RiverCaptureFinder: A New Tool for Identifying and Classifying Drainage Captures in Landscape Evolution Models

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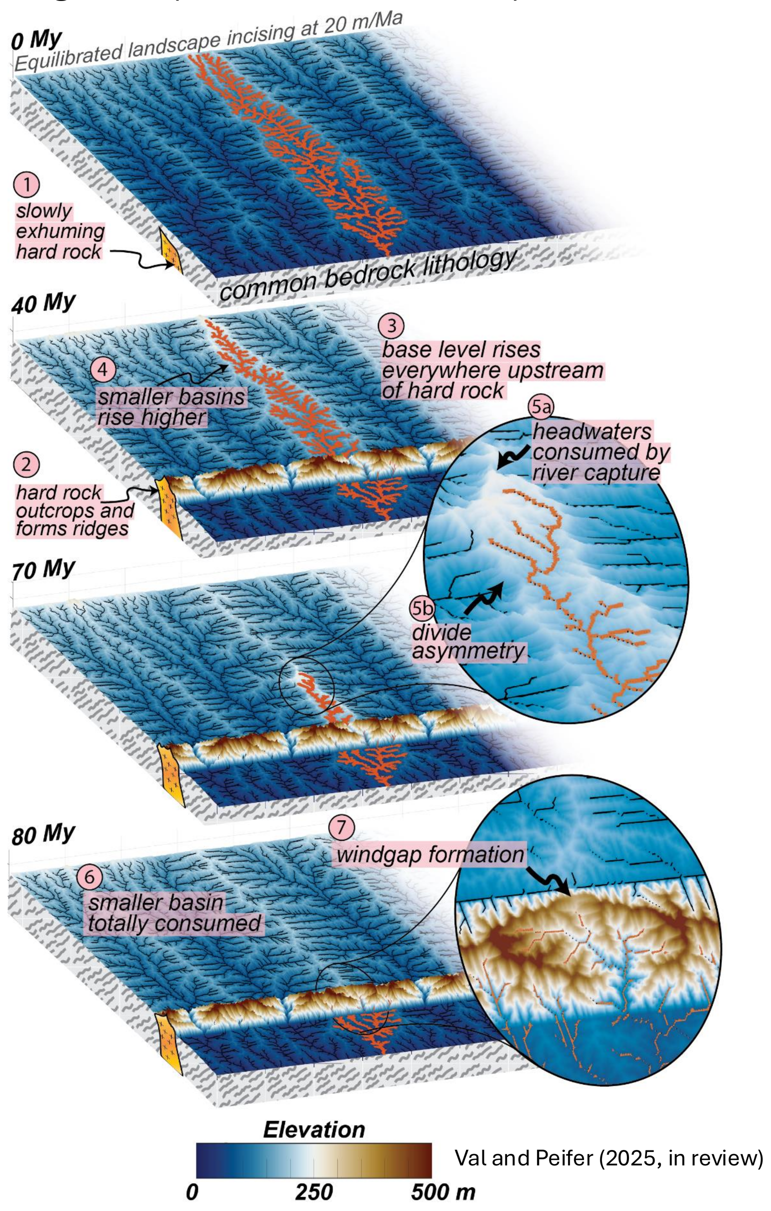
1. Introduction

- Drainage capture and divide migration are fundamental processes shaping landscapes, yet **their frequency and magnitude under different lithologic, tectonic, and climatic conditions remain poorly quantified**.
- We introduce ***RiverCaptureFinder***, a new LandLab function that automatically identifies capture events and computes geomorphic metrics (drainage area, local relief, mean elevation, slope, χ, ksn) in numerical landscape evolution models.
- To show its functionality, we simulated transient landscapes under three scenarios by varying:
  - **Scenario 1:** Resistant rock layer width (map-view thickness), fixed erodibility and uplift
  - **Scenario 2:** Erodibility of the resistant layer, fixed width and uplift
  - **Scenario 3:** Background uplift rate, fixed width and erodibility
- Objectives:
  - Determine how lithology and uplift rate influences the frequency-magnitude of drainage captures
  - Constrain the post-capture geomorphic signatures (local relief, slope, χ, ksn) of the captured areas

