Landslides and the Colorado Front Range Debris Flows of 2013

**Created by:**

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**Purpose:**

The purpose of this laboratory exercise is for you to become familiar with the different types of landslides and their properties, and how landscape-scale factors such as slope aspect, vegetation, and geology can impact landslides.

**Essential Learning Outcomes:**

Identify the different types of landslides

Recognize the different causes of landslides

Convert between standard and metric units of measurement

Interpret graphs and maps

**Equipment required:**

Computer with internet access

**Instructor’s Notes:**

This exercise was developed for an online class and intended for students to work independently. Both readings used in this exercise are open-source and can be downloaded for free. All answers to questions can be determined from the readings.

**Background:**

Landslides, or the sudden downhill movement of soil, regolith, bedrock, and other debris under the influence of gravity, occur throughout all 50 states of the United States and in every country around the world. Mountainous regions are especially susceptible to mass wasting events. Landslides take a range of forms and can be initiated by a variety of different triggers, such as earthquakes, heavy precipitation events, animal burrowing, wildfires, development, overgrazing, deforestation, and mining.

Landslides, or mass wasting events, are classified by four criteria: 1) type of material being moved (i.e., rock, soil, water-sediment); 2) physical properties of material (i.e., hard, plastic, fluid); 3) type of motion (i.e., falling/toppling/rolling/sliding, mass flow, or fluid flow); and 4) how quickly the process occurs (i.e., inches/year to feet/second). The slowest form of mass wasting is soil or rock creep, which may move less than a few centimeters per year. Rockfalls can occur instantaneously and result in catastrophic destruction within seconds.

Some of the deadliest mass wasting events are flows. These nearly fluid events that occur after prolonged rainfall. Flows are common in mountainous regions, especially semi-arid zones, where slopes are steep and vegetation is sparse. Sediment and other debris are easily eroded by runoff and flow rapidly downhill, especially if it becomes channelized. The Colorado Front Range experiences more than 1,100 debris flow events within a one-week period in 2013. A series of high-intensity, long-duration storm events initiated the debris flows. Several lives were lost, 125 homes were destroyed, overly 3,000 homes were damaged, and economic impacts exceeded one billion dollars.

**Exercises:**

**Part 1 – Landslide Types and Processes**

Download the U.S. Geological Survey publication [*Landslide Types and Processes*](http://pubs.usgs.gov/fs/2004/3072/fs-2004-3072.html) and read it to answer the following:

1. How can the various types of landslides be differentiated?
2. Of the types of landslides described which is the slowest moving?
3. Of the types of landslides described which involves the finest material?
4. Although there are multiple types of causes of landslides, the three that cause most of the damaging landslides around the world are these:
5. A landslide induced by a wildfire is an example of what type of cause?
6. A landslide occurring at the boundary between a sand-rich layer and a clay-rich layer is an example of what type of cause?
7. A landslide induced by a wildfire is an example of what type of cause?

**Part 2 – Debris Flows**

Download and the article [*New insights into debris-flow hazards from an extraordinary event in the Colorado Front Range*](http://www.geosociety.org/gsatoday/archive/24/10/article/i1052-5173-24-10-4.htm) by Jeffrey A. Coe, Jason W. Kean, Jonathan W. Godt, Rex L. Baum,

Eric S. Jones, David J. Gochis, and Gregory S. Anderson, GSA Today, Vol. 24, No. 10, 2014 to answer the following:

1. Rainfall on September 9 – 13, 2013 triggered at least how many debris flows?
2. How many fatalities were there as a result of the combination of debris flows and flooding that occurred with this event?
3. From September 9 – 13, 2013, nearly continuous rainfall along the Colorado Front Range caused widespread debris flows and flooding in how large an area in square miles?

(*Tip: 1 mi2 = 2.59 km2*)

1. Historical debris flows in the Colorado Front Range have been triggered by rapid snowmelt and localized rainstorms, which caused debris flows over areas typically less than what size in square miles?
2. How did slope aspect affect vegetation density along the Colorado Front Range?
3. What was the range, in inches, of cumulative rainfall prior to September 9?

(*Tip: 1 in = 25.4 mm)*

1. What is the minimum antecedent rainfall, in inches, needed to initiate debris f lows?
2. How much rainfall, in inches, did the City of Boulder receive in the 7-day period of September 9 – 15, 2013?
3. How did travel distance of flows that initiated in or entered channels compare to flows that did not interact with channels?

1. What percentage of debris flows occurred on south- and east-facing slopes?
2. Which ecological zones experienced the greatest number of debris flows?
3. Slope aspect was an important control on debris flow distribution; what is the key ingredient required to increase the susceptibility of north-facing slopes to debris flows?
4. Debris flows along the west coast of the United States (e.g., the Coast Range of Oregon) are widespread about every years, while in the Colorado Front Range return periods for wide-spread debris-flow events are on the order of  years or more.