

Prolonged Influence of Urbanization on Landslide Susceptibility

Tyler Rohan

Eitan Shelef

United States Geological
Survey (USGS)

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Research Questions

We evaluated the scientific literature and conducted research into landslide susceptibility to answer the following questions:

- *Does urbanization have a prolonged effect on landslide susceptibility?*
- *Do the factors that influence landslide occurrence differ between urban and non-urban areas?*

Rationale

Landslides pose a threat to life and infrastructure and are influenced by anthropogenic modifications associated with land development. These modifications can affect susceptibility to landslides, and thus quantifying their influence on landslide occurrence can help inform sustainable development efforts. Although landslide susceptibility has been shown to increase following urban expansion, the long-lasting effect of urbanization on landslide susceptibility remains largely unquantified. Hence, susceptibility maps developed based on inventories from non-urbanized areas may incorrectly evaluate the hazard in urbanized areas. To quantify this effect, we analyzed landslide inventories from southwestern Pennsylvania, where a pulse of urbanization, peaking in the late 1950's occurred more than a decade before the landslide inventories were created (1970's).

Approach

This research examines the prolonged influence of urbanization on landslide susceptibility by using pre- and post-urbanization landslide inventories from southwestern Pennsylvania, with road density as a proxy for the spatial pattern of urbanization. The inventory of old, pre-urbanization landslides, is used as a control for potential biases in landslide mapping and analyses because it is not expected to differ between urbanized and non-urbanized areas. The inventory of landslides that occurred post-urbanization is used to quantify the difference in both landslide susceptibility estimates and in landslide-related factors between urbanized and non-urbanized areas.

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Findings

The analysis points at the long-term effects of urbanization on landslide susceptibility in Southwestern PA. This relies on susceptibility estimates based on inventories of active landslides in urbanized and non-urbanized areas, which show differences in ranking of landslide-related factors between these areas (Figure 1). This is corroborated by analysis of old, pre-urbanization landslide inventories, used as a control dataset, which show a general similarity in the ranking of landslide-related factors between urbanized and non-urbanized areas (Figure 1), hence suggesting that the analysis of the active landslide inventories likely captures the influence of urbanization on landslide susceptibility.

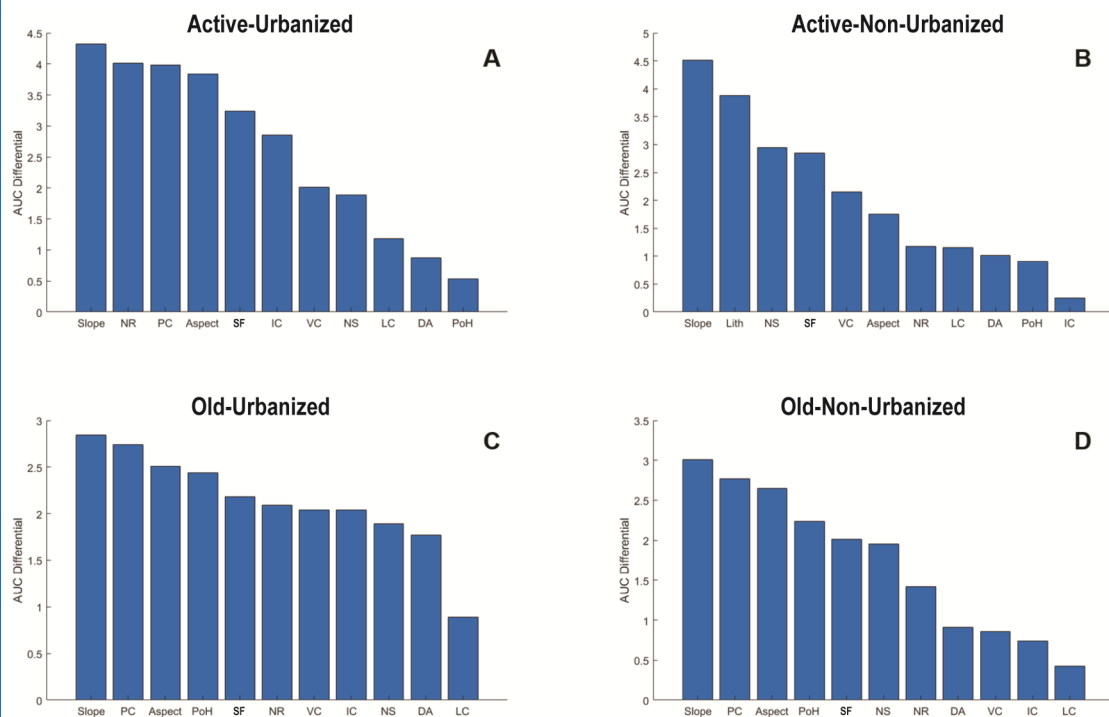


Figure 1: Ranked importance (y-axis) of landslide-related factors (x-axis) by a statistical analysis (random forest) based on different landslide inventories: A) Post urbanization landslides in urban areas, B) Post urbanization landslides in non-urban areas, C) Pre urbanization landslides in urban areas, B) Pre urbanization landslides in non-urban areas. Factors: Slope, Nearest Road (NR), Profile Curvature (PC), Aspect, Stratigraphic Formation (SF), Nearest Stream (NS), Land Cover (LC), Vegetation Cover (VC), Drainage Area (DA), Impervious Cover (IC), and Position on Hillslope (PoH). Note the difference in factor ranking (y axis) between urban and non-urban areas for landslides that occurred post urbanization (A vs B), compared to the general similarity in factor ranking between urban and non-urban areas for landslides that occurred pre urbanization (C vs D).

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Findings Continued

Analysis of inventories of active landslides further shows that compared to non-urbanized areas, urbanized areas are associated with higher susceptibility values, stronger association between landslide occurrence and proximity to roads, and higher likelihood for landslide occurrence over lower topographic slopes. Our analysis of old, pre-urbanization landslides indicates that the mapping of landslides might be generally biased by proximity to roads. Despite this bias, the consistent differences in susceptibility patterns between urbanized and non-urbanized areas suggest that urbanization has a decades-lasting effect on landslide susceptibility and that landslide susceptibility estimates should be made separately for these two different environments.

Implications

- **Understanding urbanization impact:** The results provide insights into how urbanization can affect landslide susceptibility over an extended period. This knowledge can help urban planners and policymakers make more informed decisions about land use, zoning regulations, and infrastructure development.
- **Enhanced risk assessment and mitigation strategies:** By better understanding the prolonged influence of urbanization on landslide susceptibility, experts can assess landslide risk and susceptibility in urban areas more effectively.

***Urbanization has a lasting impact on
landslide susceptibility***



Contact Us:

Email

PittWater@pitt.edu

Website

www.water.pitt.edu