2. Motivation

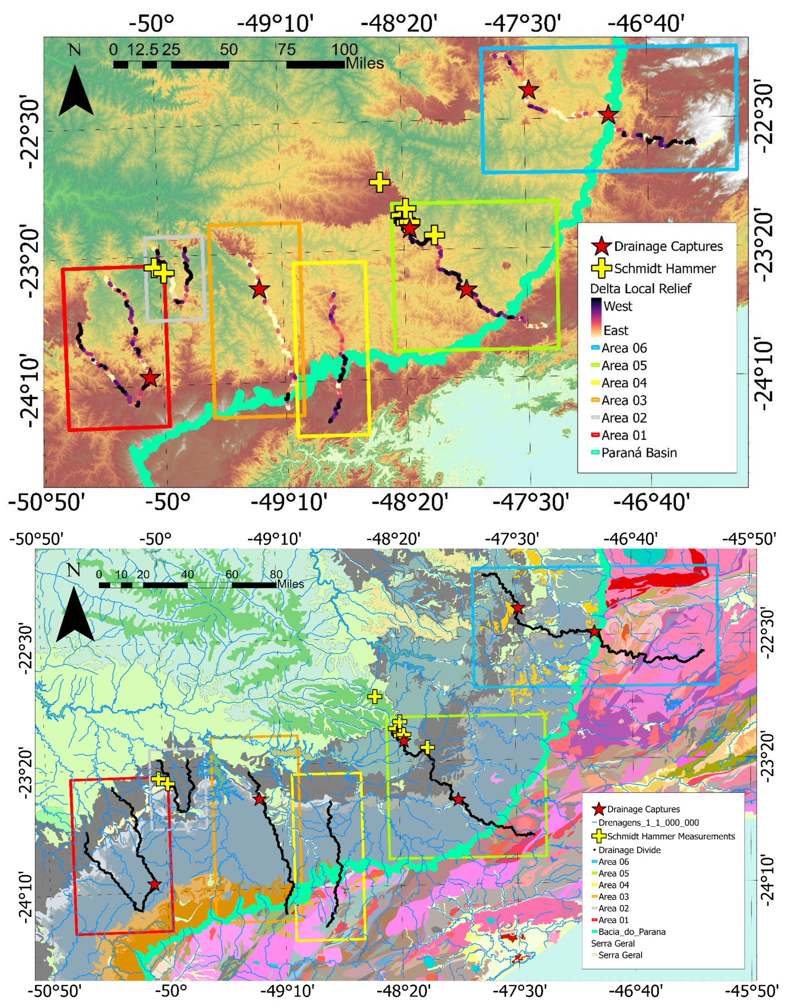
- The exhumation of resistant rock layers can lead to processes of systematic expansion and shrinking through drainage capture and divide migration (Da Silva et al., 2024a).

