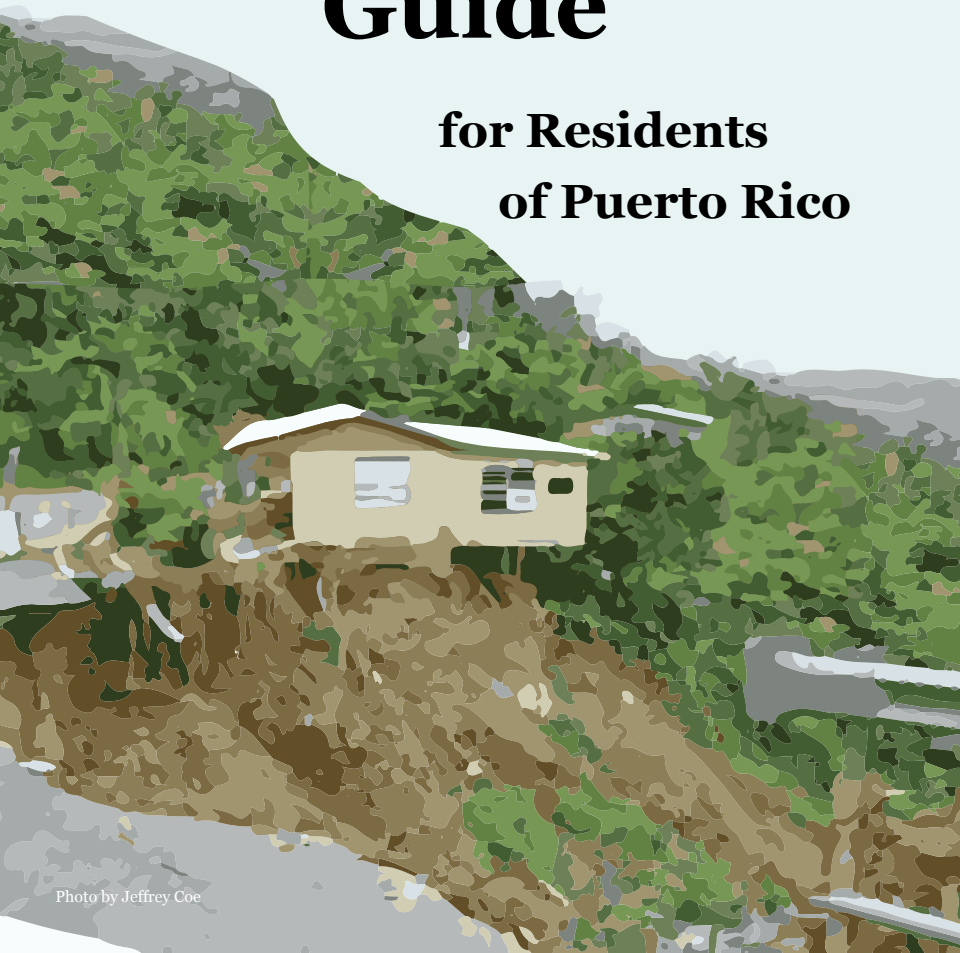


# Landslide Guide

for Residents  
of Puerto Rico



# What is a landslide?

A downward movement of soil, rock, and organic material affected by gravity and influenced by the shape of the terrain.

It is important to take adequate mitigation measures to diminish the risk of losses to property and lives.

