A global perspective of sediment flux from a New Mexican Arroyo

Kyle Stark

2021 NMGS Spring Meeting

New Mexico Bureau of Geology and Mineral Resources
New Mexico Tech
Earth Science for the 21st Century

US Army Corps of Engineers®

NMGS

NEW MEXICO TECH
SCIENCE • ENGINEERING • RESEARCH UNIVERSITY

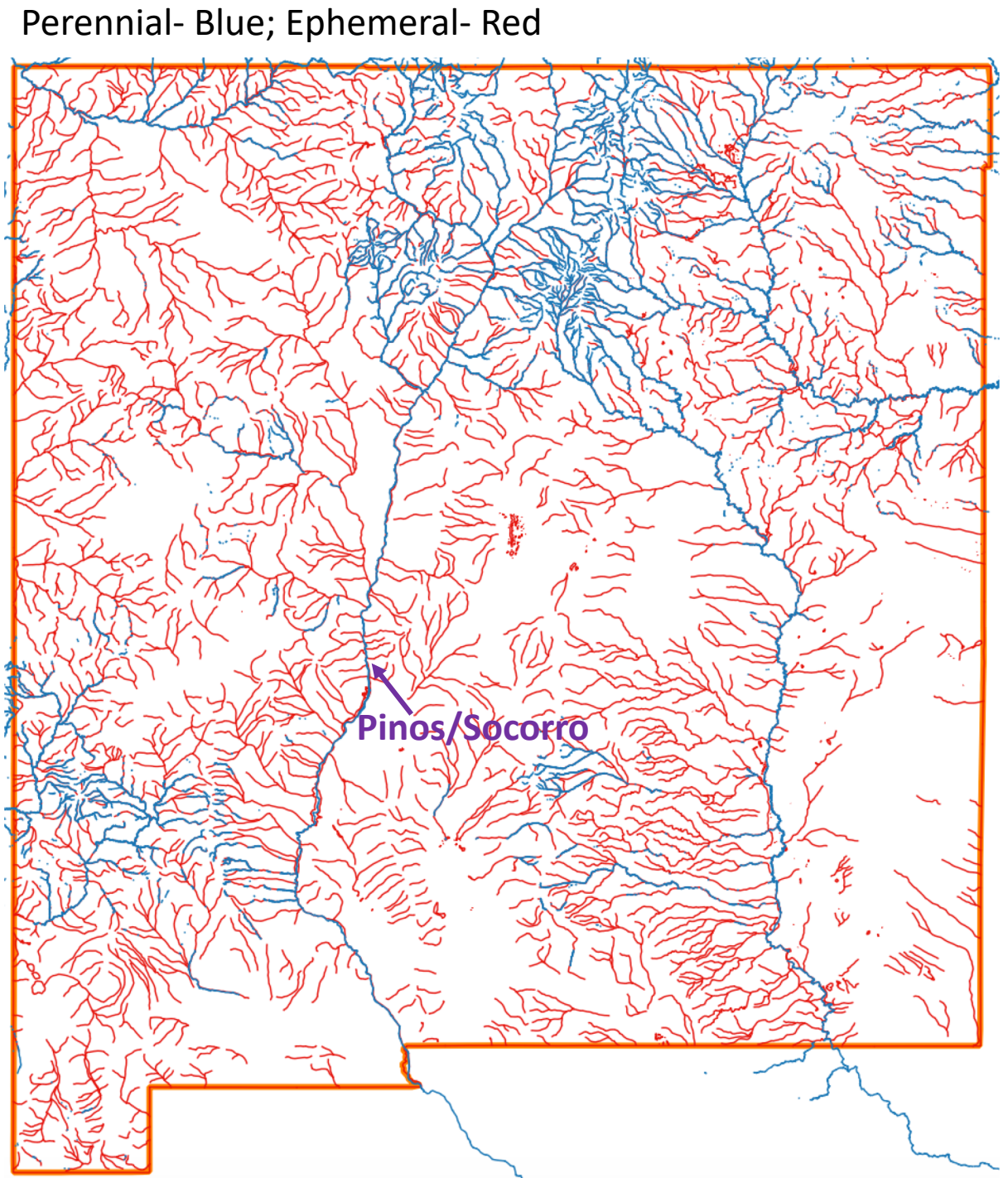
NSF

BUREAU OF RECLAMATION

Ben-Gurion University of the Negev

Ephemeral channels are everywhere in New Mexico

- Ever-present in New Mexico and worldwide.
- Understudied when compared to perennial streams.
- Primary connection between hillslopes and trunk rivers.