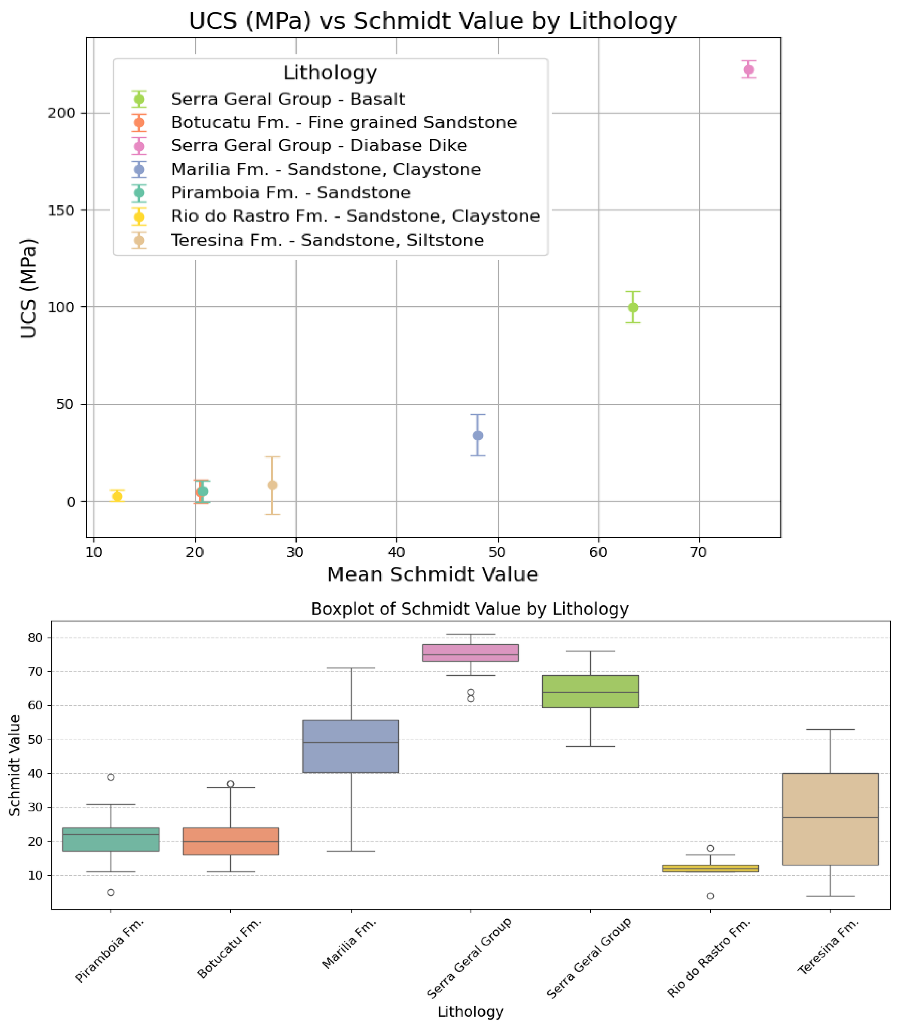


Val and Peifer (2025, in review)