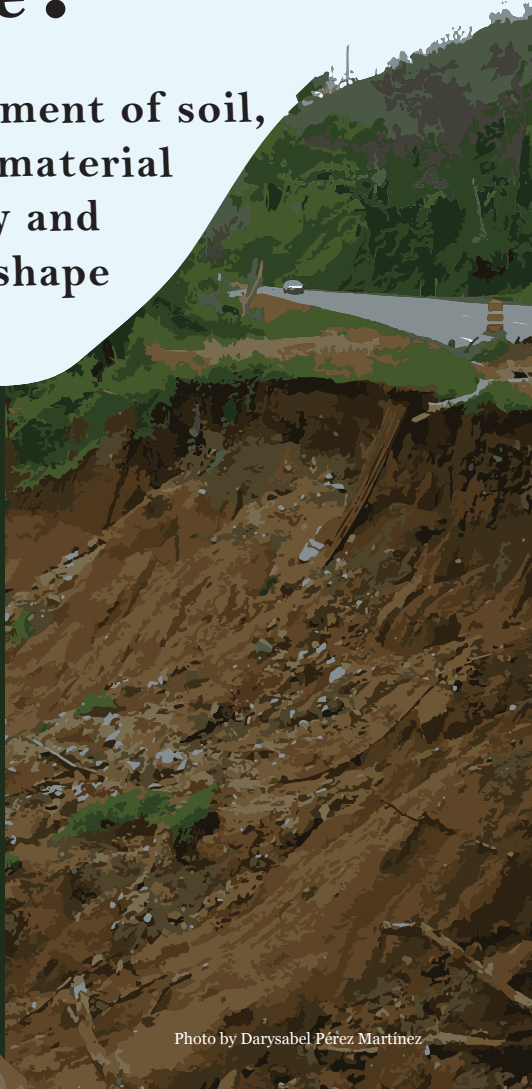
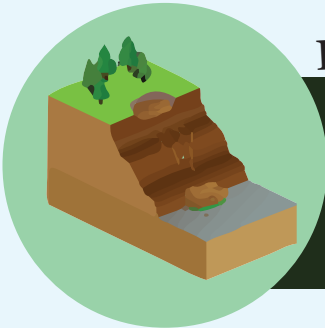


Photo by Darysabel Pérez Martínez

# What do these look like?

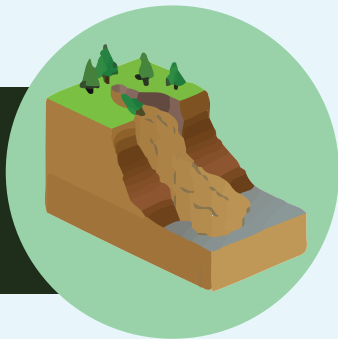


## Rock fall

Downward movement of rock and/or earth that detach from steep slopes or cliffs.

## Flow

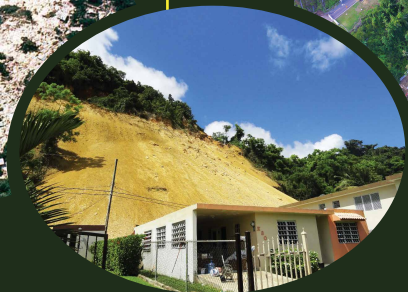
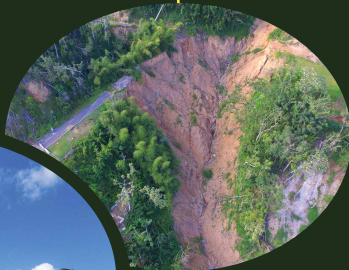
Rapid displacement in which rock and/or earth combine with water to form a mixture that flows down the slope.



## Slide

Detachment of rock and/or earth that usually occurs slowly along a surface.

# Landslides on the Island



Photos by:  
K. Stephen Hughes  
James Joyce  
Ramón Alonso Harris  
Jenniffer Santos-Hernández



# Possible effects on infrastructure



**Rock fall**



**Flow**

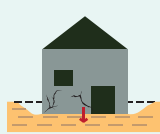


**Slide**

Fast



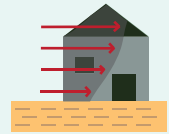
Slow



Sinking



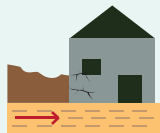
Rock impact



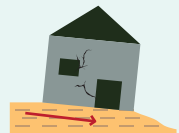
Airborn dust



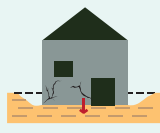
Burial



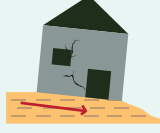
Lateral impact



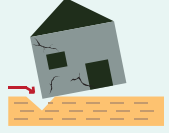
Lateral movement



Sinking



Lateral movement



Undermining

Landslides can take only seconds to occur or can take years to develop.