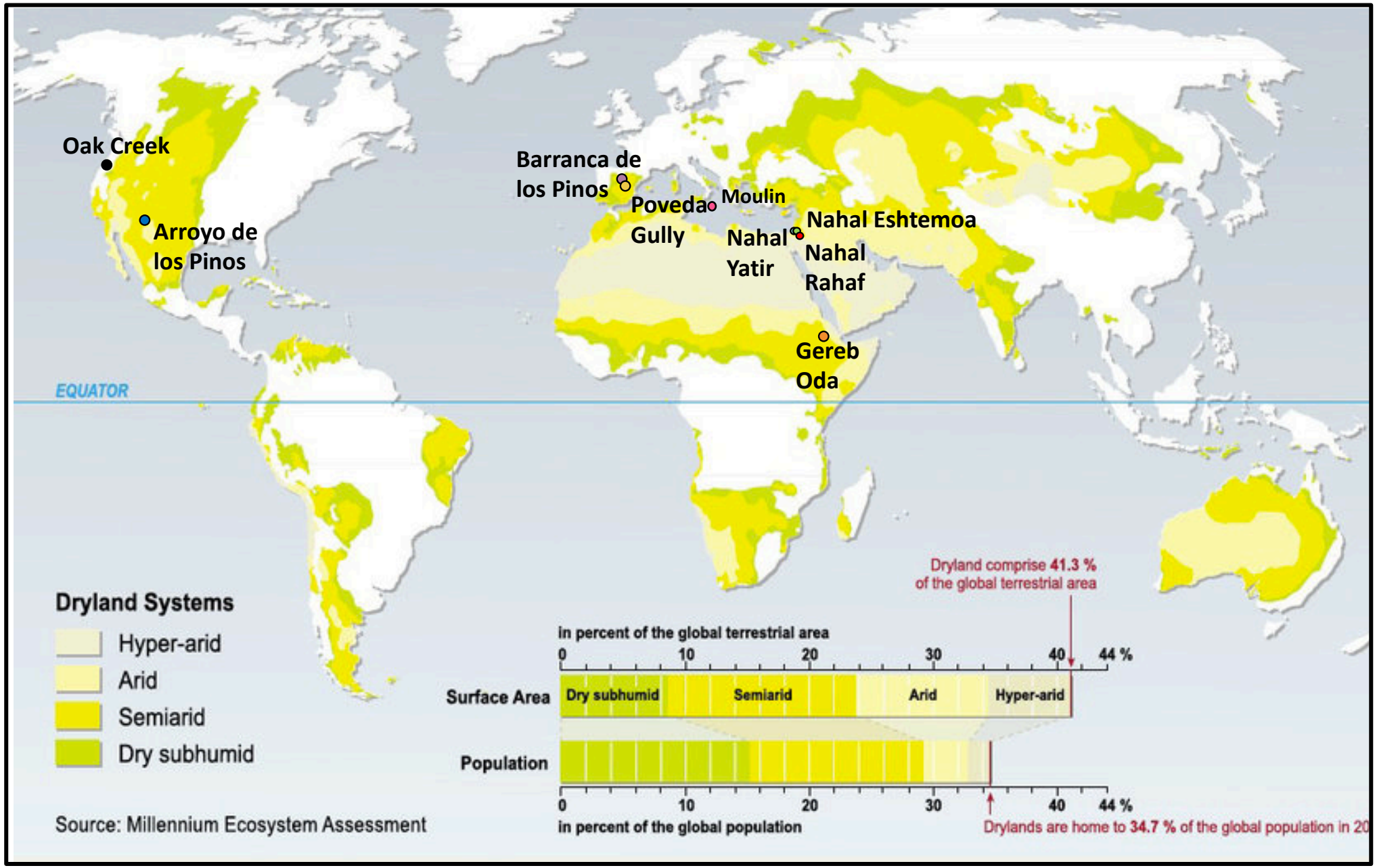
Modern, high quality sediment transport data

- The Arroyo de los Pinos, an ephemeral tributary to the Rio Grande, has been monitored since 2018.

- The data consists of high-quality suspended and bedload transport datasets.

- How do these (NMGS supported!) data compare to those collected from a range of studies across arid regions?