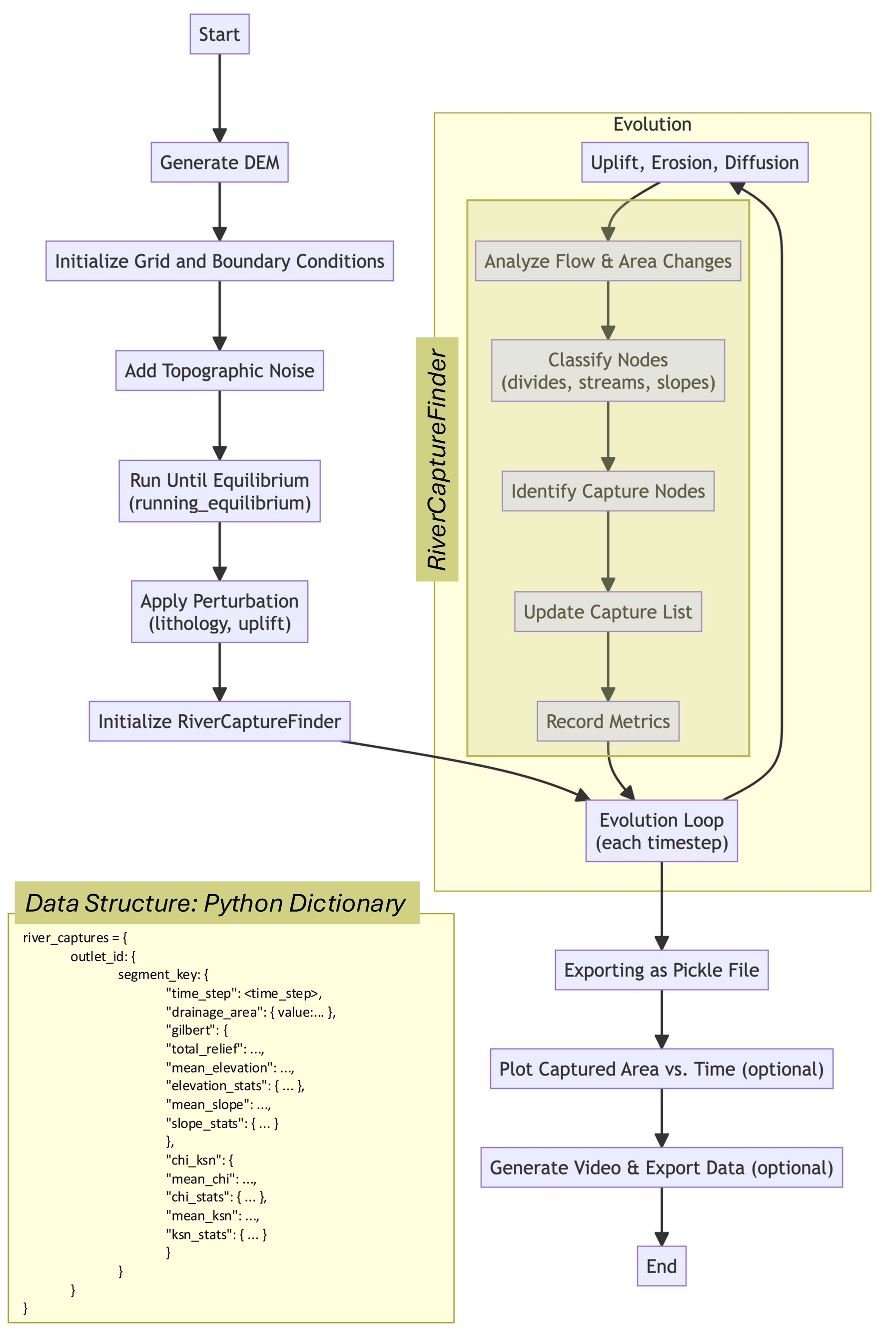
3. Natural Laboratory

- Landscape evolution in tectonically quiescent regions is highly sensitive to rock erodibility contrasts.
- Da Silva and Val (2024b) examined how different rock erodibilities influence divide asymmetry, river capture, relief, and river steepness in the Eastern Paraná Basin in Brazil. This region features semi-parallel basins that cut through rocks of differing resistance, leading to lithologic influences on local base levels and differential erosion.



