the most notorious wildfires

Data Analysis



The collective dataset represents a large number of observation spanning a wide range of fire and environmental conditions.

Resulting Rule of Thumb

A wildfire's forward rate of spread (R) can be estimated as follows:

$$R = 10\% \text{ of the average 10-m open wind speed}$$

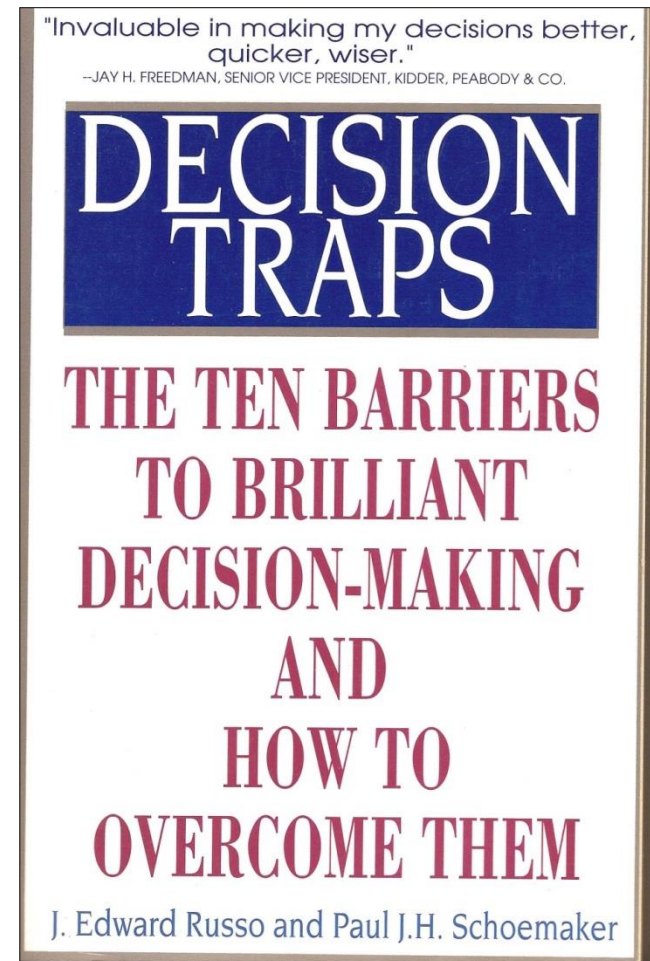
For example, for a 10-m open wind speed of 30 km/h, $R = 3$ km/h.

Note: The rule of thumb is independent of the unit system used.

Remembering Decision Trap 5: Shortsighted Shortcuts

Too often people trust rules of thumb as if they were certainties and fail to recognize when they should make an independent analytical decision.

One should know enough about why a rule of thumb works to be able to know when it will fail.



Principal Assumptions Limitations

- Applicable to large, multi-hour wildfire runs
- Wildfire is spreading on level to undulating terrain in either conifer forest, dry eucalypt forest and/or shrubland fuel types; not applicable to grasslands but shown to work in MPB forests.
- Effect of spotting in determining the overall fire spread rate is implicitly accounted for.
- There are no appreciable barriers to fire growth; existent ones are easily overcome by spotting.

... continued

- Wind speed is either measured or forecasted for a standard open height or represents an estimate based on using the Beaufort Wind Scale.
- It works best when fine dead fuel moisture content is low (less than 7.5% or FFMC greater than ~93.5); its use under moister conditions will result in an over-prediction bias.
- Expect the rate of spread prediction to have an error interval of up to $\pm 50\%$ of the observed rate of spread at best.

When Time is of the Essence

Forecasts of wildfire spread into wildland-urban interface areas are of critical importance in alerting members of the public of the potential threat.

Could a simple rule of thumb like the one described have provided a better appreciation of the fire propagation potential and averted the magnitude of the tragedies that ensued in terms of the loss of life?