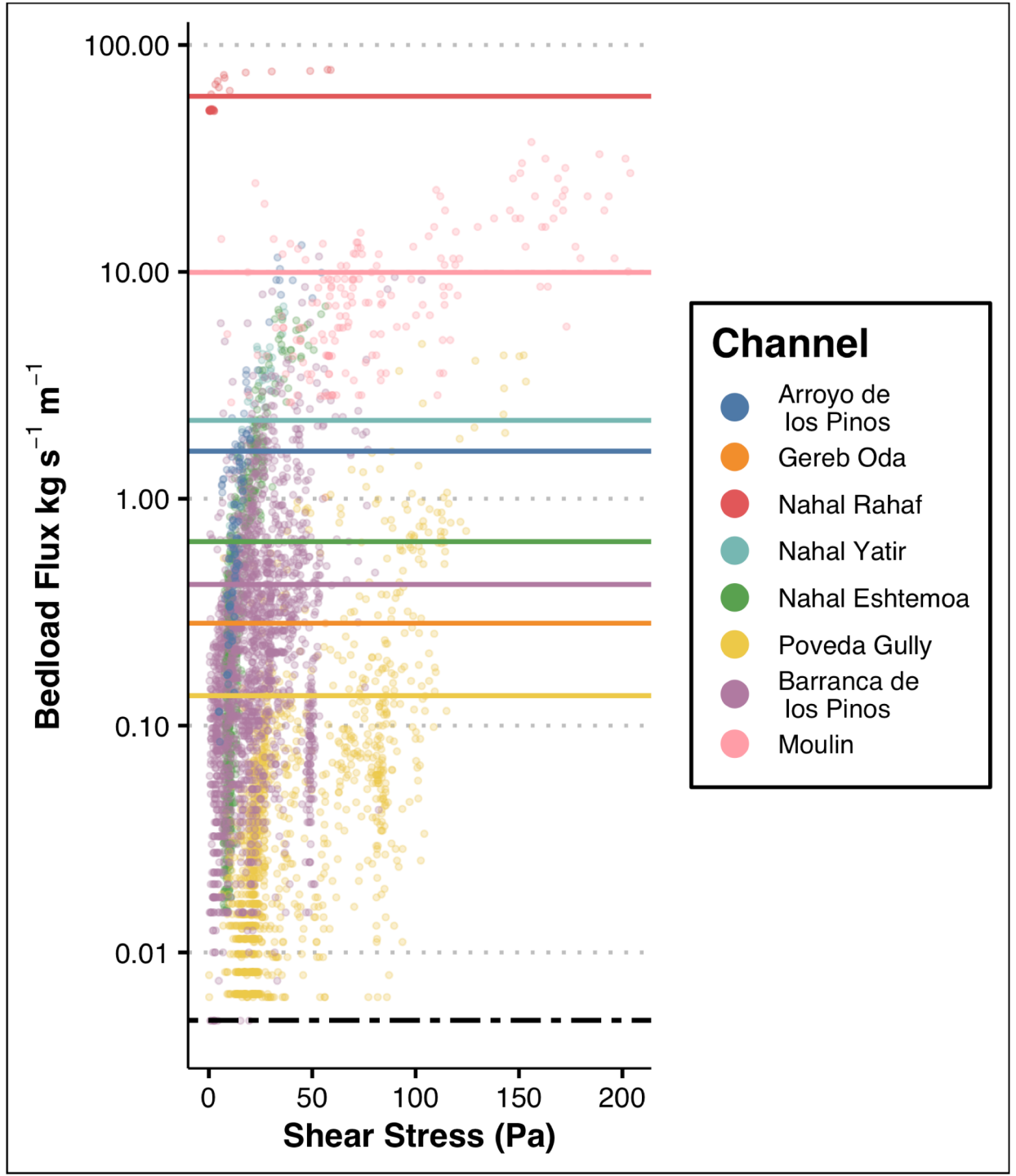
A worldwide dataset



- Eight ephemeral channels.
- One benchmark perennial gravel bed channel
- Wide range of aridity

A worldwide dataset

- Bold horizontal line represent a mean measured flux.
- Even in desert channels, sediment flux can span orders of magnitude.
- Dashed line represents Oak Creek – a “typical” perennial channel.
- *But there’s a problem*: these channels are very different. They have vary widely in grain size, aridity, and watershed size. We need to find a way to make them more directly comparable.



Evaluating on a common scale

- To compare data over a wide range of scales in grain size and watershed size, we have attempted to nondimensionalize our dataset.

- This process of nondimensionalization is typical across geomorphology. The variables become unitless and are more directly comparable.