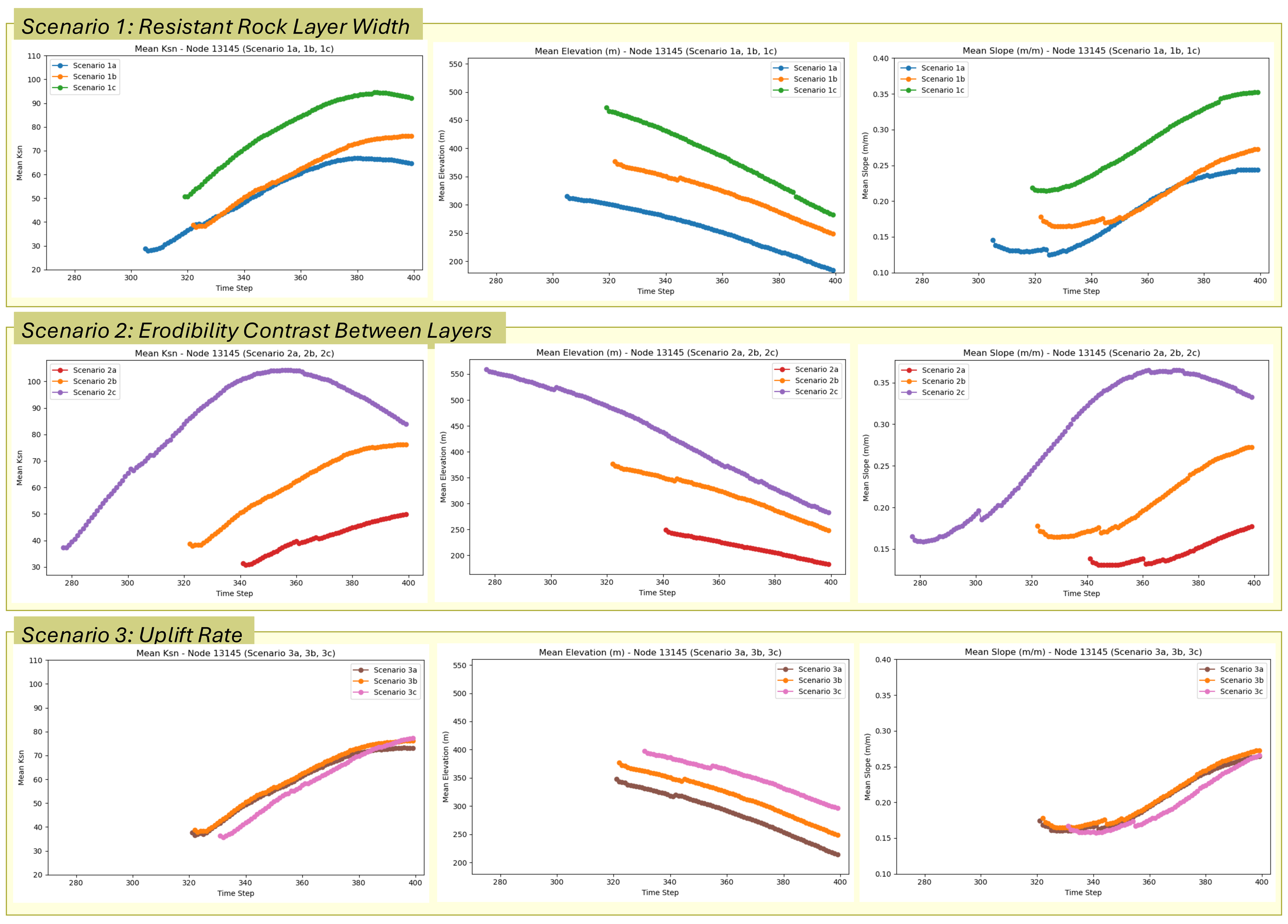


4. Study Design

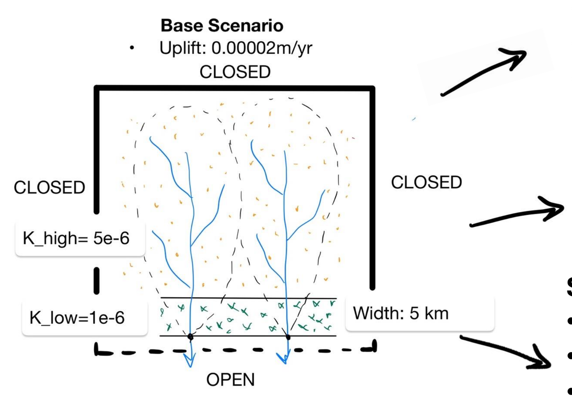


5. Results

5.1. Dashboard (Ksn, Elev., Slope)



- We tested three scenarios: **(1)** resistant-layer thickness (Scenarios 1a–1c), **(2)** lithologic contrast (Scenarios 2a–2c), and **(3)** uplift rate (Scenarios 3a–3c).



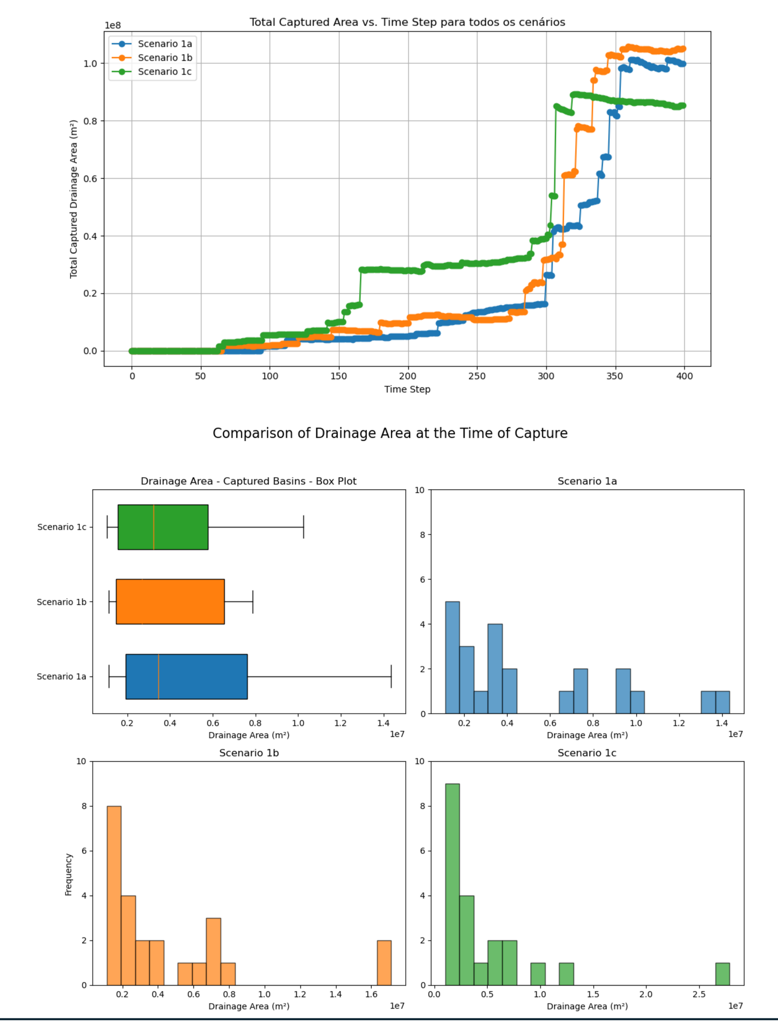
Scenario (1)
- 3 km (15 rows)
- 5 km (25 rows) (Base)
- 7 km (35 rows)