Tubbs Fire, Northern California

Initial Run of October 8-9, 2017

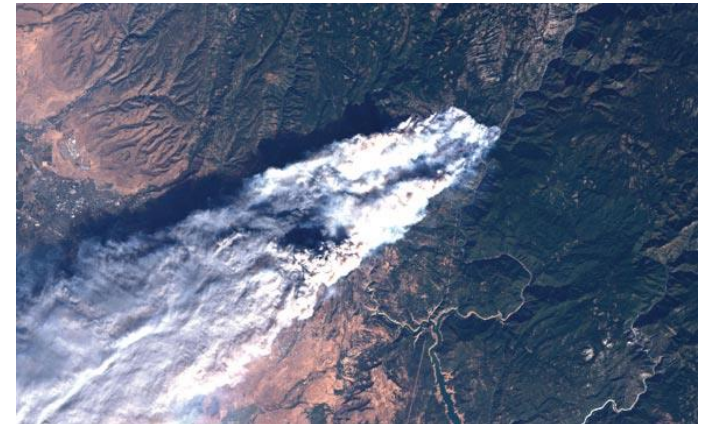
- 22 persons killed in Santa Rosa; 5643 structures destroyed
- ROS: 6.3 km/h (fire spread ~19 km in first 3 hours or so after ignition at 9:43 pm)
- Winds 73 km/h
- Rule of Thumb estimate: 7.3 km/h
- Evacuation order for Santa Rosa not issued until 11:58 pm



Camp Fire, Northern California

Initial Run of November 8, 2018

- 85 persons killed in Paradise; 18,084 structures destroyed
- ROS: 3.1 km/h
- Winds: 28 km/h
- Rule of Thumb estimate: 2.8 km/h
- Fire detected at 6:33 am; first enters Paradise at 8 am




Details of study published in the June 2019 issue of *Annals of Forest Science*

Annals of Forest Science (2019) 76: 44

<https://doi.org/10.1007/s13595-019-0829-8>

RESEARCH PAPER

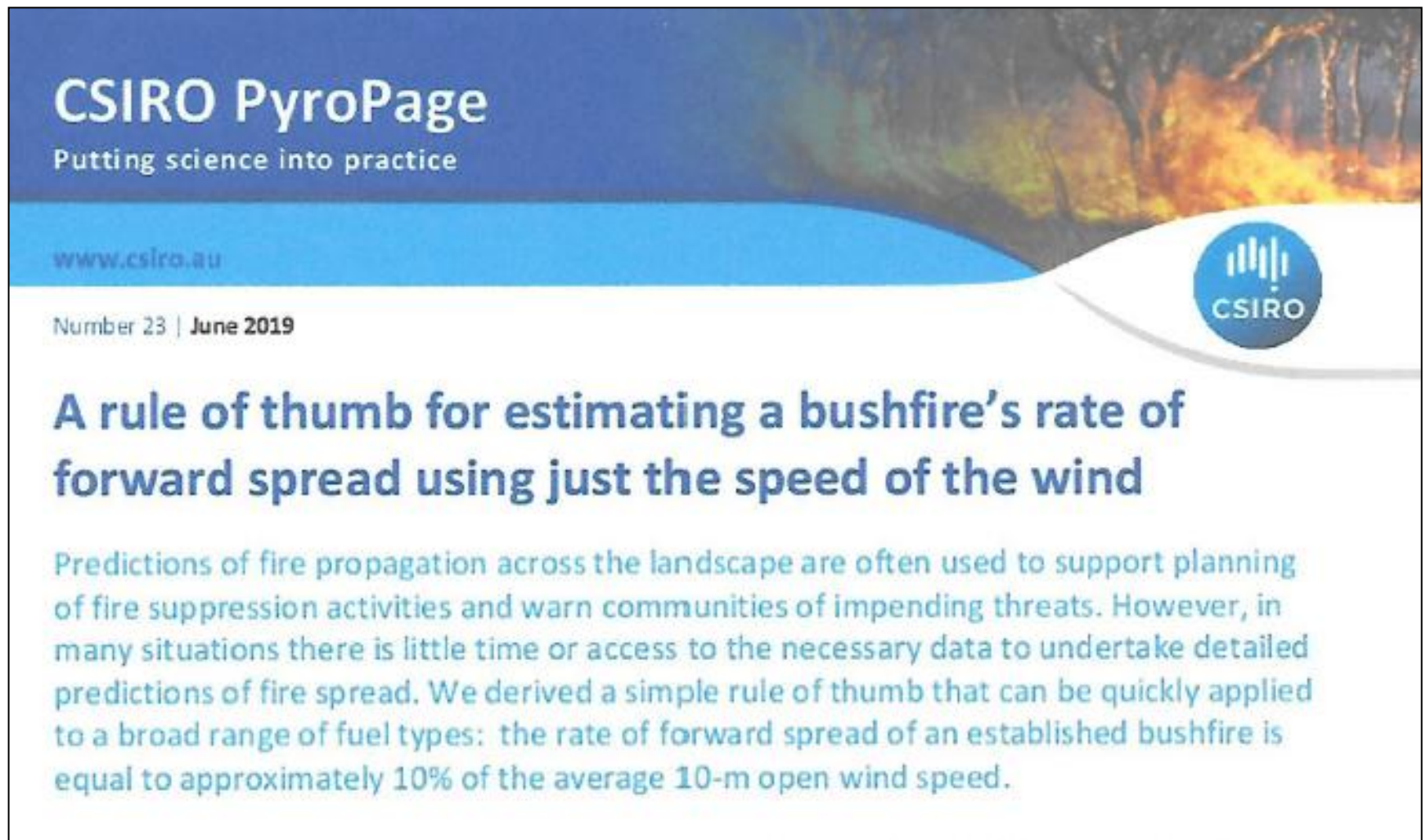
The 10% wind speed rule of thumb for estimating a wildfire's forward rate of spread in forests and shrublands