- Shear stress is nondimensionalized using the Shields equation:

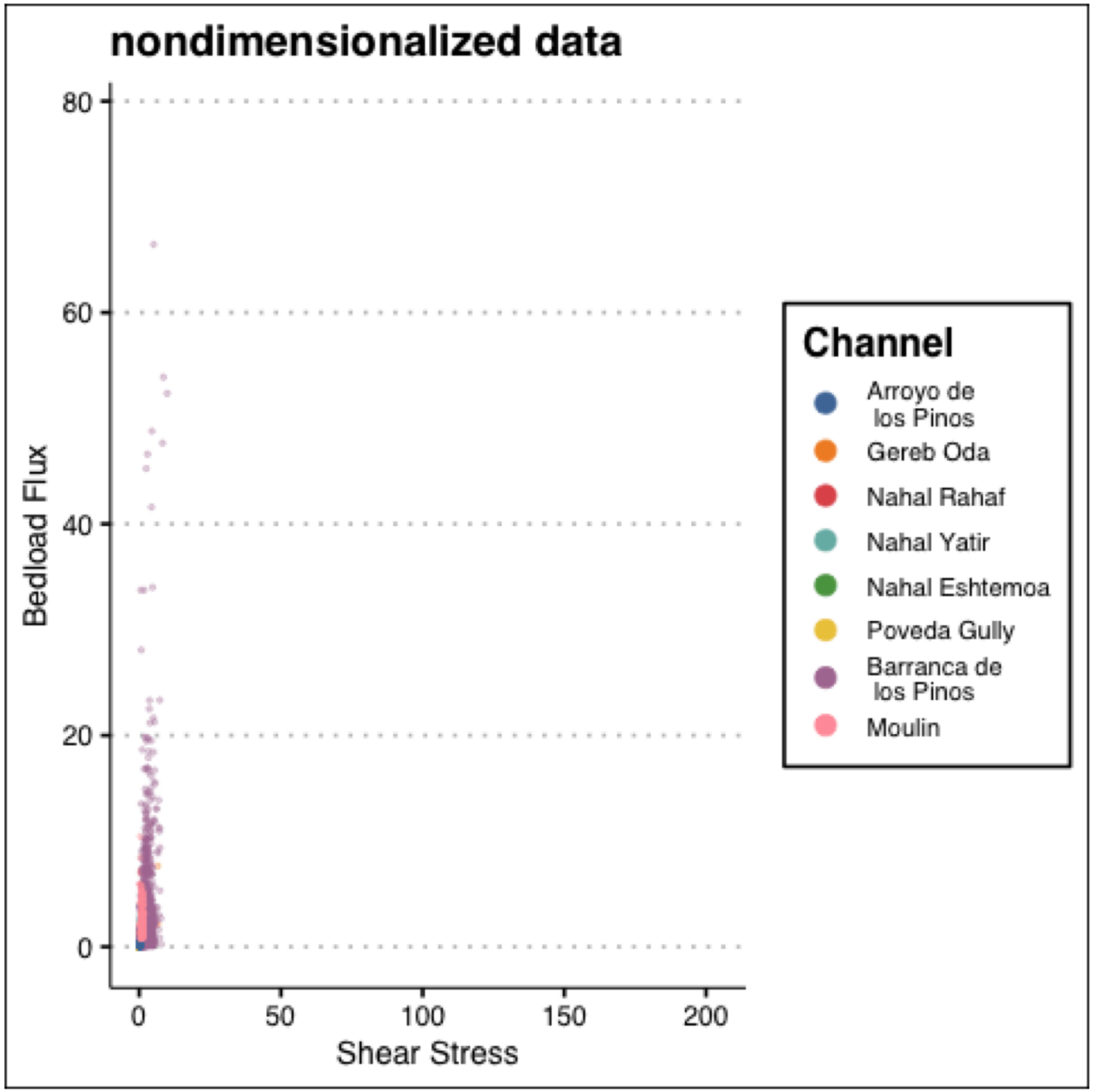
$$\tau^* = \frac{\tau}{g(\rho_{sed} - \rho_w)\,\boldsymbol{D_{50}}}$$

- Bedload flux is nondimensionalized using the Einstein parameter:

$$q_b^* = \frac{q_b}{\rho_{sed}\sqrt{g\boldsymbol{D_{50}^3}\left(\frac{\rho_{sed} - \rho_w}{\rho_w}\right)}}$$