Scenario (2) high/low
- 2 (5e-6/2.5e-6)
- 5 (5e-6/1e-6) (Base)
- 10 (5e-6/0.5e-6)

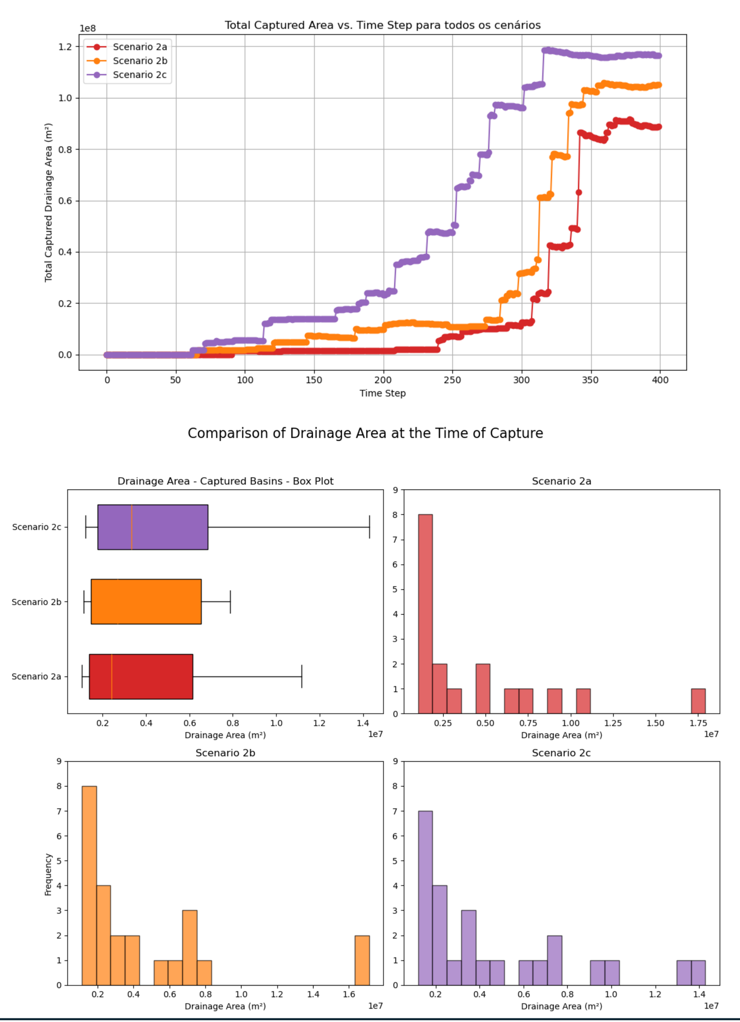
Scenario (3)
- 0.00001 m/yr
- 0.00002 m/yr (Base)
- 0.00003 m/yr

- **(1) Resistant-Layer Thickness:** Wider resistant layers (from 1a-1c) **delay the onset of the drainage captures**. Once captures start, they form steeper local channel slopes, ksn peaks, and more abrupt mean elevation decreases.
- **(2) Erodibility Contrast:** Increasing the contrast between soft and hard lithologies (from 2a- 2c) amplifies differential erosion, leading to a faster elevation loss, channel slope steepening, and more rapid ksn increasing after capture.
- **(3) Uplift Rate:** Increasing uplift rates delay first captures and promote slightly faster ksn and slope increasing. The main elevation increases linearly with uplift.