Photo by Jennifer Santos-Hernández

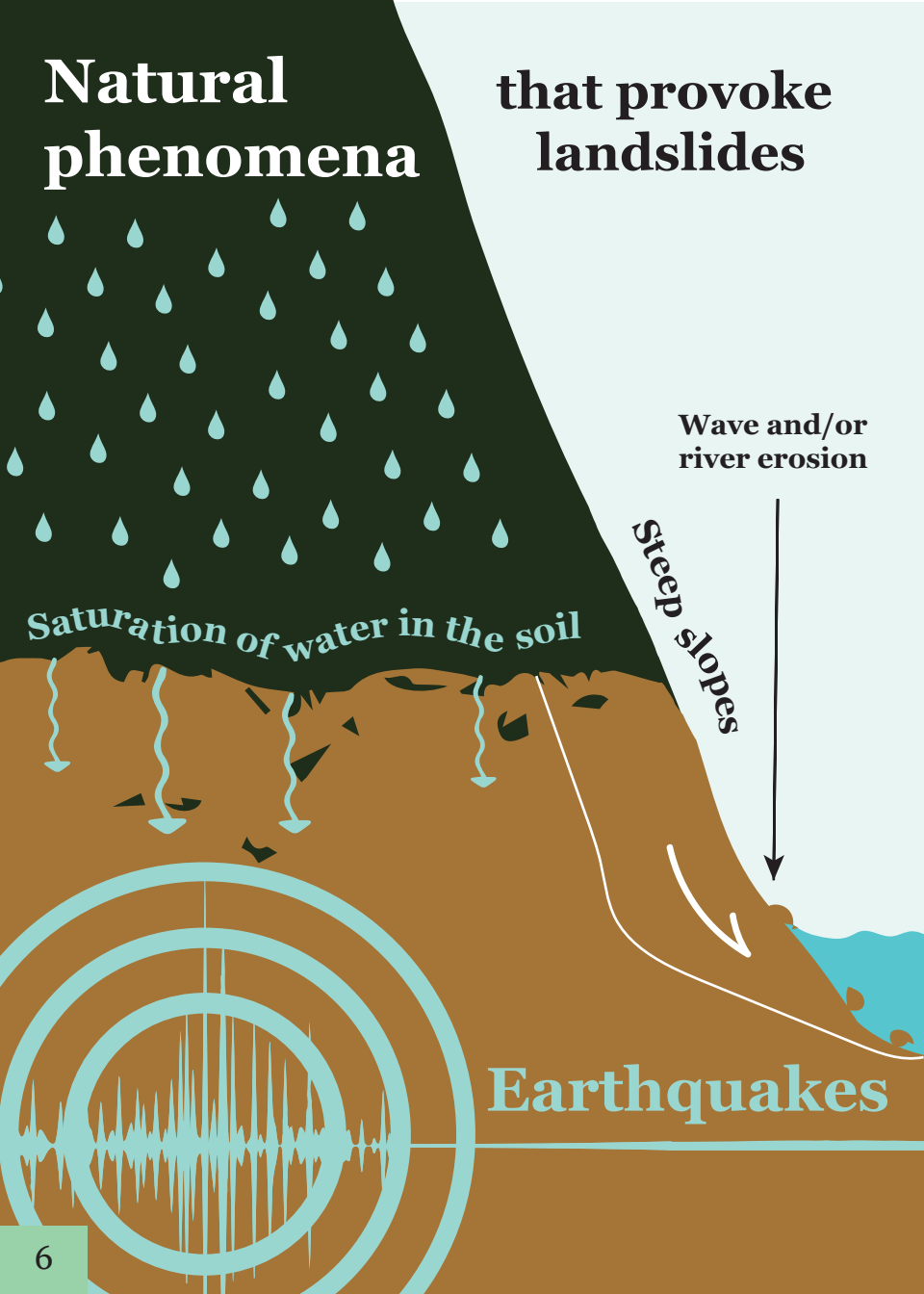


Photo by Lindsay Davis



# Natural phenomena

# that provoke landslides



Wave and/or  
river erosion

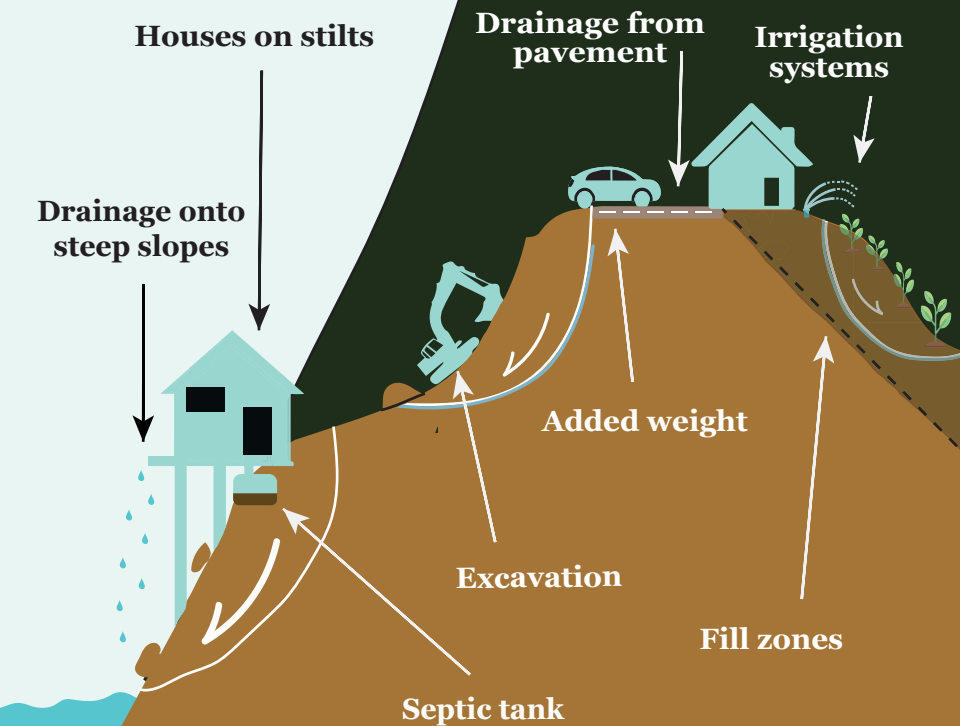
Step slopes

Saturation of water in the soil

Earthquakes

# Human activities

that contribute to landslide susceptibility



Consult a professional to make sure your property has proper drainage.

The effect of erosion is greater when deforestation occurs.

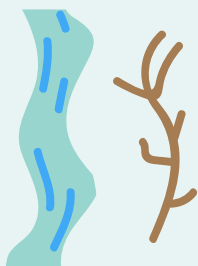
# Possible signs of landslides

## In nature

**Tilted trees** are evidence that a slow movement of land is occurring.



Photo by K. Stephen Hughes



**Springs** develop in new places at the surface, or streams stop flowing suddenly due to landslides obstructing the passage of water.

**Cracks** in terrain facilitate the infiltration of water.



Photo by K. Stephen Hughes

**Distortion** of structures;  
broken, displaced, or dislocated pipes.

**Cracks** that extend in the streets or  
in the walls or floors of houses and around  
windows or doors.

Floors, posts, or walls that are **tilted**.

Windows or doors that suddenly begin  
to **stick**.



## In infrastructure

Photos by K. Stephen Hughes

Important: These are a sample of some, but not all, of the signs that could indicate some danger associated with landslides. These signs could also have other causes. Consult with a professional engineer if you notice all or some of these features. Remember to monitor any type of change in your residence or surrounding area.

# Mitigation

## Before



Avoid making cuts in steep slopes.



Use drains and culverts to direct water away from slopes and areas prone to landslides.



Avoid deforestation and increase the planting of trees on slopes.



Do not build in areas prone to landslides and consult with a professional.



# and preparedness

## Keep yourself prepared with an **emergency backpack**



Remember to have a family plan in which you have a meeting place and action plan identified.