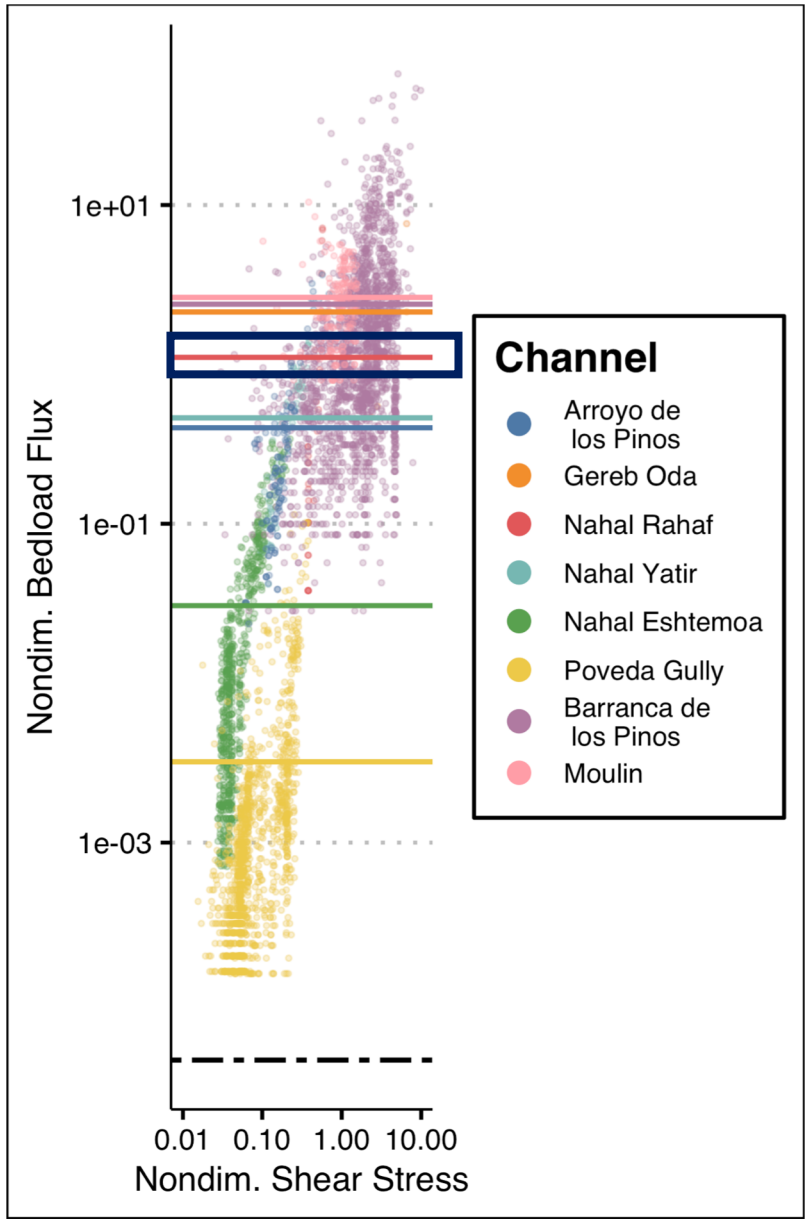
Shields, 1936
Einstein, 1950

Evaluating on a common scale



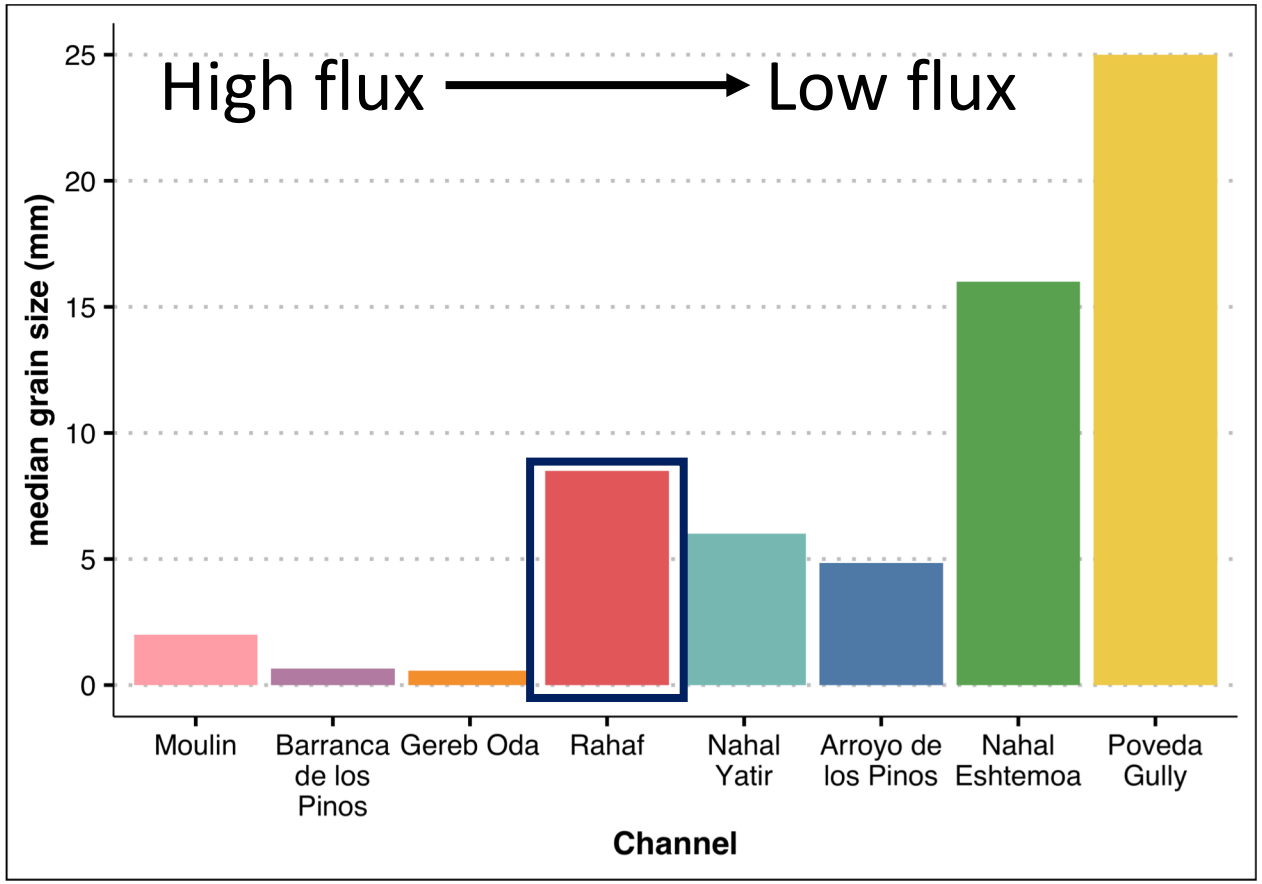
- With nondimensionalization, biases are removed and data are collapsed on to a common scale.
- New patterns emerge.
- Data are all transformed in the same way.