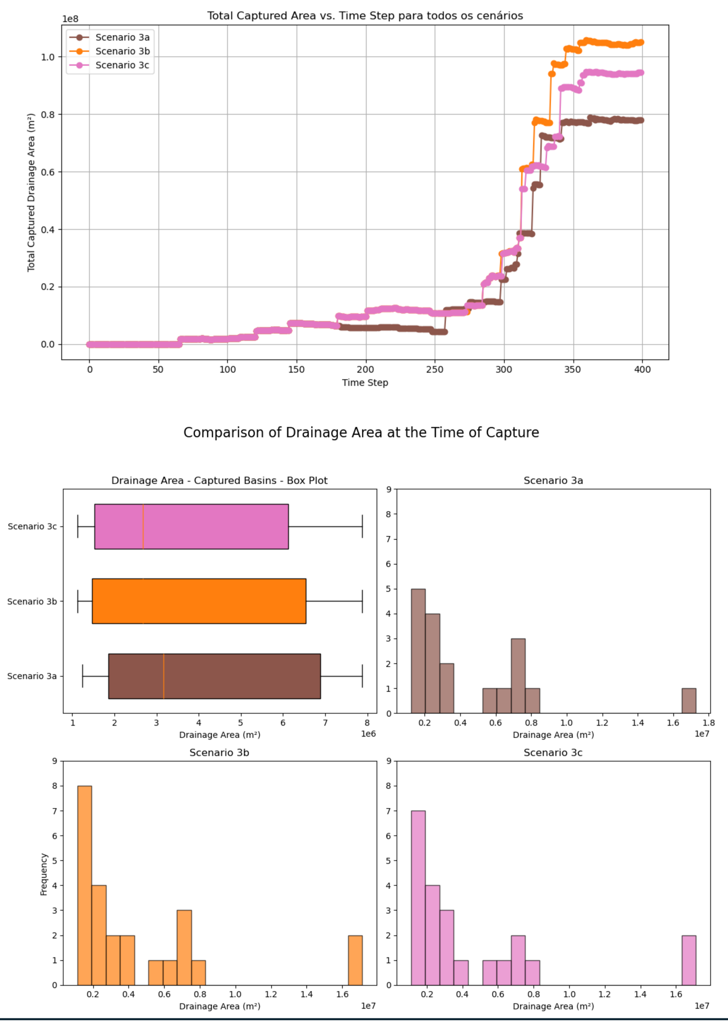
5.2. Resistant Rock Width



5.3. Erodibility Contrast



5.4. Uplift Rate



6. Conclusions

- The ***RiverCaptureFinder*** is under development, yet, functioning effectively on synthetic landscapes created by LandLab.
- It has successfully identified drainage captures simulated over millions of years and stores this information in a data structure that allows for retrieving, post-processing, plotting, and river capture analysis.
- As an initial application, we show that **variations in lithologic thickness and erodibility contrast can increase the number of drainage capture events** and **systematically influence divide migration**.

7. Future Steps

- Identify drainage captures in real landscapes and create a global database of fluvial piracy.
- This global database will be used alongside a synthetic database generated using the ***RiverCaptureFinder*** to improve the performance of a convolutional neural network (CNN) model for identifying drainage captures.
- The combined database will be utilized to predict and infer basins that are likely to be captured or that have been captured in the past, as well as to estimate the timing for both scenarios.

8. References and QR code

- Da Silva, R., Oliveira, P., & Val, P. (2024a). The shrinking and expanding of basins: insights from a Landscape Evolution Model with high lithological contrast (Version 1.0.0). Zenodo. https://doi.org/10.5281/zenodo.12738032
- Da Silva, R., Oliveira, P., & Val, P. (2024b). The shrinking and expanding of basins: Insights from a Landscape Evolution Model with high lithological contrast (Abstract No. 1726540) [Conference abstract]. In the American Geophysical Union 2024 Fall Meeting. Retrieved from https://agu.confex.com/agu/agu24/meetingapp.cgi/Paper/1726540

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