Know your neighborhood. Pay attention to where potentially vulnerable residents such as the elderly or persons with disabilities may live.

# Response

## During



Stay alert to any change in noise. Moving landslides can make the ground shake.

Move away from windows or areas where sediment could enter.



If you are not able to evacuate the area in time, move away from any area of the structure that is more vulnerable.

Stay calm and evacuate the affected structure immediately.

# and recovery

## After



Help the people that have been affected.



Stay informed and consult emergency management offices.



Report damage to houses and property as soon as possible.



If you have lost your home, go to a temporary shelter with your family.



Replant terrain that has been affected to avoid additional erosion.

Stay away from active landslide areas in case more landslides occur.

# Construction

**Before building in an area susceptible to landslides, consult with an engineer, geologist, or geotechnical professional.**



Avoid building without a permit or without a geotechnical investigation.



Avoid building houses on stilts.



Avoid drainage or septic systems on steep slopes.



Avoid houses on top of or at the bottom of a steep hill.

Book available through the University of Puerto Rico, Mayagüez:  
*Rehabilitación de casas en zancos, 2013: Martínez-Cruzado, J., López-Rodríguez, R., and González Avellanet, Y.: The Puerto Rico Strong Motion Program.*

# Home insurance

## with respect to landslides



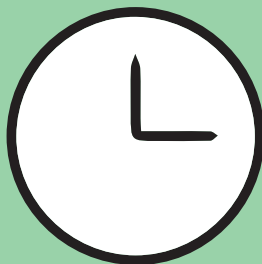
Familiarize yourself with your home insurance policy, they rarely cover landslides.



Take photos of your house before and after the event.



Have important documents in order (proof of residence, copy of geotechnical investigation, service invoice, etc.).



Remember that there is a time limit for making claims after an incident.

## For more information:

### USGS Landslides Hazards Program:

[www.landslides.usgs.gov](http://www.landslides.usgs.gov)

### SLIDES-PR:

[www.facebook.com/SlidesPR](http://www.facebook.com/SlidesPR)

### EcoExploratorio:

[www.ecoexploratorio.org](http://www.ecoexploratorio.org)

### Inundaciones y Derrumbes en Puerto Rico:

#### Guía de mitigación de daños

(CIAPR, AEMÉAD, FEMA)

### Department of Natural Resources Geology Division:

[www.drna.pr.gov/oficinas/division-de-geologia/](http://www.drna.pr.gov/oficinas/division-de-geologia/)

### Puerto Rico Seismic Network

[www.redsismica.uprm.edu/english/](http://www.redsismica.uprm.edu/english/)

### Contributors/Reviewers:

Lindsay Davis, Jocelyn West, and Lori Peek

*Natural Hazards Center, University of Colorado Boulder*

K. Stephen Hughes and James Joyce

*University of Puerto Rico, Mayagüez*

William Schulz and Jonathan Godt

*U.S. Geological Survey*

Darysabel Pérez Martínez

*Puerto Rico Highway and Transportation Authority*

Gisela Báez Sánchez, Glorymar Gómez Pérez, and

Carolina Hincapié Cárdenas

*Puerto Rico Seismic Network*

Christa von Hillebrandt

*NOAA Caribbean Tsunami Warning Program*

Lorna G. Jaramillo Nieves and Jenniffer Santos Hernández

*University of Puerto Rico, Río Piedras*

NOAA National Weather Service, San Juan

Puerto Rico Science, Technology,

& Research Trust

Puerto Rico Planning Board

### Guide Design and Layout:

Raquel Lugo Bendezú and

Yahaira D. Álvarez Gandía

*University of Puerto Rico, Mayagüez*

[hazards.colorado.edu/puertorico](http://hazards.colorado.edu/puertorico)

This publication was produced with funding provided to USGS<sup>®</sup> as part of the Additional Supplemental Appropriations for Disaster Relief Requirements Act 2018 (P.L. 115-123).

Learn more:

<https://www.usgs.gov/natural-hazards/usgs-supplemental-disaster-recovery-activities/>

Photo by K. Stephen Hughes