The effects of grain size

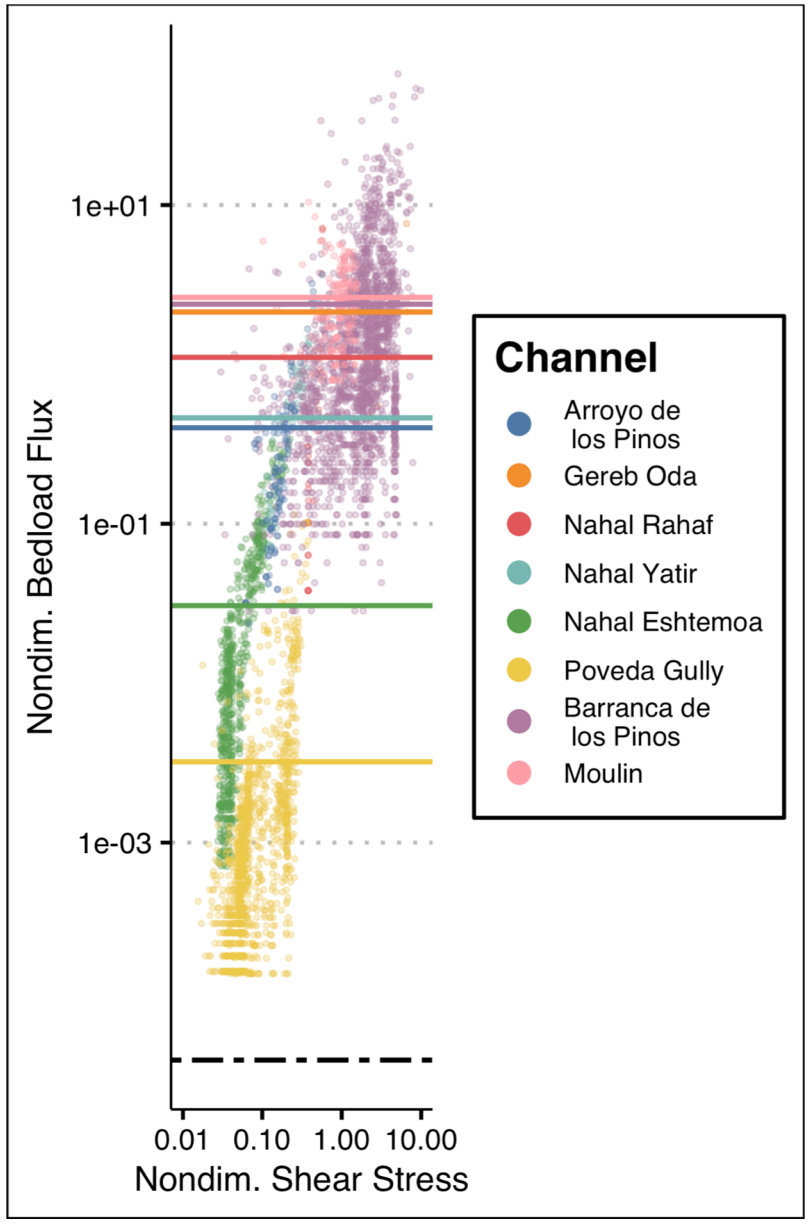


- Sand-bedded channels are the most efficient, with grain size generally increasing.