Miguel G. Cruz¹  • Martin E. Alexander²

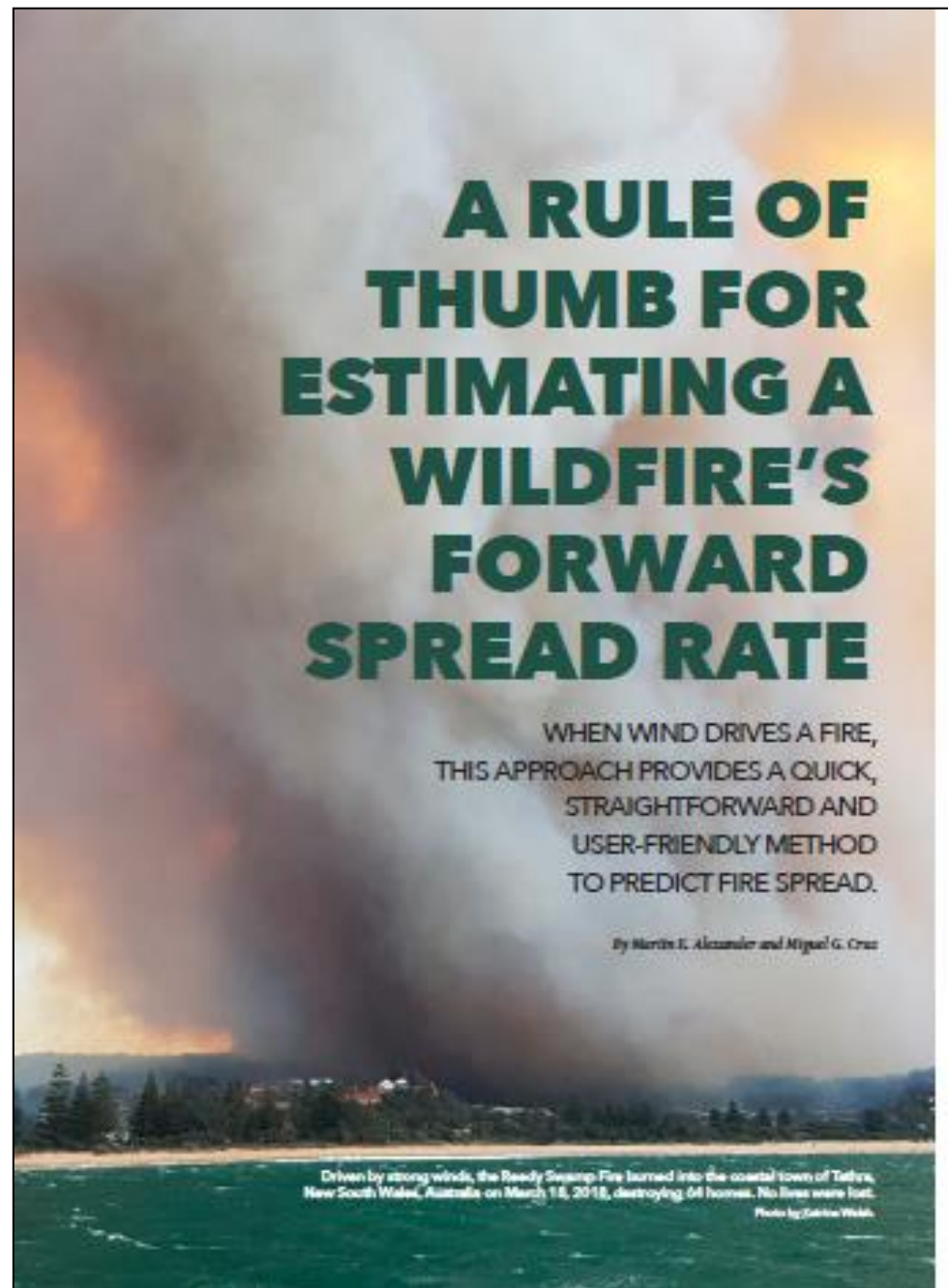
<https://link.springer.com/article/10.1007/s13595-019-0829-8>