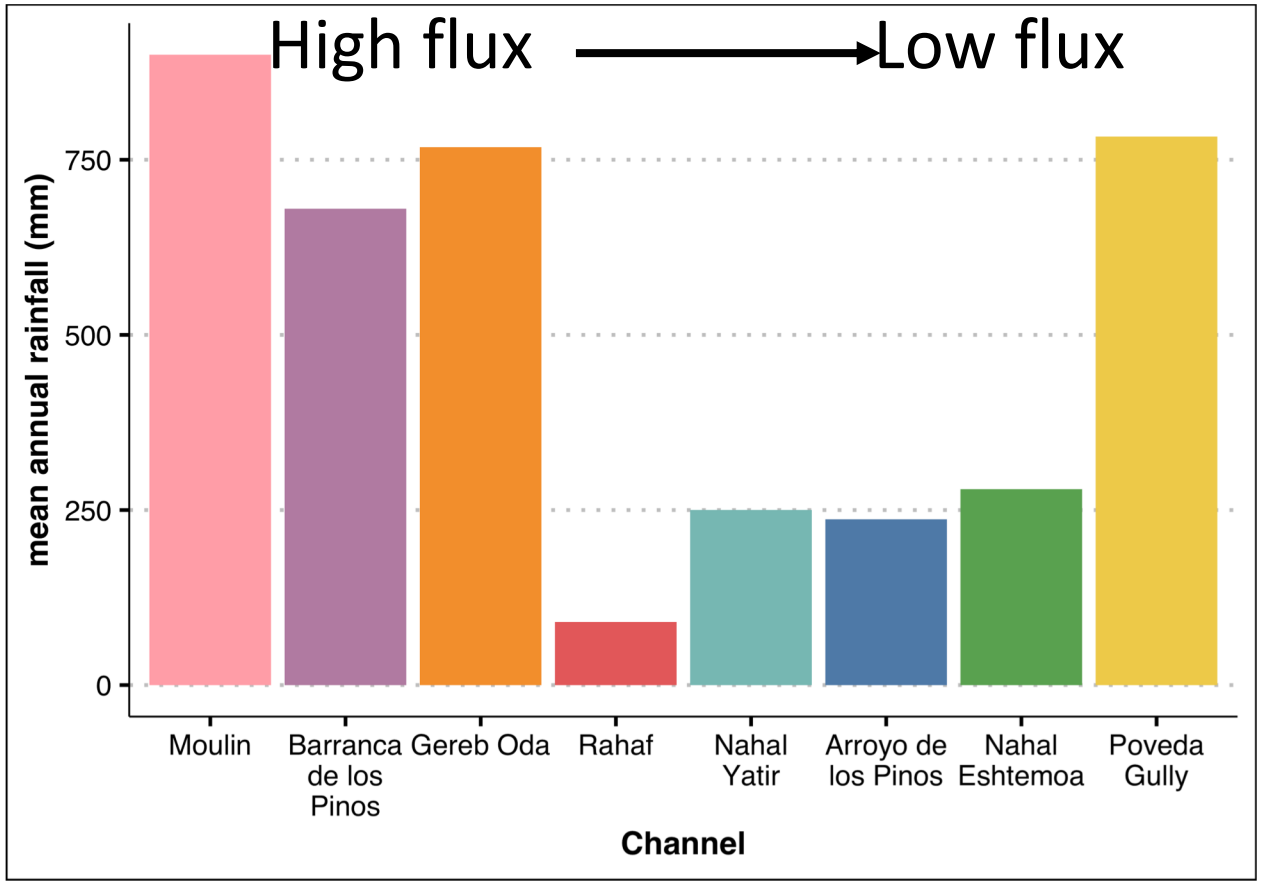
- One exception is the Nahal Rahaf – it suggests that other dynamics contribute to it's high nondimensional bedload flux.



The effects of aridity

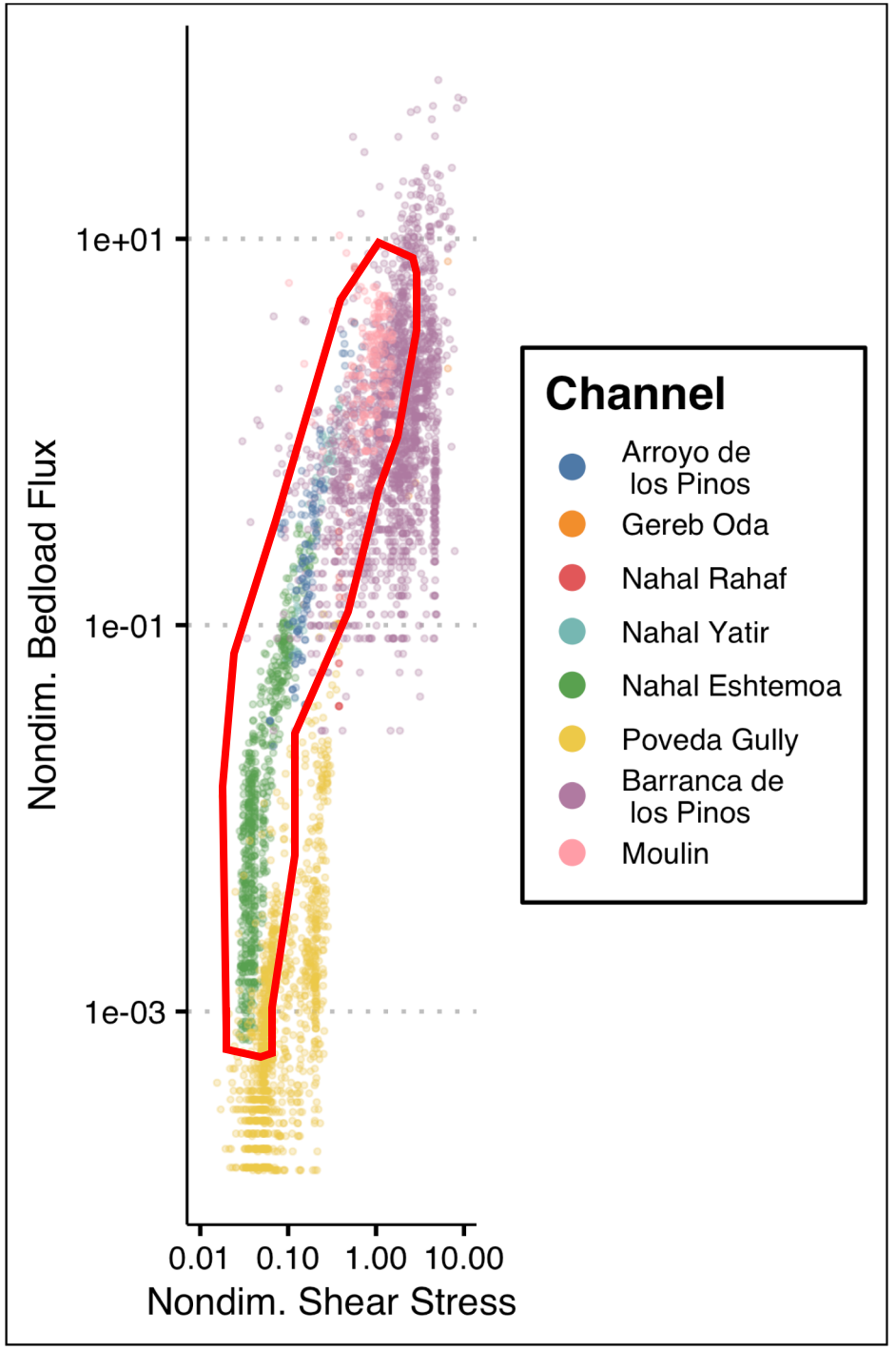


- No clear trends with respect to aridity
- The Nahal Rahaf still an outlier
- Channels in Mediterranean climate are still efficient (with the exception of Poveda Gully)



Ephemeral channels are enormous movers of material

- The Pinos is part of an envelope of data from channels alongside Moulin, Nahal Yatir, and Nahal Eshtemoa.
- These data form a theoretical maximum transport flux for a given shear stress.
- Measurements from perennial channels are orders of magnitude less efficient at transporting sediment, particularly at low shear stresses.



Conclusions

- Sediment is being transported down ephemeral rivers at rates that is orders of magnitude higher than perennial channels.
- Sand-bed channels have higher rates of sediment flux than gravel-bed rivers.
- The Arroyo de los Pinos, a gravel-bed river with a large sand component, forms an upper-bound to the accumulated data. Its characteristics afford efficient transport for its given range of measured shear stresses.
- The ubiquity of these channels in arid regions, combined with this global dataset emphasize their importance in regional river sediment budgets.