Technology & Information Transfer

1) CSIRO PyroPage 23 issued in June 2019




2) Article in the
October 2019
Issue of
Wildfire
magazine



<https://www.iawfonline.org/wildfire-magazine/>

3) Sticker coming out shortly

Kelsy Gibos (Alberta Agriculture & Forestry) has collaborated with the authors in developing a sticker to facilitate application of the rule of thumb by end-users.



Operational Fire Behaviour Rule of Thumb

A wildfire's forward rate of spread (R) can be estimated as:

$R = 10\%$ of the **AVERAGE 10-m OPEN WIND SPEED***

For example: 30 km/h wind = 3 km/h rate of fire spread

* Apply when you need a quick approximation and time does not permit a detailed prediction of fire spread. The main assumptions and limitations are: (1) the wildfire is spreading on level to undulating terrain in either conifer forest, dry eucalypt forest or shrubland (not applicable to grasslands); (2) there are no appreciable barriers to fire growth; (3) the wind speed is either measured at a 10-m height in the open or is a representative forecasted value; and (4) the rule of thumb works best when fine dead fuel moisture content is low.

Source: MG Cruz & ME Alexander (2019) The 10% wind speed rule of thumb for estimating a wildfire's forward rate of spread in forests and shrublands. *Annals of Forest Science* 76(2), 44, 11 p.

KE Gibos, MG Cruz & ME Alexander 2019

Actual dimensions: 5.3 by 12.7 cm (2.1 by 5 in.)

Feedback to date



FBAN using 10% Rule of Thumb on recent NSW bushfires in Australia

On Model Validation or Evaluation

“... no model can be validated in an absolute sense; i.e., a model can never be proved correct, it can only be proved wrong. ... in practice, validating a fire model is really a problem of invalidation. The more difficult it is to invalidate the model, the more confidence we have in it.”

-- John M. Watts, Jr. (1987) Validating fire models.
Fire Technology **23**: 93-94.

Ongoing Research

Evaluation of the rule of thumb against independent wildfire observations compiled as part of the **gloBal-scale analysis and mOdelliNg of FIRE behaviour potential project**



Project coordinated by Dr. Paulo Fernandes
(UTAD, Vila Real, Portugal)

<https://www.researchgate.net/project/BONFIRE-gloBal-scale-analysis-and-mOdelliNg-of-FIRE-behaviour-potential-PTDC-AAG-MAA-2656-2014>

Thank you your attention!
Questions? Comments?

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